

2. The Mammals

By LORD MEDWAY

INTRODUCTION

SEVERAL EARLIER zoological expeditions interested in mammals have visited Tioman, but dates and personnel have been mentioned only *en passant* in scattered accounts of the animals collected. Visits which failed to produce publishable taxonomic results may have gone unrecorded. A survey of the literature discovers mention of the following: 1899, Dr. W. L. Abbott with C. B. Kloss (Miller, 1900, 1903, Kloss, 1908); 1906, H. C. Robinson (Thomas, 1908); 1907, H. C. Robinson and E. Siemund (Kloss, 1908); 1912, H. C. Robinson and E. Siemund (Robinson, 1912); 1915, H. C. Robinson (Robinson, 1917); 1916, C. B. Kloss (Chasen, 1940).

As a result of their efforts, twenty-seven species of mammals were recorded from Tioman, of which seventeen, a very high proportion, had been described as endemic subspecies. No formal list of the mammals of the island has previously been published, although most records were mentioned by Chasen (1940).

During our visit we failed to find four of the mammals previously reported from Tioman (two bats, the Slow Loris, and the Shrew-faced Ground Squirrel); we were unable to collect one (the Hairless Bat); and we refrained from collecting another (the Long-tailed Macaque). On the other hand we succeeded in collecting five species not hitherto recorded (three bats, a flying-squirrel and a rat⁶) bringing the total number of land mammals known from Tioman to thirty-one. Stories from the islanders suggest that another civet may remain uncollected. It is also possible that further bats exist undetected. With these exceptions, it is unlikely that future expeditions will add significantly to the list.

No mammals have hitherto been recorded from P. Tulai.

In the following pages all the mammals known from these islands are discussed, and the habitat that each occupies is outlined. Unless otherwise indicated, all measurements are given in mm. Our observations of the food of the specimens that we collected, and of the reproductive condition of females, are given in some detail. The taxonomic position of the Tioman population of each species is also examined as far as material permits. Where they exist, accepted English names are given together with the colloquial equivalents current on Tioman, which in several cases appear to be unique to the island dialect.

All permanent specimens have been deposited in the collections of the Department of Zoology, University of Malaya.

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I am grateful to Mr. J. A. Bullock for identifying arthropod material from the stomach contents discussed below, to B. L. Lim for making available certain specimens and other data collected by the I.M.R. team during their visit to Tioman, and to Professor J. L. Harrison of the University of Singapore for making available the unpublished data appearing as Table 8.

6. These new records are marked with an asterisk in the list below.

ANNOTATED LIST

PULAU TIOMAN

Hylomys suillus tionis Chasen.

Lesser Gymnure, ? *Salak ba'a*.

We trapped only an adult male and a subadult female of the Lesser Gymnure, both on the ground in the bamboo forest near the summit of G. Kajang. On two occasions, single animals, active by day, were also seen on the slopes just below Camp V. We did not record the species below 2,700 feet. On Tioman, as throughout its present range, it appears to be common only on high ground above about this altitude.

One animal came to a bait of cooked fresh meat, the other to coconut, but in both cases the stomach was empty when examined and the bait had not obviously been eaten.

The occurrence of a normally montane terrestrial mammal on Tioman is of some interest. It should be noted that the Juara villager who offered the curious name *Salak ba'a* (which was not recognised in other villages, where nobody could be found who had seen *Hylomys* alive) claimed that the animal also occurs at much lower altitudes. Whether or not this is true, the recent discovery (Medway, 1964) of a mandible of *Hylomys* in a archaeological deposit little above sea-level at Niah, Sarawak, at a depth corresponding to a C¹⁴ date of c.39,000 B.C., indicates that in the late Upper Pleistocene the habitat of this mammal extended to the lowlands⁷. This important archaeological discovery (the specimen was recognised by the Earl of Cranbrook) demonstrates that, at a period when a lowered sea-level had either joined Tioman to the Sunda land-mass or at least had considerably diminished the intervening sea barrier, *Hylomys* occurred in the lowlands, and would thus have had an increased opportunity to colonise the island either directly overland or by rafting.

Based on two skins collected in 1915 and 1916, Chasen (1940) separated the Tioman population from *maxi* Sody of mainland Malaya and of Sumatra by the following characters: Upperparts "very slightly more richly coloured, the difference being especially noticeable on the posterior half of the back, and on the outside of the thighs. Prevailing colour of the underparts buffy, not grey. Skull very slightly longer than in the available specimens and records of *maxi*".

For comparison with our single adult skin (evidently the third from Tioman) I have two recently collected skins from Kg. Janda Baik, on the Selangor-Pahang border. On the latter (*maxi*) the upperparts are indeed very slightly darker and less fulvous than on the former (*tionis*), due to somewhat greater prominence of the black guard hairs. The underparts are indistinguishable; in both cases the hairs are grey for most of their length, distally tipped buff⁸. The length of the skull of *tionis* (greatest length 37.8 mm., cf. 37.9 for the type) fractionally exceeds the longest skull of *maxi* (greatest length 37.1 mm.). In all other measurements there is overlap. The Tioman *Hylomys* is thus marginally distinct from the mainland population, and on the present specimens retention of the subspecific name can be justified.

7. The greatest depression of sea-level during the last glaciation was within 100 m. (330 feet) (Zeuner, 1959) and cannot have significantly affected the present altitudinal boundaries.

8. Chasen's description of *tionis* was based on only two skins, 25 years old, which may well have lost colour.

Crocidura malayana tionis Kloss. Malayan White-toothed Shrew, *Tikus pahit*.

We obtained two males and three females of this small shrew. One was taken from a cat in a house on the hillside above Juara. The other four were trapped by Longworth small mammal traps in a variety of sheltered habitats: tall coconut plantation just behind the beach, scrub and grass (not *Imperata*), tall secondary forest without undergrowth, and primary forest near Camp II. We failed to trap or see this shrew on the high ground around Camp V, or on G. Kajang, and it probably does not range to these altitudes.

Trapping figures are analysed in Table 1, and show an overall catch of just under 4 per 100 trap nights. This rate indicates that the shrew must be very much commoner in Tioman as a whole (including unproductive habitats) than in any comparable tract of forest on the mainland, where to date in over 400 trap nights in forest habitats I have caught only one *Crocidura* in the Longworth trap.

TABLE 1

Mammals caught in the Longworth small mammal trap					
Habitat	No. of trap nights	<i>Crocidura</i>	<i>Rattus tiomanicus</i>	<i>Rattus exulans</i>	
Foreshore ...	4	0	0	1	
Coconut plantation ...	11	1	0	0	
Harvested <i>ladang</i> ...	10	0	1 (juv.)	0	
Lowland scrub and grass ...	20	1	0	0	
Tall secondary forest ...	4	1	0	0	
Primary forest at 1,000 ft. ...	24	1	0	0	
Primary forest over 2,500 ft. ...	30	0	0	0	
	—	—	—	—	
Total ...	103	4	1	1	
	—	—	—	—	

As *tikus pahit*, the shrew was familiar to the islanders, several of whom asserted that it often enters houses. This claim was supported by our catch of one male taken from a cat in a house and, since *Suncus* the usual commensal shrew is absent, it may well be true.

All stomachs were empty: one contained traces of unidentifiable insect food.

One out of three females was pregnant, with a single foetus in the right uterine horn.

The Tioman shrew belongs to the group of middle-sized, close-furred and moderately long-tailed *Crocidura* of South-east Asia, of which *C. malayana* is the representative on the Malayan mainland. The Tioman form was originally described as a separate species, based on a series of five specimens collected in 1915 (Kloss, 1917). But these specimens were not apparently compared with shrews from the mainland and, on doing so, I can find no characters warranting specific separation.

I have before me a good series of *C. malayana* collected by the Institute for Medical Research, Kuala Lumpur, including seventeen taken from one restricted area (Bukit Lagong Forest Reserve, Selangor). As shown in Table 2, which gives the principal flesh measurements, there is considerable overlap, although the ten from Tioman are on average slightly smaller, with slightly longer tails than the mainland series. Statistically, the difference does not warrant separation of the two populations, which are equally indistinguishable by skull characters and by texture and length (3 mm. mid-dorsum) of the fur. Since the mainland series were all preserved in spirit it is not possible to compare the fur colour of the two forms.

A single freshly collected skin of *malayana* is however available in the Zoology Department collection. The Tioman skins are all consistently very slightly browner in overall colouration than the mainland skin. The form *tionis* was described as being comparatively brown (Kloss, 1917) and until further material is available this character may be taken to distinguish the island race.

TABLE 2

Principal flesh measurements of *Crocidura* from Tioman and the Malayan mainland.

Locality	No. of Specimens	Head and Body		Tails as % of H and B	
		Range	Mean	Range	Mean
Bt. Lagong F.R., Selangor ...	17	75-95	86.8	67-77	71.9
P. Tioman ...	10	70-92	82.2	69-83	76.8

***Cynocephalus variegatus taylori* (Thomas).**

Flying Lemur, *Kujul*.

Not rare. Recorded from coconut gardens (by night) once at Tekek and once at Mokut, and once from primary forest at about 2,600 ft. in the pass between Camp V and G. Kajang (by day).

An adult female was collected on 4th April, carrying an unweaned juvenile male (head and body 263 mm., weight 372 gm.), and also pregnant with one male foetus (head and body c.45 mm., weight with maternal reproductive tract 33 gm.) in the left uterine horn.

The Tioman flying lemur is distinguished subspecifically from geographically neighbouring forms, including the distinct race on nearby Pulau Aor, by the proportionately large size of its teeth, particularly the anterior teeth. Measurements in mm. of the adult female, collected 4th April, 1962 (with those of the type, a subadult male, in parentheses) are as follows: Head and body 398 (338); tail 255 (179); hind foot 69 (49); ear 21 (16). Skull: condylobasal length 71.4 (66); zygomatic breadth 46.8 (42.3); interorbital breadth 20.6 (17); upper toothrow 36.4 (35); length of anterior maxillary tooth 6.8 (7.1), of second maxillary tooth 5.9 (5.8), and of the four molariform teeth 14.8 (15).

***Pteropus hypomelanus lepidus* Miller.**

Island Flying Fox, *Kluang*.

There are two large roosts of this bat, permanent according to reports, in coconut palms on the foreshore, one just south of Tanjong Mesoh, Tekek, and the other at the east end of Kg. Mokut. Specimens have also been collected in the past at Juara (Hill, 1961), but at that village residents claim no knowledge of a roost nearer than Tekek. At Setegap, near Juara, these bats came to the fruiting durian trees soon after dusk, and fed on the fruit already opened by squirrels. Evidently their feeding range included the whole island.

We collected nine bats from one roost in a coconut tree at Tekek; all were male, suggesting the possibility of segregated roosting.

Pteropus hypomelanus is characteristically restricted to islands. The race *lepidus* is widely distributed, extending from the east coast Malayan islands to the Anamba archipelago.

****Cynopterus brachyotis brachyotis* S. Müller.**

Malaysian Fruit-bat.

This bat was repeatedly caught by night in mist-nets set in scrub and young plantation at Tekek, in overgrown plantation, belukar and tall forest at Mokut, and in primary forest around Camp II. It did not enter nets set on high ground above 2,500 ft. in the vicinity of Camp V, and is probably restricted to the lowlands, where it is common and widespread.

Seven females from Tulai and Tioman together were kept for specimens. Within this sample reproductive condition varied widely: two females were in advanced pregnancy, one in mid-pregnancy, one had a newly implanted embryo, and three showed no signs of breeding. One conceptus was present per pregnant bat, in either uterine horn.

Three races of *Cynopterus brachyotis* are known from the Malayan mainland (Hill, 1961). Measurements of the forearm (65–68 mm.) and ear (15–19 mm.) of our series of twelve (5♂, 7♀) from Tioman and Tulai, although somewhat larger than average, are within the range of dimensions of the nominate race, which extends from Borneo to the Malayan lowlands as far north (on the west coast) as central Perak; its range on the east coast is uncharted.

***Eonycteris spelaea** Dobson.

Cave Fruit-bat.

This bat was also caught in mist-nets in scrub and plantation at Tekek and Mokut, but was not obtained in forest. No roost was located.

One female was trapped; it was pregnant with one foetus in the right uterine horn.

Emballonura monticola monticola Temminck.

Sheath-tailed bat.

A female, pregnant with a mid-term foetus in the left uterine horn, was shot over the beach at Tekek (19th March).

Rhinolophus refulgens refulgens Andersen.

Horseshoe bat.

We obtained a male from Mokut, and a male from Tekek, both in tall forest on the lower slopes of the hillside. Both on Tioman and elsewhere Rhinolophids and other microchiropterans have successfully been trapped by night in large numbers by means of standing mist-nets set in forest. It is therefore significant that no bats were caught in our mist-nets during 16 net-nights in the vicinity of Camp V. Che Ismail, a professional collector of the edible nests of cave-dwelling swiftlets (see Medway, this *Bulletin*, on Birds, p. 43) knew of no bat roost in any of the numerous caves at higher altitudes that he habitually visited.

This species is distinguishable from the following one by a somewhat shorter forearm, a high triangular (as opposed to rounded) prominence on the connecting process between anterior and posterior nose-leaves, and a dark brown pelage uniformly coloured to the bases of the hairs. Flesh measurements are: Head and body 40, 40; forearm 39, 40; ear 15, 15; weights 4.5 and 5.3 gm. respectively.

Rhinolophus klossi Andersen.

Horseshoe bat.

In the type description, this bat was said to occur on both Tioman and Pemanggil. On the other hand Hill (1960), in his account of mammals collected by H. C. Robinson (who visited Tioman repeatedly, as noted above), listed specimens only from the latter island. We did not find it, and its inclusion among the fauna of Tioman may be erroneous.

Rhinolophus affinis superans Andersen.

Horseshoe bat.

A male and female were netted in forest at Mokut with *R. refulgens* (above). The female was pregnant with one late foetus.

This bat has previously been recorded from Tioman by Hill (1960). Collector's measurements of the two present specimens are (male and female respectively): Head and body 52, 51; tail 16, 15; forearm 44, 47; ear 21, 20.

****Hipposideros bicolor atrox*** Andersen. Roundleaf Horseshoe bat.

A female in advanced pregnancy was taken from an evening flight stream in disturbed forest at Mokut on 7th April. Measurements agree with the mainland Malayan race: Head and body 52, tail 28, forearm 47, ear 17.

Hipposideros larvatus barbensis Miller. Roundleaf Horseshoe bat.

This race of *H. larvatus*, described from St. Barbe Island (=P. Pejantan) between Lingga and Borneo, is recorded from Tioman and Aor by Hill (1960). We did not find it.

Cheirodeles torquatus Horsfield. Hairless bat.

The Hairless Bat is recorded from Tioman in a footnote to Thomas (1908) provided by H. C. R. (obinson). It is the largest microchiropteran in our region, and in flight its action and silhouette are unmistakable. Small evening flights above the forest canopy were seen originating from points inland of Tekek and about 1 mile south of Juara, but neither roost could be located.

Tupaia glis sordida Miller. Common Treeshrew, *Kenchong*.

As shown by our overall trapping results (cage traps) in Table 3, treeshrews are very abundant on Pulau Tioman. Below 1100 ft. they were trapped in all habitats except the arid foreshore and belukar, but were taken most frequently in undisturbed primary forest. By day we often encountered small parties, usually one to four in number, on the ground or in shrubs or in the lower storeys of the forest. Although conspicuous, they were not noticeably tamer than on the mainland. On the hills above 2,500 ft. no treeshrews entered our traps, and in six days we saw only one animal, this at the lower margin of the zone, near the pass between Camp V and G. Kajang.

Of the many treeshrews obtained, eight (3 ♂, 5 ♀) were retained as specimens. Four stomach contents were examined and contained respectively (sex and habitat in parentheses): (♂, rice stubble) banana (=bait), plus one small beetle; (♀, lower edge of forest) banana (=bait), plus well masticated insect food including two fragmentary orthopteran tegmina (?Gryllidae), two hemelytra of a heteropteran bug, and one beetle (?Chrysomelidae); (♀, lower edge of forest) banana (=bait), one caterpillar, one hind wing of a heteropteran bug; (♂, scrub and grass; shot, not trapped) chiefly a hard-coated, black-seeded fruit, plus one large wing of a heteropteran bug and one slug.

Of five females, only one showed overt signs of breeding: from Tekek, 17th March, pregnant, one foetus in each uterine horn, and mammary glands active.

Many races of *Tupaia glis* have been described from the mainland and islands of Malaya. Most of the latter, including *T. g. sordida* from Tioman, are endemic to single small islands. With the use of a reflectometer, Hill (1960) has shown that in dorsal colouration, the race *sordida* is only very slightly duller than *T. g. ferruginea* from corresponding latitudes on the west coast of the mainland. It can still be distinguished by its darker underparts and very dull, almost obsolescent shoulder flash. Fresh skins of *T. glis* in the collection of the Zoology Department, University of Malaya, from Rompin, Pahang, opposite P. Tioman on the east coast of the mainland, are considerably brighter and redder than skins from the west coast, and are thus even more distinct from the Tioman specimens. The Tioman race is also smaller on average than mainland *ferruginea* although, as our data show, there is overlap in all flesh measurements. Of eight specimens with fully erupted dentition, head and body measure 157-184, tail 134-155, and hind-foot 37-42 mm.

TABLE 3
Mammals caught in baited cage traps.

Habitat	Trapping days	<i>Rattus tiomanicus</i>	<i>Rattus subanans</i>	<i>Rattus swirfer</i>	<i>Rattus exulans</i>	<i>Rattus tremori-venter</i>	<i>Callosciurus notatus</i>	<i>Callosciurus nigrovittatus</i>	<i>Lorisicus insignis</i>	<i>Hylomys suillus</i>	<i>Tupaia glis</i>	Total	Catch per 100 trap day/nights
Foreshore ..	10	..	..	..	*	..	..	..	..	..	..	0	0
Coconut plantations ..	30	2	..	..	..	..	..	..	..	..	1	3	10
Rice stubble ..	147	17	2	..	12	..	..	..	..	..	6	37	25
Scrub and bush (<i>Lantana</i>)	70	17	..	2	1	2	1	..	..	..	4	27	38.5
Belukar and secondary forest ..	81	26	7	2	..	..	1	..	..	..	..	36	44.5
Primary forest below 1200 ft. ..	168	6	8	4	..	..	..	1	1	..	22	42	25
Primary forest over 2500 ft. ..	202	4	13	24	..	1	..	..	7	2	..	51	25.4
Totals ..	708	72	30	32	13	3	2	1	8	2	33	196	36.2
I.M.R. team trapping figures (all lowland habitats) ..	n.k.	19	3	6	..	1	2	2	2	..	20	55	..

*One *R. exulans* was trapped in a Longworth small mammal trap on the foreshore.

Nycticebus coucang insularis Robinson.

Slow Loris.

In 1917, Robinson recorded that the Slow Loris "is apparently rare in Tioman, and is unknown to the majority of the inhabitants". This remained true in 1962. At Tekek and Juara, several villagers asserted that it did not occur on the island. Only at Mokut was it known; there people remembered that a single animal had been caught and kept for some time in 1958. The only published record, the type specimen of the endemic race *insularis*, "was obtained in felling a patch of heavy jungle" at S. Nipah (Robinson, 1917). Thus all available evidence indicates a small population restricted to the southern end of the island.

Macaca fascicularis laeta (Elliot).Long-tailed Macaque, *Kera*.

Only this monkey is found on Tioman. It is common and, according to the islanders, a pest of cultivation. We regularly found a large troupe in tall forest on the Juara side of Camp II. More usually, we saw troupes in fringing forest, near the ricefields at Tekek, not far from the shore at Tk. Nipah, and on the hillsides above Mokut⁹.

The populations on P. Tioman and P. Tinggi are described as very brightly coloured, and on this character have been separated from the mainland as a distinct subspecies (see also Hill, 1960).

Ratufa bicolor tiomanensis Miller.Black Giant Squirrel, *Mengkawak*.

This squirrel is common in the upper storeys of the primary forest throughout the length of the Tekek-Juara path. It is noisy and unafraid, usually giving its presence away by its loud alarm call, scolding furiously from the tree tops. At Mokut it was said to be a pest of young coconut trees in plantations on the upper slopes; at Tekek it was seen in the strips of low secondary forest which ran between areas of cleared ladang. On high ground we did not record it, but a skeleton was found in the pass (2,367 ft.) between Camp V and G. Kajang.

The endemic race is distinguished from the mainland form *R. b. peninsulae* Miller by its shorter tail (Thomas, 1907). The distinction is confirmed by our series of three (2 ♂, ♀), the tails of which measured 325–395 mm. (cf. 29 specimens of *peninsulae*, 395–540 mm., in Hill, 1960).

Callosciurus notatus tenuirostris Miller.Plantain Squirrel, *Tupai Kampong*.

Abundant in plantations in all settlements, and a serious pest of coconuts. It also ranges into the scrub and secondary growth at the lower margin of the forest; but, as stomach contents emphasise, in all habitats it depends for food on either plantation crops (principally coconut) or fruits of associated weed plants. Two animals entered our ground traps, but the majority of the specimens collected (6 ♂, 6 ♀) were shot.

Examined stomach contents were as follows: (♀ early pregnancy, in coconut plantation) mostly ripe *Lantana* berries, plus at least 20 large winged ants; (♀ lactating, coconut plantation) mostly coconut flesh, plus a few *Lantana* berries and two or three ants; (♀ early pregnancy, coconut plantation) mostly coconut flesh, plus a few *Lantana* berries and mixed insects comprising a score of small worker ants of two sorts (one red, one black), 3 abdomens (4 mm. long) of large winged ants, 1 caterpillar (c. 8 mm.), 1 thrips (3 mm.), 1 mite, and 1 small parasitic wasp; (♂, coconut plantation) 9 large caterpillars (20 mm.); (♂, lower edge of

9. The anti-malaria team, U.S.P.H.S., (see Warren, this *Bulletin*, on Malaria) shot seven macaques for blood samples, but unfortunately were unable to arrange to keep any of the carcasses for permanent preservation.

forest) mostly *Lantana* berries; (♀, lactating, fruiting durian tree) 80% vegetable matter, chiefly durian pulp, plus a hard stone (4 mm. long) of some other fruit and unidentified yellow pulp, the remainder insects including recognisable fragments of ants and beetles. These stomach contents indicate a mixed diet similar to that taken by *C. notatus* on the mainland (Harrison, 1962).

Of six females, four were lactating without obvious signs of recurring pregnancy (17–26th March), and two (17th, 18th March) were in early pregnancy, both with two foetuses in the left uterine horn only.

The endemic Tioman race is little differentiated from the form on the neighbouring mainland, but may be distinguished by a shorter rostrum, and a proportionately shorter tail (79–92% head and body) which with a very few exceptions lacks the red tip (see Hill, 1960). It is more sharply differentiated from the forms on Pemanggil and Aor, which are markedly smaller.

***Callosciurus nigrovittatus microhynchus* Kloss.**

Black-banded Squirrel, *Tupai Kampong*.

C. nigrovittatus is not rare, but still is very much less common than *C. notatus*. At Tekek and Juara it was recorded only below 500 ft. in the lower storeys of the forest, extending into coconut plantations alongside *C. notatus*. Both species, with *S. tenuis*, were feeding together in fruiting durian trees at Setegap, Juara, at the end of March. We did not encounter *nigrovittatus* in forest above 500 ft., and failed to record it altogether at Mokut.

Three stomach contents were examined: (♂, in coconut plantation) entirely coconut flesh; (♂, in durian tree) durian pulp, plus one small black ant; (♀, lactating, in durian tree) chiefly durian pulp, plus unidentified yellow pulp, and a high proportion of insect remains, including about six large worker ants (10 mm. long). These data indicate a diet similar to the mixed fruit and insects taken by mainland *nigrovittatus* (Harrison, 1962), and suggest that on Tioman, where the ranges of *C. notatus* and *C. nigrovittatus* overlap, the two species are competing for the same foods.

Of the two females collected, one (26th March) was lactating.

The endemic subspecies on Tioman was originally separated from the north-eastern Malayan form of *C. nigrovittatus* on the basis of relative dimensions of the nasal bones. But Hill (1960) has shown that this character does not distinguish it from *C. n. joherensis* (Robinson & Wroughton) of southern Malaya, from which it can only be separated by a slight difference in the shade of the tail colour. It is also on average somewhat smaller, but the overlap in measurements is too great to warrant separation statistically.

***Sundasciurus tenuis tiomanicus* (Robinson).** Slender Squirrel, *Tupai Chelis*.

Common throughout the tall forest, from the lower margin to Camp V and the summit of G. Kajang. It was usually seen in small parties of four or so animals, foraging in the lower and middle storeys, rarely descending to the ground. It was seen in company with *C. notatus* and *C. nigrovittatus* only in the fruiting durian trees at Setegap.

Harrison (1962) has recorded that the diet of mainland *S. tenuis* consists mostly of fruit, with a comparatively small amount of insects. This was also true of seven Tioman animals examined, all of which (including a lactating female) had taken much less insect food than was common among *C. notatus* and *C. nigrovittatus*: (♂, forest) unidentified vegetable pulp, plus two ants; (♂, forest) stomach more or less empty, no matter identifiable as of animal origin; (♂, forest) as above;

(♀, forest) unidentified fruit and vegetable pulp, plus one large black and yellow banded leg of a big ?spider; (♀ lactating, in durian tree) chiefly durian pulp, plus a seed coat, and a few insect remains; (♂, highland forest) exclusively unidentified vegetable pulp.

Of two females collected, one was lactating (26th March).

The endemic subspecies on Tioman is distinguished from *S. t. tenuis* (Horsfield) of comparable latitudes on the mainland only by the slightly duller, less ruddy colouring of the dorsal surfaces of the hands and feet.

Lariscus insignis fornicatus Robinson.

Three-striped Ground Squirrel, *Tupai Belang*.

This squirrel was found in tall forest only, at all altitudes from the lower margin (150 ft.) of the forest to the higher slopes of G. Kajang. It was common on the relatively level stretch of ground on the Juara side of Camp II (where we did not trap—cf. Table 3), and on the slopes around Camp V; in both places we frequently encountered animals by day, usually singly. One animal, on being released from the trap, instantly ran down a hole in the ground between the roots of the undergrowth.

The villagers at Mokut claimed that this squirrel was a pest of coconut seedlings, attacking the young shoots. We found that, although coming readily to vegetable baits, trapped animals usually ate little if any of the bait. We killed and skinned two adults whose stomach contents were: (♂, highland forest, trapped on banana bait) no obvious bait or vegetable matter, identifiable animal remains consisting of part of the mesothorax of a large muscid, leg and other sclerites of a large beetle, leg and sclerites including the tegmen of a ?blattid; (♀ lactating, lowland forest) banana (=bait), plus some indeterminate vegetable matter and the remains of two beetles. A third specimen killed was a subadult male (17th April) and although it was almost full-grown (head and body 169, tail 98, weight 145 gm.) its stomach contained only milk.

The adult male had large scrotal testes, and the female was lactating (23rd March).

TABLE 4
Dimensions of the nasal bones of *Lariscus insignis*

			Median length of nasals	Greatest breadth of nasals	Length/breadth ratio
<i>L. i. fornicatus</i>					
ad	♂	...	12.9	6.1	2.11
ad	♀	...	14.4	6.6	2.18
<i>L. i. jalorensis</i> (Selangor)					
ad	♂	...	13.8	6.4	2.15
ad	♀	...	14.6	6.1	2.39

The endemic subspecies *fornicatus* was characterised as: "Differing from other forms of *Lariscus insignis* (Cuv.), in its somewhat slighter skull, the nasals broadening less anteriorly and by having the rostrum decidedly more arched laterally, i.e. the nasals meet at an angle instead of lying practically in the same plane" (Robinson, 1917). This description was based on two adults and "two somewhat immature males" (Robinson, *l.c.*), but since juvenile rodents characteristically have shorter, more arched nasal regions than mature adults of the same species,

it is doubtful whether the latter should have been included. In the absence of measurements, which are not given by Robinson, it is hard to compare our specimens. Measurements of the breadth and length of the nasals of the two adults from Tioman, and of two adults from Selangor, show only slight overlap (Table 4), but longer series are desirable before the status of *L. i. fornicatus* can be reassessed with confidence.

Rhinosciurus laticaudatus robinsoni Thomas. Shrew-faced Ground Squirrel.

The type description of the endemic race of this squirrel is based on a series of three collected from the region of Kg. Juara (Thomas, 1908). Four specimens (undated) are listed among the Robinson collected by Hill (1960). But during our stay we neither trapped, nor saw, nor obtained any indication of the presence of this squirrel. Previous reports (Thomas, 1908; Robinson, 1912) do not suggest that this squirrel was rare on the island fifty years ago and our experience suggests that the population has been severely depleted, if not exterminated, within these few decades.

The Tioman race was described as differing markedly from *R. l. tupaoides* Blyth of the Malayan mainland and the Anamba Is., showing affinities with the Bornean *R. l. laticaudatus* (Müller).

Petaurista petaurista melanotus (Gray). Red Giant Flying Squirrel, *Kandau*.

The many typical tree squirrels (*C. notatus*, *C. nigrovittatus* and *S. tenuis*) that were feeding by day in the fruiting durian trees at Setegap, Juara, retired at dusk and were replaced by this and the following species of flying squirrels, which glided in from neighbouring trees soon after nightfall. Neither group appeared to be roosting in the durians. We did not see flying squirrels elsewhere but they were reported common, and pests of coconut.

Two females were collected, neither pregnant.

The Tioman population cannot be differentiated from the mainland form.

***Iomys horsfieldi cf. davisoni** (Thomas). Horsfield's Flying Squirrel, *Kunsam*.

Although well known to islanders throughout Tioman, this flying squirrel has not previously been recorded from the island in scientific literature. We saw it only in the durians at Setegap, but by report it was widespread.

Two females were collected, neither in breeding condition.

TABLE 5

Collector's measurements of *Iomys horsfieldi* (in mm.)

No.	Sex	Head and Body	Tail	Hind Foot	Ear
T62.49	♂	185	190	33	21
T62.50	♀	190	188	34	23
T62.60	♀	195	172	35	24
*R51.921	♀	165	183	34	24

*Collected and kindly made available by B. L. Lim of the I.M.R.

Only two skins of the mainland race are available, but comparison suggests that the Tioman form may prove to be distinguished by slightly duller, less ruddy underparts. Measurements of those collected by ourselves and by the I.M.R. team are given in Table 5.

Rattus sp. tiomanicus (Miller).Tioman Field Rat, *Tikus*.

This rat, with the following (*R. exulans*), is a serious pest of cultivated land on Tioman. It swarms in ladang doing extensive damage to the rice crop, and infests coconut plantations and durian orchards, feeding on fallen fruit already opened by squirrels or porcupines; it also extends to the surrounding scrub and brush, and belukar and secondary forest throughout the lowlands. But it is also common in the primary forest at all altitudes, and its range evidently includes the whole island (Table 3).

Three stomach contents were examined: (♀, pregnant and lactating, coconut plantation) 75% coconut flesh, plus other unidentifiable vegetable matter, and at least four small cyclorrhaphan larvae (4 mm.); (♂, coconut garden) mostly ripe *Lantana* berries; (♂, lower edge of forest) 70% banana (=bait), remainder coconut flesh.

Of nine adult females skinned, seven were lactating (17th March, 16th April, 20–22nd April); of these five were also pregnant. The remaining two females had recently ovulated. An occupied (but apparently unfinished) nest, from which a rat escaped, was found in the hollow in the top of a rotten coconut palm stump, 2 ft. tall, on 10th April. The nest consisted of a rough ball of dry grass blades (*Imperata cylindrica*) and dry broad leaves, having two entrances.

The taxonomic position of this rat is discussed below (Medway and Lim).

Rattus exulans concolor (Blyth).Little Burmese Rat, *Tikus*.

This rat was trapped only in or near houses (including one on the foreshore at Tekek, just outside the rest house), or in the rice stubble. It is abundant to the degree of being a pest within this range (Table 3) but does not occur outside it¹⁰.

Of five adult females collected, all were in active breeding state: of four taken on 19th and 20th March, two were lactating and not obviously pregnant, one was in early pregnancy (four foetuses), and one in late pregnancy (three foetuses); a fifth female collected on 24th April was lactating.

The Tioman population is not distinguishable from *R. e. concolor*, which is widespread on the Malayan mainland and offshore islands, and on islands of the southern and western South China Sea.

Rattus sabanus stridens (Miller).Long-tailed Giant Rat, *Tikus Mundok*.

R. sabanus is common in forest of all type at all altitudes; a few animals were also trapped in the rice stubble at Tekek (Table 3). It was abundant in the primary forest on the stretch of relatively flat ground to the east of Camp II, and we found it unshy and easy to watch by torchlight at night. Here we also excavated several burrows, leading to leaf-filled nest chambers; but none were occupied.

It came readily to all vegetable baits (banana, coconut, and sweet potatoes) and generally ate much if not all the bait in the trap. Three stomach contents were examined: (♂, highland forest) much bait, the bulk of the remainder unidentified vegetable pulp, plus at least 7 small termites; (♀, highland forest) chiefly bait, plus a few insect remains, including ants and termites; (♂, open secondary forest) chiefly bait, plus the remains of several worker termites. The small number of insects taken contrasts with Harrison's report (1962) that in the diet of mainland *R. sabanus* insects are a "major item with vegetable matter".

Only one adult female was killed; this was lactating, and also in early pregnancy (4 foetuses).

10. Hendrickson and Harrison (1961) have stated that *R. exulans* "is the commonest rat on Tioman Island". Locally this may be true, but in most habitats *R. exulans* is absent, and it is certainly not numerically the most abundant rat on the island.

The ground colour of the dorsal pelage of our series from Tioman is slightly richer and redder than that of recently collected specimens of the mainland form *R. s. vociferans* (Miller); the effect is perceptible mainly on the flanks, where the prominent black guard hairs are sparse. The Tioman race also averages somewhat smaller in body measurements with a proportionately shorter tail. But statistical comparison of these measurements on eight adults from Tioman, compared with seven from Selangor and from Rompin, east coast Pahang, shows that the overlap is considerable, and the coefficient of difference (0.608) is below the conventional level of subspecific difference (see Mayr *et al.*, 1953: 145-6).

***Rattus surifer binominatus* (Kloss).**

Common Spiny Rat.

This rat was found only in forest or bush, and was not trapped in the rice fields. It occurred at all altitudes, but was relatively more abundant on high ground than at lower levels (Table 3). Near Camp II we again found burrows attributed to this species.

It came to all vegetable baits, but unlike *R. sabanus* often ate very little of the bait in the trap. Eight stomach contents were examined: (♀, juvenile, lower edge of forest) practically all *Lantana* berries; (♀, early pregnancy, lowland forest) some banana (=bait) plus the head of a terrestrial gastropod (a snail or, since no shell was found, probably a slug) and a considerable amount of insect remains including a beetle elytron and several metallic green sclerites of ?muscid; (♀, juvenile, lowland forest) banana (=bait) plus a maggot (5 mm.) and a few unidentified insect sclerites; (♀, recent ovulation, lowland forest) banana (=bait) plus unidentified insect remains; (♂, lowland forest) banana (=bait) plus one ant, and a fair number of unidentified insect sclerites; (♂, highland forest) well masticated insect remains comprising mostly red-brown sclerites, lacking wings, likely to be nymphal orthopterans or blattarians; (♂, highland forest) 25% coconut (=bait), pieces of the hind body of a small snake, plus unidentifiable insect sclerites; (♀, not breeding, highland forest) a little coconut (=bait), part of a gastropod, and insect remains including portions of a beetle; (♂, highland forest) a little coconut (=bait) but mostly unidentifiable insect remains. Harrison (1955a) has already noted that "insect is the most important foodstuff" (sic) in the diet of mainland *R. surifer* and/or *rajah*, but did not record gastropod or vertebrate remains in the stomachs of his samples.

Of five adult females collected, two were in reproductive condition: one (22nd March) pregnant with four early implants in the right horn only, the other (10th April) recently ovulated.

Hill (1960) has discussed the status of the two spiny rats, *R. surifer* and *R. rajah*, and has shown that the endemic forms of Tioman, Pemanggil, and Aor, are correctly ascribed to the species *surifer*. The Tioman population is distinguished from the mainland *R. s. surifer* (Miller) by somewhat darker and duller dorsal coloration, by a tail on average proportionately shorter, and by the reduced crowns of the molars (Kloss, 1908). The reduction of the molars is accompanied by enlargement of the rostrum and other modifications which in rodents characterise adaptation to an insectivorous diet (extreme in *Rhinosciurus*, for instance).

In separating adults of mainland *R. surifer* from *R. rajah peltax* (Miller) the number of scale rings per cm. of the tail at about mid-point, as noted in the original descriptions, has proved a useful character, being 10 or less per cm. in *rajah* and 11 or more in *surifer* (Harrison, 1957: 14). In Tioman *surifer*, however, the number of scale rings in the tails of our adults varies from 11.5-9.2 per cm. Nonetheless, the absence of any specimen referable to *rajah* on pelage characteristics supports the contention that the two forms are specifically distinct (cf. Harrison, 1957).

***Rattus cremoriventer** subsp.

Pencil-tailed Rat.

Specimens of this rat were trapped in belukar at Tekek and at Mokut, and in bamboo forest on G. Kajang at 2,900 ft. Since it does not freely enter traps set on or near the ground (as most of ours were) these low trapping figures cannot be compared directly with catches of other Tioman rats. Still it does not appear to be common.

The contents of one stomach were examined: (♀, not pregnant, montane bamboo forest) mostly coconut (=bait), plus greenish sclerites of a ?muscid, and a few other insect remains.

One of the two females collected was pregnant, with one early implant in each horn (9th April).

TABLE 6

Measurements of *Rattus cremoriventer* from the Malay Peninsula and from P. Tioman (in mm.)

Measurement	P. Tioman (4 skins)		Malay Peninsula (Hill, 1960)	
	Range	(Mean)	Range	(Mean)
Head and Body	... 147-156	(152)	121-162	(138)
Tail ... ..	... 189-196	(192)	172-216	(190)
Skull:				
Greatest Length	... 36.6-38.7	(38.0)	n/a	
Condylbasal length	... 33.7-35.8	(34.7)		
Zygomatic breadth	... 16.9-17.5	(17.2)	30.1-34.4	(31.9)
Interorbital breadth	... 6.3-6.7	(6.4)	15.4-17.1	(16.0)
Maxillary toothrow	... 6.1-6.4	(6.2)	5.5-6.3	(5.9)
			5.7-6.5	(6.0)

Four specimens were collected by the combined teams. In coloration they are not distinguishable from the mainland race *R. c. cremoriventer* (Miller). However, while the tail again averages proportionately shorter, in other dimensions (particularly of the skull) the Tioman rat is larger. A longer series would probably warrant subspecific separation (Table 6).

Atherurus macrourus tionis Thomas.Brush-tailed Porcupine, *Landak*.

Porcupines are extraordinarily abundant on Tioman. Everywhere the lowland forest is criss-crossed with porcupine trails, and characteristic heaps of droppings are found in many rock shelters. The animals are active chiefly by night, when many descend to feed in cultivated areas. By night we found large numbers of porcupines under the fruiting durians at Setegap, nosing out the durians as soon as they fell and gnawing immediately through the thorny skin; they were remarkably tame and fearless. In the highland zone we did not encounter porcupines, although a freshly barked tree near the pass below G. Kajang indicated that they do range up to this height.

A large proportion of the population evidently subsists off plantation crops, including fallen coconut and other fruits, and tapioca, but the stomach contents of a female (not pregnant) shot in the forest, contained only other vegetable matter (unidentifiable). Exposed roots, and the bases of trunks up to 18 ins. above ground, of two species of trees, *Erytania corymbosa* (Apocynaceae) and *Dysoxylum* cf. *flavescens* (Meliaceae), were frequently barked by porcupine. There is evidently plenty of naturally occurring food available in the forest.

Two females were collected, both subadult and not in reproductive condition.

The endemic subspecies on Tioman is separated from the mainland *A. m. macrourus* (Linn.) by its smaller size. A comparative series is not available, but the measurements of our specimens agree well with the type of *A. m. tionis*.

Paradoxurus hermaphroditus milleri Kloss. Palm Civet, *Munsang jebat*.

Reported to be quite common, although we only saw two specimens, one in a coconut palm on the foreshore at Mokut, the second in forest above Tekek at about 700 ft.

The one female collected was subadult.

The subspecies *milleri* is endemic to Tioman. It is distinguished from the mainland form by paler, more bleached coloration overall, with less defined black markings on the dorsum, and by smaller average size. In the type description (based on one adult female examined) a number of distinctive skull characters were also noted separating *milleri* from a single adult male from Kuala Kangsar, Perak, on the mainland. Measurement of a longer series of skulls from the mainland shows that these characters are not constant and do not serve to distinguish the races.

?Arctogalidia trivirgata. Small-toothed Palm Civet, *Munsang akar*.

A number of villagers at Mokut insisted that there were two civets on the island. Their descriptions of the second suggest this species.

Tragulus napu rufulus Miller. Mouse-deer, *Pelandok*.

There is only one species of mouse-deer on Tioman, but it is very abundant. As a basis for comparison with other localities, on a short test walk by night in primary forest along the path leading east from Camp II, eleven animals were encountered in twenty minutes; similar frequencies were commonplace throughout the lowland forest on Tioman, but would be very unusual (if not improbable) anywhere on the mainland. Mouse-deer were also encountered in cultivated land and throughout the forest up to the high ridge by Camp V.

One female was collected, pregnant with a single foetus near parturition.

The race *rufulus* is endemic to Tioman. It is distinguished by its bright coloration and by size, being intermediate between the Larger and Smaller Mouse-deer of the mainland. Chasen (1940) assigned it to the former, now known as *T. napu*, Hill (1960) to the latter (as *T. kanchil* Raffles = *javanicus* Osbeck); I have followed Chasen.

(Bos sp. Domestic cattle).

Herds of feral domestic cattle used to occur in several parts of the forest on Tioman. Many have now been rounded up, and the remnants are reported to occur only inland of Telok Dungun on the east coast. These herds have bred freely in the feral state, and the wild-raised calves are said to be unusually fat and fit.

PULAU TULAI

Cynopterus brachyotis Müller.

Several were netted in the low "pass" in the centre of the island. They are unlikely to have crossed from Tioman.

The specimens collected have been discussed above.

Macroglossus lagochilus cf. *lagochilus* Matschie.

A male, indistinguishable from the mainland form, was collected hanging from a palm frond at night.

Rhinolophus sp.

A small colony of a rhinolophine bat was noted, roosting in the interstices between big boulders at the foot of the ridge.

Callosciurus notatus Boddaert.

Only this squirrel occurs on Tulai. It is abundant throughout the island, although villagers at Tekek assert that within human memory, before coconuts were planted, there were no squirrels on Tulai.

Stomach contents: (♀, lactating) mostly coconut flesh, plus pollen, two caterpillars, and unidentified insect sclerites; (♀, lactating) mostly unidentified fruit pulp, with the remains of perhaps two insects.

Three females were collected (3rd April); two were lactating, one pregnant with two foetuses in the left horn. On the same date, two occupied nests were located in the mangrove fronting Camp III, one 25 ft., the second 15 ft. from the ground. The latter was collected. It was a domed sphere, with a single lateral entrance, consisting of cup-shaped foundation of unidentified dry twigs, supporting a roof of strips of the fibrous leaf-sheath of coconut palm, and an inner lining (1½ ins. thick) of the same material, finely shredded. This nest contained a pair of young (head and body 77, 78).

Three adults were collected. They are not distinguishable from the Tioman population.

Rattus cf. tiomanicus group.

The Tulai rat is abundant throughout all parts of the island, including the mangrove patch. Animals were active even by day, and a great nuisance in the camp by night. Despite the considerable overcrowding indicated, all animals collected or observed were healthy.

Observations by night indicated that this rat depended largely on a diet of fallen coconuts, damaged by squirrels. The stomach of one female (lactating) shot, contained much coconut flesh, plus the abdomen of one ant.

On April 4th, one female of two collected was lactating; on 23rd April, of four collected, one had recently ovulated, one was lactating, and a third gave birth in the trap (one live young seen, 4.4 gm.).

The taxonomic position of this rat is discussed elsewhere (Medway and Lim).

Rattus exulans Peale.

A male and female were trapped near the abandoned settlement; but this rat was not common.

DISCUSSION

ECOLOGICAL RELATIONS

The number of species of mammals found on Tioman, both generally and in any one habitat is very much fewer than in any comparable tract of land on the mainland. In Table 7 the number of species found in all types of forest on P. Tioman is compared with the number collected from a circumscribed area of lowland and submontane forest in Selangor (Bt. Lagong Forest Reserve) by the Institute for Medical Research, 1948-60 (I.M.R., 1960: 76-77). The mammals collected by the I.M.R. do not include many of the larger forest species, notably gibbons, deer, tapir, rhinoceros and elephant, none of which are present on Tioman. The success of feral cattle on Tioman suggests that under prevailing ecological conditions the island could support a viable population of larger ruminants.

TABLE 7

Collected faunas of the lowland and submontane forest of
P. Tioman and Selangor

Family	No. of species collected P. Tioman	No. of species collected Selangor
Erinaceidae	1	2
Soricidae	1	4
Cynocephalidae	1	1
Pteropidae	3	9
<i>Microchiropteran genera</i>	4	14
Tupaiaidae	1	3
Lorisidae	1	1
Cercopithecidae	1	3
Sciuridae	8	16
Rhizomyidae	0	1
Muridae	4	13
Hystriidae	1	2
Manidae	0	1
Mustelidae	0	2
Viverridae	1	5
Felidae	0	2
Tragulidae	1	2
Suidae	0	1

Although impoverished, the Tioman fauna shows considerable diversity, and few major ecological niches remain unfilled. Apart from the large game animals, the most significant mammalian group lacking comprises the predacious carnivores, absent at all altitudes from all habitats, aquatic, terrestrial and arboreal. Also absent are large primates of the canopy (gibbons and leaf-monkeys), and several other specialised mammals or groups of mammals: the termite-eating Pangolin (*Manis*), mammals of fresh-water (otters, water shrew, Moonrat), or the group associated with bamboo (*Rhizomys*, *Chiropodomys*, *Tylonycteris*).

On the other hand, offsetting the paucity of species, the number of individuals in several cases is very great. The following non-flying mammals have been noted as very distinctly more abundant (in some cases only within restricted habitats) than in equivalent habitats on the mainland: *Crocidura malayana*, *Tupaia glis*, *Ratufa bicolor*, *Callosciurus notatus*, *Sundasciurus tenuis*, *Lariscus insignis*, *Rattus* sp. *tiomanicus*, *Rattus exulans*, *Rattus sabanus*, *Rattus surifer*, *Atherurus macrourus*, *Tragulus napu*. In the case of small mammals of the forest floor and lower arboreal storeys, trapping results support our subjective assessments of abundance. In all habitats combined, lines of baited cage traps in over 700 trap day/nights caught an average of 36.2 small mammals per 100 trap day/nights (see Table 3). Excluding cultivated and fringing lands, in forest habitats alone in 451 trap day/nights 129 mammals were trapped, an average of 28.6 per 100 trap day/nights. Comparable

figures based on much longer trapping runs in field habitats on the mainland have kindly been made available by Professor J. L. Harrison (Table 8). His "Forest" habitat evidently includes some fringing land (in which trapping is more likely to be successful) but nonetheless yielded only 5.0 animals per 100 trap nights. Thus trapping figures indicate that the total biomass of small mammals of the ground and lower storeys of the forest on Tioman may exceed five times the biomass of small mammals of this habitat in mainland forest.

TABLE 8

Mammals trapped near Kuala Lumpur by the Scrub Typhus Research Unit, Institute for Medical Research, during the years 1948 to 1950
(Data kindly made available by J. L. Harrison)

Habitat*	No. of Trap Nights	Catch per 100 Trap Nights
Town	65,000	9.5
Scrub	12,000	5.5
Forest	65,000	5.0
Oil Palm	18,000	6.0

* The habitats and methods of investigation were as follows: *Town*—trapping carried out in houses by householders; *Scrub*—a variety of lightly wooded terrain ranging from the edge of rubber plantations through parkland, *Melastoma* bushes, to openalang grassland; *Forest*—trapping by aborigines in forest, and among their gardens and ladang; *Oil Palm*—trapping by estate labourers in the Elmina Oil Palm Estate, Sungei Buloh

Some of the strikingly abundant mammals (*Callosciurus notatus*, *Rattus exulans*, and *Rattus sp. tiomanicus* in cultivated areas) feed largely on crop plants or associated weeds; others (for instance *Atherurus macrourus*) may depend on crops to a considerable extent. But an equal number of very common species are as clearly quite independent of crop plants as a food source (*Crocidura*, *Lariscus*, *Rattus surifer*, *Tragulus*). By inference it is doubtful that the wholly or partly dependant groups owe their abundance solely to the presence of these crops.

To some extent the absence of elements of the mainland forest fauna must have permitted the species on Tioman to exploit ecological niches normally occupied by closely related and competitive forms. An obvious example is *Rattus tiomanicus*, which is common throughout the island, occupying an even wider range of habitats than those that on the mainland are divided among three forms of the *Rattus rattus* group, the commensal *diardi*, the ricefield *argentiventer*, and the field and woodland *jalorensis*.

Morphological evidence suggests that *R. surifer* of Tioman is more significantly insectivorous than the mainland form. This is supported by trapping figures, which indicate that this rat (with *Hylomys*) replaces the primarily insectivorous tree shrew in the forest habitat at higher altitudes (Table 3 and cf. Dunn, this *Bulletin*, later). This modification however would represent a shift rather than a broadening of the ecological niche. There is also some evidence that a reverse shift, away from a diet rich in insects towards a diet primarily vegetarian, may have taken place among *R. sabanus*.

On the other hand, there are also several striking instances of ecological conservatism. For example, above 500 ft., in all storeys of the forest the medium-sized squirrel niche is unoccupied, although both *C. notatus* and *C. nigrovittatus* are

present at lower altitudes. On the mainland *C. notatus* is commonest in cultivated land, although it ranges far into primary forest, and *C. nigrovittatus* is more or less restricted to lowland forest. On Tioman, *C. notatus* is apparently less adaptable and rarely extends beyond plantations and the fringing forest. The encroachment of cleared land on the relatively narrow border of lowland forest has apparently restricted the habitat of *C. nigrovittatus* and brought it into competition with the more aggressive and successful *notatus*. The latter species is virtually commensal with man, and over much of its range undoubtedly owes its wide distribution to the extension of plantation crops, particularly coconut (cf. the situation on Tulai). The introduction of the coconut palm to Tioman is relatively recent, and the population of *C. notatus* may also have originated only in recent times.

Other examples of ecological conservatism are shown by *Rattus exulans*, which remains tied to houses and rice fields, and *Macaca*, which remains restricted primarily to lowland forest fringing on cultivated land. In all cases there may have been a marginal extension of the ecological niche, not brought out by our data, but overall there is no evidence that any small mammal, except *R. sp. tiomanicus*, owes its abundance on Tioman to the reduction of interspecific competition.

The one factor that convincingly accounts for the great abundance of all members of this varied group of small mammals is the absence of mammalian carnivores. Apart from snakes, monitor lizards and raptorial birds, there are no carnivorous animals on Tioman from which these small and medium-sized mammals are liable to predation. Harrison (1956) has suggested that in mainland habitats snakes account for about a quarter of all deaths of rats. The extreme abundance of small mammals on Tioman, despite the presence of predatory snakes (python and black cobra, see Hendrickson, this *Bulletin*, p. 67), emphasises the importance of mammalian predators, over and above any others, in controlling the arboreal and terrestrial small mammal population in the normal mainland forest habitat.

Of the remaining mammals, bats are probably more or less immune from predacious carnivores, and the population on Tioman is presumably limited by other factors. The scarcity of bats at higher altitudes on the island is not satisfactorily explained.

The macaque is hardly more abundant on Tioman than it is in stretches of fringing forest on the mainland where it is as little molested by man. Excluding the activity of man, the population of these large primates is probably controlled by factors other than predation.

With one exception, the remaining mammals (Flying Lemur, Slow Loris, flying squirrels, the Pencil-tailed Rat, and the civets) are principally arboreal and nocturnal. As a group they do not appear to be particularly abundant, except in unusual situations such as the fruiting durian trees at Setegap. But since none readily enter traps, and none are easy to collect by other means, a confident assessment of the populations cannot be given.

The exception is *Rhinosciurus*, the Shrew-faced Ground Squirrel, which we completely failed to record in 1962, although no previous account has indicated that it was rare on the island. Restricted island populations are often subject to semicyclic fluctuations in population, related to levels of disease and parasite infestation. The present evidence suggests that the population of the Shrew-faced Ground Squirrel may have suffered some such catastrophic downfall, leading even to extinction. We have no evidence that other Tioman mammals are subject to such variations. It was in fact noted that all specimens of all species handled were apparently fit and in good condition.

TABLE 9

Fecundity of small mammals on Tioman and on the Malayan mainland as shown by frequencies of litters (born or unborn) of stated size.

Species	Number of conceptuses							N u m b e r o f p r e g n a n t f e m a l e s			
	1	2	3	4	5	6	7				
<i>Crocidura malayana</i>	..	Tioman	..	1	—	—	—	—	—	No data	—
	..	Malaya	..	—	—	—	—	—	—		
<i>Cynocephalus</i>	..	Tioman	..	1	—	—	—	—	—	No data	—
	..	Malaya	..	—	—	—	—	—	—		
<i>Tupaia glis</i> *	..	Tioman	..	—	1	—	—	—	—	—	—
	..	Malaya	..	—	5	—	—	—	—		
<i>C. notatus</i> *	..	Tioman†	..	—	3	1	—	—	—	—	—
	..	Malaya	..	2	18	3	2	—	—		
<i>R. tiomanicus</i>	..	Tioman	..	—	—	—	1	—	—	—	1
<i>R. jalorensis</i> ‡	..	Malaya	..	2	3	31	27	11	2		
<i>R. exulans</i> *	..	Tioman	..	—	—	1	1	—	—	—	1
	..	Malaya	..	3	9	9	38	19	12		
<i>R. sabanus</i> *	..	Tioman	..	—	—	—	1	—	—	—	2
	..	Malaya	..	2	18	20	7	5	—		
<i>R. surifer</i> *	..	Tioman	..	—	—	—	1	—	—	—	—
	..	Malaya	..	—	2	9	3	2	—		
<i>R. cremoriventer</i> *	..	Tioman	..	—	1	—	—	—	—	—	—
	..	Malaya	..	—	1	4	3	2	—		

*All Mainland data from Harrison (1955).

†Tioman data includes one specimen collected by I.M.R.

‡Data for *R. jalorensis* from all habitats, in Harrison (1951).

One of the signs of overcrowding among a restricted island population is a reduction in fecundity (cf. Harrison, 1951). In Table 9, details of the number of conceptuses per pregnant female from Tioman and from mainland samples are given. Records from Tioman are too sketchy for statistical comparison. But the data available do not suggest that the fecundity of the rodents on the island is reduced below the mainland norm.

ORIGIN OF THE FAUNA

With the exception of *Hylomys*, the mammalian fauna of Tioman comprises only characteristic lowland species. The significance of the presence of *Hylomys* is greatly reduced by the archaeological discovery, already discussed, indicating that an apparently identical form occurred in the lowlands of Borneo in the late Upper Pleistocene. Admittedly the extent of land above the 2,500 ft. contour on Tioman is limited, but on Maxwell's Hill (3,400 ft.), Perak, an outcrop of comparable size and altitude on the mainland, the following montane rodents have been recorded (I.M.R., 1960): *Tamias maclellandi*, *Rattus bowersi*, *R. edwardsi*, *R. niviventer*. The comparison is a little stretched, for Maxwell's Hill is connected to the higher G. Hijau (4,751 ft.) but since *Hylomys* occurs on Tioman, it is likely that viable populations of other characteristically montane small mammals could also be supported. Their absence suggests the possibility that the existing fauna of Tioman represents not a relict, isolated by the submersion of the Sunda shelf, but an oceanic fauna built up by successive invasions from the adjacent Malayan lowlands.

This supposition would explain not only the absence of montane forms, but also the other apparently random anomalies in the list of lowland mammals represented on the island. It is supported by a comparison of the faunas of the three major outer islands of the Johore-Pahang archipelago, P. Tioman, P. Pemanggil and P. Aor (fig. 1). No mammal species occur on the two outer islands that do not also occur on Tioman, suggesting that colonisation took place across the sea barrier via Tioman, rather than by random isolation (Table 10). The progressive depletion of the fauna from the mainland, through Tioman, to the two distant islands is characteristic of an oceanic distribution. In addition the poverty of the faunas of Pemanggil and Aor is undoubtedly related also to the smaller size of two islands, and to the greater effect of recent human intervention on the natural flora (cf. P. Tulai). The apparent absence of *Crocidura* and *Cynocephalus* from Pemanggil may be due to the same factors, but may also be accounted for by the less intensive zoological collection that has taken place on the outer islands. The absence of the commensal *Rattus exulans* emphasises the role of man as carrier of this rat. It was probably introduced directly to Aor at a recent date.

TABLE 10

Mammals (excluding Chiroptera) of the outer islands of the Johore-Pahang archipelago

Species	Pulau Tioman	Pulau Pemanggil	Pulau Aor
<i>Hylomys suillus</i>	x	
<i>Crocidura malayana</i>	x	x
<i>Cynocephalus variegatus</i>	x	x
<i>Tupaia glis</i>	x	x
<i>Nycticebus coucang</i>	x	
<i>Macaca fascicularis</i>	x	
<i>Ratufa bicolor</i>	x	
<i>Callosciurus notatus</i>	x	x
<i>Callosciurus nigrovittatus</i>	x	
<i>Sundasciurus tenuis</i>	x	
<i>Lariscus insignis</i>	x	
<i>Rhinosciurus laticaudatus</i>	x	
<i>Petaurista petaurista</i>	x	
<i>Iomys horsfieldi</i>	x	
<i>Rattus rattus</i> group	x	x
<i>Rattus exulans</i>	x	x
<i>Rattus surifer</i>	x	x
<i>Rattus sabanus</i>	x	
<i>Rattus cremoriventer</i>	x	
<i>Atherurus macrourus</i>	x	x
<i>Paradoxurus hermaphroditus</i>	x	
<i>Tragulus napu</i>	x	
Total ...	22	5	8

With only one exception (*Crocidura malayana*), our additional material from Tioman has confirmed that the majority of non-flying mammals are distinct from the mainland forms, and has upheld subspecific separation. A general trend towards smaller size, and especially shortening of the tail, is shown. In only one instance (*Rhinosciurus laticaudatus*) does the endemic Tioman race resemble the Bornean more closely than the mainland Malayan form. However, since the

population of this squirrel on the intervening Anamba Is. is not distinguishable from the mainland form (Chasen, 1940), the Bornean resemblances of the Tioman population are clearly an instance of convergence and not of true affinity.

Apart from *R. exulans*, all the mammals of both Pemanggil and Aor have been further separated as endemic subspecies. Hill (1960) has shown that the pattern of subspeciation is again typical of a group of oceanic faunas with the most divergent forms occurring on the most distant islands, and intermediates on the inshore islands. An exception is *C. notatus* of P. Dayang, a small off-lier of P. Aor, which closely resembles the mainland race. It is very likely that the Dayang population of this virtually commensal squirrel represents a very recent introduction (perhaps with coconuts for planting direct from the mainland).

On the other hand, the faunas of the major islands of the Trengganu archipelago, some 240 miles to the north, show many similarities to the faunas of the Johore-Pahang group. The former are geographically quite unconnected to Tioman, although standing in approximately the same relation to the Malayan mainland. From the largest island, Pulau Redang, the following mammals (other than Chiroptera) have been recorded: *Crocidura* sp., *Tupaia glis*, *Macaca fascicularis*, *Callosciurus notatus*, *Sundasciurus tenuis*, *Rattus tiomanicus* group, *Rattus surifer* and *Tragulus* sp. (apparently *javanicus*); from P. Perhentian Besar, *Cynocephalus variegatus*, *Tupaia glis*, *Presbytis obscurus*, *Callosciurus notatus*, *Rattus tiomanicus* group, and *Rattus surifer*; from the smallest, P. Perhentian Kechil, *Cynocephalus variegatus*, *Tupaia glis* and *Callosciurus notatus* (all records from Kloss, 1911). In these instances, the similarities cannot be due to steppingstone colonisation. With the exception of the semicommsal *Rattus tiomanicus* group, which is probably very widespread in Asia, the mammals that occur most often on the islands of both archipelagoes (*Cynocephalus variegatus*, *Tupaia glis*, *Macaca fascicularis*, *Callosciurus notatus*, *Sundasciurus tenuis*, *Rattus surifer*) are all widespread throughout the major land masses of the Sunda shelf, with only a limited distribution beyond the region. The fact that the common members of these island faunas are all characteristic of the Sunda region suggests either that these forms are better adapted to cross the sea barrier, or that the same relict elements formed the basis of each island population. It is relevant that the diversity of the faunas throughout the whole group of east coast Malayan islands is in each case directly related to the size of the island.

Presumably both factors have operated. A proportion of the mammalian fauna comprises species that arrived after isolation by rafting or by the intervention of man, and the remainder represent relict populations of the ancient Sunda fauna. The number of relict species that survived isolation on each island could be expected to be related to the size of the exposed land surface, and consequently to be greatest on P. Tioman, the largest island of the group.

Archaeological work in the region has shown that equivalent subspecific variations have evolved since the late Quarternary in a number of mammals (Hooijer, 1949). Among restricted island populations subspeciation may occur at a very fast rate (e.g., Ashton & Zuckerman, 1950-51) and it is not necessary to postulate a very long period of isolation in order to explain the high rate of endemicity among the mammals of Tioman.

SUMMARY

Thirty-one species of land mammals are recorded from P. Tioman, and five from P. Tulai. These are listed in systematic order, and the distribution of each on the island, the food and reproductive condition of specimens examined, and the taxonomic relations of the island population are discussed in each case. The taxonomic separation of seventeen named forms from Tioman is upheld, and it is suggested that longer series might show that two other mammals also represent endemic island forms. The mammalian faunas of both islands are shown to be considerably depleted. On the other hand many species are shown to be much more abundant on P. Tioman than in equivalent habitats on the mainland. It is suggested that this abundance is related to the absence of predators, particularly carnivores, rather than to differences in ecological relations. The population of one mammal (*Rhinosciurus laticaudatus*) has apparently declined sharply during the last forty years or so, but other species show no signs of population fluctuation. It is suggested that the faunas of Tioman, and of other islands off the east coast of Malaya, represent relicts of the late Upper Pleistocene lowland Sunda mammalian fauna, supplemented on each island by later invaders, and depleted on each island in relation to the extent of exposed land surface.

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