Treubia 1999 31(3):177-217

MAMMALS OF GAG ISLAND

Ibnu Maryanto[1] and Darrell J. Kitchener[2]

1)Division of Zoology, Research and Development Centre for Biology-LIPI, Jl Raya Jakarta-Bogor Km 46 Cibinong 16911, Bogor, Indonesia.
E-mail: mzb@indo.net.id

2) Western Australian Museum, Francis Street, Perth, 6000 West Australia.

Summary

Gag island, with 13 species of mammal recorded from a brief survey of only 10 days, has a relatively rich mammal fauna for its area (56 km^2). This mammal assemblage was more influenced by faunal elements from nearby Irian Jaya and North Maluku than from elsewhere. More intensive surveys on Gag island will undoubtedly reveal further species of small microchiropteran bats. Habitats on the ultrabasic substrates were richer, more diverse and overall had a higher relative abundance of bats than those on the volcanics. The period of the survey and immediately preceding it was one of intense breeding activity for most, or all, of the bat species and for Rattus sp. The taxonomic status of two still to be identified mammals, a murid rodent Rattus sp. and the Tube - nosed Bat (Nyctimene sp.) on Gag island require further clarification.

Introduction

The mammal fauna of Gag island is less known than for the other terrestrial vertebrate groups; no native species have been confirmed from the island. In eastern Indonesia, the mammal fauna of the Maluku Utara region and the adjacent islands in the Irian Jaya Province, incorporating Gag island, is amongst the poorest documented.

The survey of Gag island reported in this paper is, then, an important contribution to our understanding of the mammal fauna of this region and to the assemblage of mammals found on small ultrabasic islands. In addition to producing an inventory of the mammal species on Gag island, this report provides details at some important aspects of the natural history of the Gag island mammals, particularly their broad reproductive condition and habitat preferences at the time of the survey.

Methodology

The mammal survey of Gag island was carried out between 10-20 July 1997. Although the object was to carry out a preliminary survey and not to conduct a disciplined benchline program against which future monitoring could be carried out, many aspects of a benchline survey were also met without compromising the need to discover the mammal species that occurred on the island.

Patterns in the distribution of biota generally reflect gradients in the physical environment (Krebs, 1972) and this is also true for mammals. These gradients must be sampled in a representative way to express these patterns and document the number of species present in an area or island (species richness) and trends in the number of species and the number of individuals in each species (species diversity). Most classical methods of sampling rely on transects or line intersects (Lyman, 1980) which are usually positioned in stratified random manner and use replicates (Whittaker, 1975). However, Gillison and Brewer (1985) convincingly showed that the selection of a transect along the most pronounced gradients (gradsect), provided the area sampled is representative of the area as a whole, has marked advantages of the more time consuming and often impractical classical approach. We adopted the gradsect approach and felt that our selection of a north- south gradsect amply covered the major change from the upthrusted shoreline reef limestone, which intruded into the island for several hundred meters in certain places, through the volcanic basalts in the northern one -third of the island and then continuing southwards through the ultrabasic substrates which dominate the southern part of the island. A second gradsect was chosen to sample the ultrabasic valley, slope and ridge vegetation. Other smaller distinct habitats were also sampled, including: a small embayment of mangal and pandanus; a patch of Alang alang (*Imperata* sp.) grassland, a sago swamp, a small coastal cave which was tidally inundated; a series of small limestone caverns; and a coconut plantation.

A total of 17 sites were sampled for mammals and specimens were collected from all these sites. Some of these sites were in similar habitat. Their location is shown in Figure 1.

The major habitats were trapped for mammals using a standard mammal trapping line and/ or were mist- netted. The traps used were small cage traps made from wire with dimensions of 28 x 12 x 12 cm which captured animals alive; and standard commercial steel snap rat traps of a manufacture available the world over. The snap trap was sprung by the animal's weight on a treadle as it removed an anchored bait. The cage trap door was sprung by a thin wire attached to a baited hanging hook. The standard mammal trapping line consisted of 10 cage and 20 snap traps arranged so that the first three traps in the line were snap then followed by two cage and so on in that sequence, with the last five traps in the line being snap. Two types of bait were used in each standard line. These were a lightly roasted coconut and a paste mixture comprising oats, peanut paste and shrimp paste (each bait was placed in a gauze bag to contain it on the hook or treadle). The standard line consisted of the first two traps in the line baited with coconut and the next two with paste and that sequence continued for all 30 traps.

Standard trap lines were set in each location for three nights. Evidence from trapping mammals in Irian Jaya (Kitchener, Boeadi and Sinaga, 1997), and throughout Nusa Tenggara and Maluku (personal observations) indicated that there was a substantial reduction in captures using mammal traps and mistnets after three consecutive trapping nights.

The mistnets used were made of polyester 75d/2 ply and 31mm. They were of two lengths (9 and 18m) and manufactured by M. Nakamori and Co., Yokkaichi, Japan. They were all set in the lower canopy.

Trapping sites were visited every morning. Animals were removed from the traps and mistnets and bagged. The site number, trap type and bait type were recorded from each animal. Bait was replenished as required. Animals were then removed to a field laboratory where they were identified to putative species, weighed (gm) and measured (all in mm). The measurements taken for ground mammals were: body (snout tip to anus), tail, ear, and foot (excluding claws) lengths, for bats, forearm length was also measured. The skull and external character of bat measurements follow Kitchener *et al.* (1993). The measurements are as follows: gsl, greatest skull length; cbl, condylobasal length; rl, rostrum length; rh rostrum height (alveoli of canine directly above to dorsal surface of rostrum); bb, braincase breadth (at point of posterior contact of zygoma with cranium; zw, zygomatic arch width; m1m1, width across the first uppers molars from the outside alveoli edge; c1c1, width across upper canines from the outside alveoli edge; iob, interorbital breadth; pob, postorbital breadth; mfw, mesopterygoid fossa breadth at the widest point; p4p4, breadth of palate between the fourth upper molar; ml, mandible length from condyle to anteromost point of dentary; ch, dentary coronoid height; c1m2, lower canine to second molar length at the alveoli; fa, forearm length; tail, tail length; and ear, ear length.

Reproductive stage condition was observed by dissection and examination made with the aid of a hand held lens. Male testes length and position and distention of the epididymis were recorded. In females, teat shape, mammary gland development, number of fetuses and their crown to rump length, and the number of uterine scars were recorded.

Specimens were fixed in 10 % formalin solution for two weeks then transferred to a 75% ethanol. All specimens were curated into the collections of the Museum Zoologicum Bogoriense, but later approximately half the specimens of each species will be transferred to the collections of the Western Australian Museum.

The age of individuals was classified into adult or juvenile category using several methods. Microbats and most rodents cannot be accurately placed into these categories on the basis of the fusion of the basicranial sutures. This is because these sutures fuse early in microbats before they reach either physical or reproductive maturity and very late in most rodents, often long after they reach sexual maturity. With microbats, individuals that had their metacarpal and first phalangeal wing joints swollen were considered juvenile. Megabats that had the basisphenoid-presphenoid suture unfused were considered juveniles (Kitchener *et al.*, 1995). Rodents that had small testes or uteri that were "threadlike" in appearance and had tiny teats and showed no indication of having suckled young were considered juveniles.

The Simpson Index of Diversity was used (Simpson, 1949). Canonical (Discriminant) Function Analysis was performed using SPSS PC+.

Observations

Habitats

Seventeen sites (A-Q were sampled for mammals) (Figure1). The vegetation at the trapping sites will be described in more detail in the section on vegetation in the final report on this expedition. However, the sites can be described briefly as follows (key sites followed by latitude and longitude):

Site A- ultrabasic slope forest (00° 10′27″ S,129° 20′ 53″ E);

Site B- ultrabasic ridge scrub (00° 00′ 27″ S, 129° 54′ 53″ E);

Site C- ultrabasic valley forest (00° 15′ 27″S, 129° 18′ 53 ″E);

Site D- coconut grove (near Camp1);

Site E- sagu palm grove (near Camp1);

Site F- disturbed volcanic forest (00° 11′ 24″ S, 129° 12′ 54″E);

Site G- disturbed volcanic forest (near Site F);

Site H- disturbed volcanic forest (near Site F);

Site I- grassland, native (00° 31′ 28 ″S, 29° 05′ 54″E)

Site J- pandanus/mangal (near Site I);

Site K- mangal (near Site I);
Site L- primary volcanic forest (behind Turtle Beach);
Site M- grassland, Alang alang (00° 18′ 29″ S, 129° 18′ 53″E);
Site N- caves, limestone (near Site F);
Site O- ultrabasic valley forest (00° 30′ 26″S, 129° 33′ 51″E);
Site P- ultrabasic ridge scrub (00° 00′ 27″S, 129° 54′ 53″E); and
Site Q- cave, basalt, tidal inundation (near Turtle Beach).

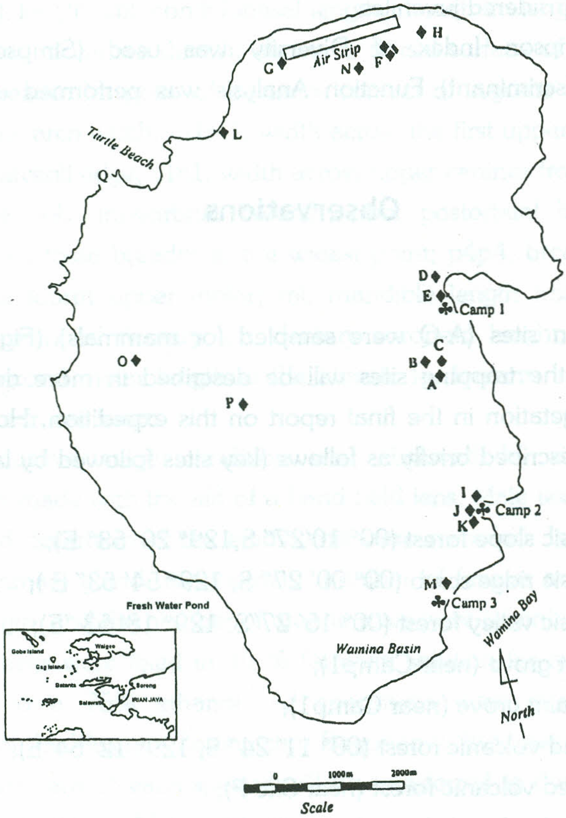

Figure 1. Map of Gag island showing the major trapping sites (A-P) for mammals during the July 1997 survey. Site Q was a coastal cave.

Trapping effort

A total of 1380 trapnights, two- thirds of which were snap traps, and 3040 m^2 of mistnet nights were set during this survey. For an explanation of trapnights and mist net effort see Table 1 caption. Standard traplines and mistnets were set at 12 localities (Table 1).

Collected species

The number of individuals of each species collected, including the numbers released from each habitat, are presented in Table 2.

A total of 12 mammal species were collected and a further murid rodent species was seen next to a trap in the Alang-alang grassland. Trapping in the Alang alang grassland was continued under the supervision of Warwick Alliston (see aknowlegments) beyond 20 July 1997 in an attempt to capture this murid, but without success. These species comprised: seven megachiropterans [Black Flying-fox, *Pteropus n. neohibernicus* Peters, 1876; Spectacled Flying-fox, *P. conspicillatus chrysauchen* Peters, 1862; Masked Flying-fox, *P. personatus* Temminck, 1835; Tubed-nosed Bat, *Nyctimene* sp. cf. *N. albiventer*; Beaufort's Bare-backed Fruit-bat, *Dobsonia beauforti* (Bergmans, 1975); Common Blossum Bat, *Syconycteris australis papuana* (Matschie, 1899); and the Northern Blossom-bat, *Macroglossus minimus lagochilus* Matschie, 1899; two microchiropterans [Small Asian Sheath-tailed Bat, *Emballonura alecto* (Eydoux and Gervals, 1836) and The Lesser Sheath-tailed Bat, *E. nigrescens papuana* Thomas,1914]; and four species of murid rodent: [Indonesian Black Rat, *Rattus tanezumi* (Temminck, 1844); Pacific Rat, *R. exulans* (Peale, 1848); Gag island Rat, *Rattus* sp. cf. *R. praetor* (Thomas, 1888); and an unidentified murid rodent from Alang alang grassland that had a white tip to its tail and diffused white markings on its back].

In addition to the native species of mammal on Gag island, introduced species include goats and domesticated cats. Neither of these species appeared to have become feral.

There was contention as to whether a *tupai* like animal occurred on the island. Several villagers described to us an animal similar to the marsupial *Petaurus breviceps*, but others strongly discounted its presence on the island.

Table 1. Trapping effort at each of the major habitat types A to P on Gag island between 10-20 July 1997.

Habitat	# Cage trap nights	# Snap trap nights	Mistnet area (m^2)
A	30	60	146
B	50	100	
C	40	80	729
D			243
E			122
F	40	80	486
G			97
H	30	60	
I	30	60	
J	30	60	146
K	30	60	292
L	30	60	146
M	20	40	
N			49
O	90	180	292
P	40	80	292
Total	460	920	3040

Remarks: A single trap set at a location for one night represents a "trap night". A single standard trapline was set at each location, except for location O, where three such lines were set simultaneously. Variable numbers of short and long mistnets were set at locations. Grasslands were not mist-netted. A single 2.7 m long mistnet set at a location for one night represents 24.3 m^2 per night; an 18 m long mistnet is double that area per night. Standard trap lines were set for a minimum of three consecutive nights at each site. Mistnets were set at a site for a period of from 3-5 consecutive nights.

Table 2. Collected species in each of the major habitat types A to Q on Gag island between 10-20 July 1997.

	Major habitat																
Species	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
P. neohibernicus						***5***											
P. conspicillatus						***6+4j***											
P.personatus				1													
Nyctimene sp.	6		3		(2)	(2)	1 (2)				2 (2)	(3)		(12)	5(11)	1(1)	
D. beauforti			2(1)	1	2(21)	(6)	(1)			(9)	(3)				(5)		8
S. australis	2		15								5				9(9)	2	
M. minimus	1		6(1)	10(4)	1(3)	2					4				(9)	2	
E. alecto														(20)			
E. nigrescens			1														
Rattus sp.		5 (1)	2			8		8	6		8	2	4		13	2	
R. tanezumi		(1)							1				4		3	1	
R. exulans												1					
Muridae													1?				

[Values in bold italics were obtained by local villagers. Numbers of specimens retained for further research are followed in brackets by those that were released immediately following their capture].

Chiropteran richness and diversity and abundance

The number of individuals of each species of chiroptera collected at each site on Gag island during the first three nights of mist- netting (no bats were released on the second night) at each site, and (in brackets) the number of individuals collected per 100 m^2 of mistnet night of trapping effort are summarized in Table 3, which combines data from similar sites, groups all species data and provides a value for the Simpson diversity index of species for each type of habitat.

Comparisons between data in Table 3 between the habitats on the ultrabasic and volcanic substrates indicated a trend for the ultrabasic habitats to: be richer in species of bat (5 *versus* 4 species); have a greater density of individuals per effort (7.6 *versus* 6.5); and have a higher diversity (0.73 *versus* 0.64).

Table 3. Misnetting effort for chiropterans and Simpson's index of species diversity on Gag island in July 1997.

	Volcanic substrate			Ultrabasic substrate			
Habitat/ Site	disturbed forest (F and G)	plantation (D and E)	primary forest (L)	Valley forest (C and O)	slope forest (A)	ridge scrub (P)	mangal/ pandanus (J & K)
effort	438	219	146	729	146	219	438
# spp.	3	4	1	5	3	3	4
#indiv.	14	38	3	77	9	5	25
#ind./effort	3.2	17.4	2.1	10.6	6.2	2.3	5.7
Diversity	0.60	0.55	0	0.71	0.49	0.64	0.67

Remarks: both number of species and individuals collected; number of individuals collected per 100 m^2 mistnet

Of the **ultrabasic sites**, the valley forests were the most speciose (5), and clearly had the highest abundance of individuals per mist- netting effort (10.6); they also had the highest bat species diversity of all the habitats sampled on Gag island (0.71). Fewer numbers of bats utilized the forest on the slopes and less again in the ridge scrub. The small embayment of mangal and pandanus also had the same four species of small and moderate sized fruit bat that were found elsewhere on the island (*Dobsonia, Nyctimene, Macroglossus and Syconycteris*), and which were moderately abundant there (5.7).

Of the **volcanic sites**, the sagu and coconut groves clearly had the highest relative abundance of bats, with 17.4 individuals captured for each 100 m^2 of mist net; and were dominated by *Dobsonia beauforti* and *Macroglossus minimus*. It was also in the coconut plantation that the only *Pteropus personatus* was captured. However, on the volcanics the highest species diversity was in the disturbed forests. There were few bats in the primary forests, where only three individual *Nyctimene* sp. were captured.

Rodent Distributions

The captured rodents were dominated by *Rattus* sp., including *Rattus exulans* and 10 *Rattus tanezumi*. These capture data are too few for quantitative analysis, it is possible to state that *Rattus tanezumi* and *Rattus* sp. are likely to occur together in most habitats on Gag island. *Rattus exulans* is likely to be restricted to the disturbed area close to the village, or to intrude only slightly into the disturbed forests on the volcanic substrates where these forests have plantation adjoining them. The pattern of captures of these three species is presented in their separate species accounts below.

Annotated species list

Greater Flying- fox, *Pteropus n. neohibernicus*

Measurements

(N = 2 adult females)- weight 1050-1200 ; snout to vent length 272-305; ear length 24 - 25; forearm length 193 - 196. (N = 3 adult males)- weight 1150 (1000 - 1250); snout to vent length 290 (275 - 300); ear length 21 (19 - 23); forearm length 199 (194 - 203).

Taxonomy

Flannery (1995a) recognised only one other subspecies, *P. N. hilli* Felton, 1961 from the Admiralty Islands. But there are five other taxon that have been placed in synonymy with these two subspecies, indicating a degree of morphological variation within the species. The measurements of the Gag island animals fall within the range presented by Flannery (1995a) for this subspecies from Sandaun province, PNG.

Distribution

Widespread on the New Guinea mainland below an altitude of about 1000 m and nearby islands. Also, Bismark Archipelago and the islands of Gebe, Karkar, Lihir, Manus, Mioko, New Britain, New Island Rambutyo, Sakar, Tabar and Umboi.

Reproduction

Both females collected on Gag island in July were carrying a single mid-term fetus, which had crown to rump lengths of 59.8 mm and 62.5 mm.

Breeding females and many females carrying half- grown young have been recorded on New Ireland in June to August; and two pregnant females were collected in PNG in January (Flannery, 1995a).

Ecology

Flannery (1995a) reports that this species forms very large colonies in swamp forest on the Sepik River, PNG nothing is recorded of the ecology of this species.

On Gag island it roosted with *Pteropus conspicillatus* in moderately large groups of up to 50 individuals in the trees near the airport.

Spectacled Flying - fox, *Pteropus conspicillatus chrysauchen*

Measurements

(N= 2 adult males): weight 750 - 900; snout to vent length 248 - 262; ear length 34 - 36; and forearm length 180 - 185. (N = 4 adult females): weight 645 (600 - 720); snout to vent length 246 (236 - 254); ear length 34.1 (33 - 35); forearm length 172.5 (169 - 177).

Taxonomy

The Australian and Papuan New Guinea form is the nominate subspecies. Another form has been described but it is usually placed in synonymy with the nominate subspecies.

Distribution

Widely distributed throughout Australia. Possibly widespread in New Guinea, but few records of them from that island are recorded in the literature. It is also known from the following islands: Alcester, Batjan, Gebe, Goodenough, Halmahera, Hull, Kiriwina, Lababia, Misool, Morotai, Normanby, Obi, Owi, Pinon, Rossel, Salawati, Sudest, Ternate and Woodlark.

Reproduction

On Gag island in July, all four adult females had a single attached young, each of which had an average weight of 206.5 (87 - 430) g. Hall (1983) stated that mating is between March and May in Australia with young born between October and December. Flannery (1995a) collected four juveniles with an average weight of 320 (240 - 400) g on Hull island, PNG, in January. Nothing, however, is known of the western subspecies. Clearly the season of births is later on Gag island than in Australia and possibly also later than in Hull island. Judging from the range in weight (and ages) of the attached young, breeding on Gag island is not particularly synchronous between females and is probably spread over many months.

Ecology

Almost nothing is known of the general biology of this species outside Australia. On Gag island they formed mixed colonies with *P. conspicillatus* numbering about 50 individuals in a single tree. We did not mist-net them on Gag island, so presumably both these two large pteropodids feed only in the upper vegetation canopy. Flannery (1995b) shot a single male while it was foraging in a mango tree.

Tube-nosed bat, *Nyctimene* sp. (Plate 7)

Measurements

Presented in Table 4.

Taxonomy

The taxonomy of this group of small fruit- eating bats in the Maluku, Irian Jaya and Sulawesi regions has been investigated extensively in recent years by Kitchener *et al.*, (1993, 1995). A number of outstanding taxonomic problems, however, still occur among some of the forms of *Nyctimene* in these regions (Kitchener, Boeadi and Sinaga, 1997).

The measurements presented in Table 4 show that the Gag island specimens are morphologically more closely allied to *N. albiventer*. They are most similar in size to *N. a. papuanus* from the Aru islands. They are generally larger than *N. a. papuanus* from Papua New Guinea and are much larger than *N. a. albiventer* from Maluku Utara. The Gag island *Nyctimene,* however, has a longer rostrum and a narrower palate than *N. albiventer*. This can be clearly seen by plotting the values in Table 4 on the figures presented in Kitchener *et al.* (1993) for bivariate plots of palate breadth at P4- P4 *versus* greatest skull length and P4- P4 breadth *versus* rostrum length for *Nyctimene keasti* and *N. albiventer* (Figure 2a and b). Discriminate Function Analysis indicated that on the second Function, which generally reflects shape characteristics, the Gag island specimens were closer to *N. keasti* (personal observations).

The Gag island *Nyctimene* appears to be an undescribed form; it is closest to *N. albiventer* and *N. keasti*.

Distribution

The distribution of this form outside Gag island is not known.

Reproduction

The species was actively breeding during the period of survey. Three of the four adult females were pregnant and had a single fetus which had a crown to rump length of 8.0- 15.2 mm. The remaining female was lactating.

Table 4. Measurements (in mm) of Gag island *Nyctimene* specimens compared with those of *Nyctimene a. albiventer* from Maluku Utara (Morotai, Ternate and Halmahera islands; Papua New Guinea; and the Aru islands (from Kitchener *et al.*, 1993); and *N. keasti* from Kai and Tanimbar islands (from Kitchener *et al.*, 1995).

Character	Gag	Maluku *N.a. albiventer*	PNG *N.a. papuanus*	Aru *N. a. papuanus*	Maluku *N. keasti*
	N=7,18*	N=5-6	N=13-15	N=26-27	N=56
gsl	27.5 (26.7-28.1)	25.7 (24.7-26.4)	26.8 (25.9-27.4)	27.4 (25.8-28.5)	29.4 (28.0-30.8)
cbl	26.2 (25.8-26.9)	24.6 (23.8-25.2)	25.7 (24.7-26.4)	26.1 (24.5-27.4)	27.7 (26.0-28.7)
rl	5.4 (4-6)	4.8 (4.7-5.0)	4.6 (4.1-5.0)	4.8 (4.4-5.4)	5.7 (5.0-6.3)
rh	6.3 (5.7-6.8)	5.8 (5.6-6.0)	6.4 (5.9-6.7)	6.3 (5.5-7.0)	6.6 (5.8-7.3)
bb	11.8 (10.9-12.2)	11.4 (11.1-11.5)	12.0 (11.4-12.6)	12.0 (11.6-13.1)	12.6 (11.6-13.9)
zw	18.0 (16.9-18.3)	17.0 (16.6-17.4)	18.3 (17.4-19.2)	18.2 (17.5-19.7)	19.3 (18.1-20.4)
m1m1	7.6 (7.4-7.7)	7.3 (7.0-7.5)	8.0 (7.5-8.3)	8.2 (7.7-9.2)	8.6 (7.7-9.1)
c1c1	5.2 (5.0-5.4)	4.8 (4.7-5.0)	5.2 (5.0-5.4)	5.4 (5.0-6.1)	5.6 (5.2-6.0)
c1m1	9.2 (8.8-9.9)	8.5 (8.2-8.7)	8.6 (8.2-9.0)	9.0 (8.4-9.5)	9.9 (8.4-10.5)
iob	5.6 (5.3-6.0)	4.9 (4.5-5.3)	5.2 (4.8-5.5)	5.0 (4.5-5.7)	5.8 (5.3-6.5)
pob	5.5 (5.0-6.2)	5.3 (5.0-5.6)	5.8 (5.1-6.4)	5.5 (4.9-6.3)	5.7 (5.0-6.7)
mfb	4.5 (4.3-4.8)	4.6 (4.3-4.8)	4.7 (4.4-5.0)	4.5 (4.1-5.4)	5.0 (4.5-5.4)
p4p4	4.6 (4.6-4.7)	4.7 (4.5-4.8)	5.2 (4.7-5.6)	5.4 (5.0-5.9)	5.5 (5.0-6.0)
ml	19.1(18.7-19.8)	19.0 (18.1-19.5)	19.8 (19.1-20.5)	20.3 (18.1-21.3)	21.9 (20.6-23.1)
ch	11.4 (10.7-12.3)	10.3 (9.6-10.8)	11.2 (10.7-11.7)	11.7 (10.3-12.7)	13.3 (12.3-14.5)
c1m2	10.2 (9.9-10.8)	9.5 (9.3-9.7)	9.6 (9.0-10.2)	10.0 (9.4-10.7)	11.2 (10.3-12.1)
fa	56.8 (55-58)	51.2 (49.953.1)	54.6 (52.7-56.8)	55.8 (53.4-59.2)	59.7 (55.1-63.0)
tail	19.5 (13.0-24.5)	20.9 (19.3-25.2)	20.7 (19.1-23.4)	22.3 (17.9-30.1)	21.2 (18.0-25.4)
ear	14.5 (12.0-18.0)	12.7 (12.1-13.3)	12.8 (11.7-14.2)	13.6 (11.7-14.7)	15.3 (14.2-16.9)

[N. sample size. *, sample size for the external measurements of the Gag island specimens].

Flannery (1995a) reported pregnant *N. albiventer* in New Guinea in January, July and August and Flannery (1995a) observed pregnant females In New Britain islands in December and lactating females at Salawati in October and December.

Ecology

Nyctimene were captured in all habitats on Gag island except for the coconut and pandan plantation (Appendix 1). There were, however, compared to mist- netting effort, significantly more captures in the habitats on the ultrabasics than in the volcanics (χ^2 = 7.1 df = 1; 0.01> p >0.001). The greatest density of captures was in the tall pristine ultrabasic valley forest at site O, where a density of 5.5 captures was recorded for each 100 m^2 of mistnet. It was interesting that the ultrabasic valley forest at Site C had far fewer captures (0.69) suggesting that it was the floristics and fruiting patterns and not the structure of the forest *per se* at Site O that made it a favored habitat for *Nyctimene* at the time of this survey.

Very little is known of the natural history of *Nyctimene albiventer* or its closely allied forms in eastern Indonesia. It does, however, appear to roost in vegetation and has not been recorded from caves or rock fissures. As it was the case on Gag island, Flannery (1995a) also found that *N. albiventer* was most abundant in undisturbed habitats.

Masked Flying-fox, *Pteropus personatus* (Plate 8)

Material examined

An adult male: weight 93; snout to vent length 121; ear length 21.5 forearm; length 90.

Taxonomy, Distribution and Ecology

Most distinctly colored black and white-striped face makes this species one of the easiest bats in the Maluku region to identify. Flannery (1995b) stated that research in progress indicated that there are two subspecies. The nominate subspecies is restricted to the Halmahera group of islands, while a darker, undescribed subspecies, occurs on the islands of Obi and Bisa.

The single specimen from Gag island is the first record of this species from the Irian Jaya Province; it almost certainly is a representative of the nominate subspecies. It was collected in the coconut plantation near the campsite. Flannery (1995b) found this species particularly common in garden areas, interspersed with Durian, Nutmeg and Clove trees.

Beaufort's Bare- backed Fruit- bat, *Dobsonia beauforti* (Plate 9)

Measurements

(N = 10 adults): weight 170.6 (152 - 196); tail to vent 26.1 (21 - 29); head to body length 148.5 (132 - 163); ear length 25.7 (24.0 - 27.5); and forearm length 110.6 (105 - 119).

Taxonomy

Very similar to *D. viridis* but differs in being generally smaller and in having minor dental differences.

Distribution

It has a restricted distribution to the islands of Batanta, Gebe, Salawati, Waigeo and Biak.

Reproduction

During the survey period of the Gag island, it was one of intense breeding activity. Eight adult females were pregnant, each having a single fetus which, on average, had a crown to rump length of 46.4 (40.5 - 52.0) mm. The similarity in size of these fetuses indicated a close synchrony in the period of births for these females

Ecology

Dobsonia is a cave roosting species and was found on Gag island in two caves: one at Site Q, where a large colony roosts in a cave that was inundated by daily tides; the other at Site N, where approximately 50 *Dobsonia* roosted in half light in a high domed limestone cavern with two large openings. *Dobsonia*

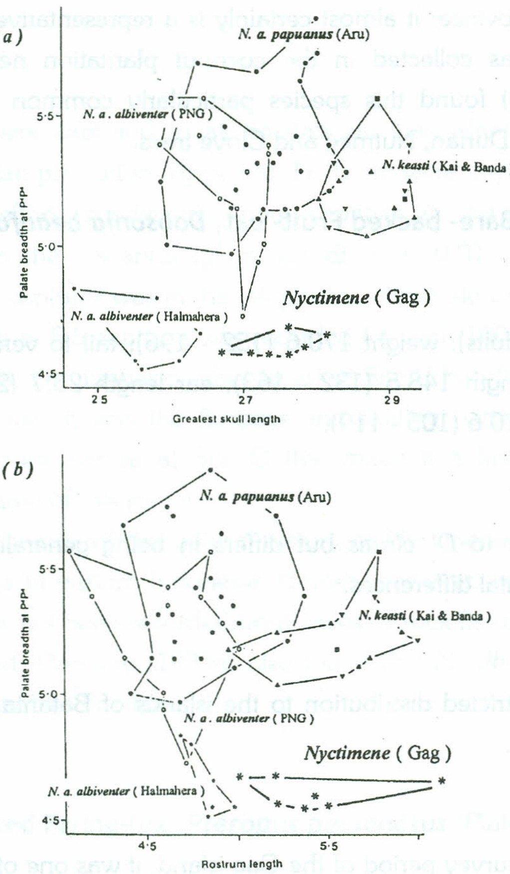

Figure 2. Bivariate plots of measurements (in mm) of palatal breadth versus both the greatest skull length (a) and rostrum length (b) for *Nyctimene* (from Gag island), *N. keasti* (Kai and Banda islands), *N. a. albiventer* (from Halmahera) and *N.a. papuana* (Aru islands and Papua New Guinea). Palatal breadth is measured between P4 or last premolar teeth. Data for the plots other than the Gag island specimens is from Kitchener *et al.* (1993).

was found in all habitats mist- netted, except for the volcanic primary forests, the ultrabasic slope forest and one of the ultrabasic valley forest sites (Site P); the other ultrabasic forest site (C) also had a low density of this species. The greatest density of *Dobsonia* on Gag island was by far that recorded in the sago plantation where 22 individuals were captured for each 100 m^2 of mistnet, this was followed by a density of 6.2 in the pandanus next to the mangal (Appendix 1). Significantly larger numbers of *Dobsonia* were captured relative to mist-netting effort in habitat on the volcanic substrates than on the ultrabasic habitats ($\chi 2 = 8.0$; df = 1; $p< 0.005$).

This species is apparently a very social one on Gag island. It roosts communally; apparently feeds in large groups, often mistnetted at the same time; and females give birth synchronously.

Common Blossom - bat, *Syconycteris australis papuana*

Measurements

(N = 19 adult males and 9 adult females): weight 18.9 (15.0 - 30.5); snout to vent length 62.2 (51 - 68); ear length 15.5 (12 - 18); forearm length 44.3 (41 - 46).

Taxonomy

Hill (1983) considered that the subspecies of *Syconycteris australis* was only weakly differentiated morphologically, although he went on to recognize the following subspecies, with their type localities in bold:

Syconycteris a. australis (Peters, 1867) - **Queensland, Australia.**

S. a. papuana (Matschie, 1899) - New Guinea; **Andai, NW New Guinea**; Aru islands.

S. a. crassa (Thomas, 1895)- SE New Guinea Is (Tobriand Is; D' Entrecasteaux Is, and **Fergusson island**).

S. a. keyensis Andersen, 1911 - **Kai Is.**

S. a. major Andersen, 1911 - **Ambon island** and Seram island.

S. a. finschi (Matschie, 1899) - **Bismark Archipelago.**

Hill (op. cit.) allowed for the possibility that the form *naias* from Woodlark island may not be a synonym of the nominate subspecies but may in fact be a distinct subspecies. Koopman (1982) considered *finschi* a separate subspecies. Andersen (1912) noted that *major* was the largest of these subspecies but that it was indeed similar in size to its geographically closest subspecies, S. *a. papuana;* while *crassa* was intermediate in size between *major* and *papuana.* Kitchener *et al.* (1994) further investigated a number of these Maluku populations of *S. australis* and concluded that the large form on Ambon and Seram islands (*major*) was morphologically distinct from *keyensis* and *papuana* and may in fact be a separate species. They also found that *papuana* from Aru was somewhat differentiated from *papuana* from New Guinea.

The specimens from Gag island are clearly allied morphologically with *S. a. papuana* from New Guinea. For example, their forearm length of 44.1 ± 1.7 (40 - 46) 29 (mean, SD, range, N) is only slightly larger, on average, than of *S. a. papuana* from Papua New Guinea [43.2 ± 1.4 (40.3 - 46.8) 36]; Kitchener *et al.* (1994: Table 1) and are very similar to those from Timika, Irian Jaya [44.3 ± (42- 47) 24] (Kitchener, unpublished data).

Distribution

This subspecies is widely distributed throughout New Guinea and its nearby islands and Aru. The species also reaches eastern Australia south to northern New South Wales.

Reproduction

During the survey period of the *Gag island*, it was one of intense breeding activity. Of the nine adult females dissected, seven were pregnant and had a single fetus, which had a crown to rump length of, on average, 16.4 (7.5 - 21.9) mm. The spread of sizes (and ages) of these fetuses indicate that the period of births was asynchronous. Two of the other three adults were lactating.

Lawrence (1991) reported that this species bred throughout the year and usually gave birth to a single young, but occasionally to twins. Five of nine females collected in the Timika region in mid February to early March 1997 were pregnant, each with a single fetus, and three of the remainder were lactating (Kitchener, Boeadi and Sinaga, 1997).

Ecology

This species was restricted to the ultrabasic habitats and was not collected in the northern volcanic parts of the island. On the ultrabasic substrates it was most abundant in the valley forests Sites C and O, particularly Site O where 6.2 individuals were captured for each 100 m^2 of mistnet. It was considerably less abundant in the slope forest and the ridge scrub. Five individuals were also captured in the mangal (Appendix 1).

Flannery (1995a) stated that it was the only bat collected in New Guinea above 1500 m; it is also known to occur as high as 3000 m above sea level (Ziegler, 1982). In the Timika region, it was the most common nectarivorous bat behind the mangrove dominated communities, but it was most abundant in primary lowland evergreen forest; it also occurred in habitats that were similar to those found on the volcanic substrates of Gag island, such as sago and coconut plantation (Kitchener, Boeadi and Sinaga, 1997).

The other small nectarivorous blossum bat on the island, *Macroglossus minimus,* was most abundant in the habitats on the volcanics and so appeared to be somewhat separated spatially from *Syconycteris*. These two species also showed clear indications of habitat separation in the Timika region, Irian Jaya in mid February to early March (Kitchener,Boeadi and Sinaga, 1997).

Northern Blossum - bat, *Macroglossus minimus lagochilus*

Measurements

(N = 11 adult males and 11 adult females): body weight 14.2 (12 - 17); snout to vent length 60.2 (55 - 67); ear length 13.5 (10 - 14.5); and forearm length 39.5 (37.5 - 41.5).

Taxonomy

The subspecies taxonomy has recently been investigated by Suyanto (1995).

Distribution

The species occurs throughout Indonesia, New Guinea, northern Australia, Philippines, up to Vietnam and Thailand. *Macroglossus m. lagochilus* occurs in Thailand, Vietnam, Malaysia, Borneo, Philippines and the Maluku islands.

Reproduction

Only three of the 10 adult females examined had fetuses; these fetuses had crown to rump lengths of 3.7, 19.7 and 21.5 mm. However, a further six females had recently given birth and were lactating. These observations indicated that this was at the end of a major period of breeding activity for this species. The presence of females having small fetus with crown to rump length of 3.7 mm, as well as many that were still lactating, indicated that the season of births on Gag island was protracted.

Nothing is published on the reproduction of this subspecies in Indonesia, but Gunnell *et al.* (1996) carried out an extensive study on the ecology and field reproduction of the nominate subspecies on Lombok island, Nusa Tenggara Timur. In that study, he concluded that *M. minimus* bred throughout the year, but had a peak period of births in October and November. Births also occurred all the year round in Papua New Guinea (McKean, 1983). A similar pattern of breeding was observed in the Philippines (Heideman and Heaney, 1989; Heaney *et al.*, 1989) and in Peninsula Malaysia (Start, 1974). In the Timika region, Irian Jaya, the period of February to March was one of intensive reproductive activity, with 80% of adult females either pregnant or recently having given birth (Kitchener, Boeadi and Sinaga, 1997).

A single young was born at each parturition. Breeding was more concentrated at the start of the rainy season (June to September).

Ecology

Macroglossus was found in all habitats on Gag island, except the volcanic primary forest (Site L) and the pandanus near the mangal (Site J). Its density was highest in the coconut and sago plantation sites near Camp 1, where values of 8.2 and 5.5 captures per 100 m^2 mistnet were recorded.. It was moderately dense in the ultrabasic valley forest at Site O (3.1). Its abundance at other sites was low (0.5 - 1.6). Overall, it was significantly more dense in the habitats on the volcanic than on the ultrabasic substrates, when compared to the relative trapping effort in these substrates ($\chi^2 = 4.2$; df = 1; 0.05 ⟩ p⟩ 0.025). However, its high abundance in these volcanic areas was dominated by captures in the plantation which was absent on the infertile ultrabasic substrates.

In the Timika region, Irian Jaya, in February and March 1997, the species was concentrated in the wide area of intertidal tall mangal, dominated by *Rhizophora and Bruguiera*, that fringed the river systems. Flannery (1995a) also recorded it from *Melaleuca* woodlands in Papua New Guinea. Elsewhere it occurred in plantations of coconut, banana, rambutan and mango from sea level to about 1200 m (Gunnell *et al.*, 1996).

This nectar and pollen feeder is one of the better studied bats of Asia (see references in Gunnell *et al.* (1996). McKenzie *et al.* (1995) studied its flight morphology and concluded that it is best suited to foraging close to its roost sites, which are large - leafed palms, trees and the roofs of disused buildings (McKean, 1983). Gunnell *et al.* (1996) found that on Lombok island the relative abundance of both sexes declined in July, which coincided with the period of peak mating activity; they suggested that at that time the population was dispersed. They also found around that period that adults of both sexes fed on *Parksia, Musa and Syzygium*, while *Eugenia* was essentially eliminated from their diet (although it had been an abundant food item). Subadults, however, continued to feed on *Eugenia* throughout the year.

Small Asian Sheathtail - bat, *Emballonura alecto*

Measurements

(N = 10 adult males and 10 adult females): weight 5.6 (4.5- 8.0); snout to vent length 47.9 (44- 52); ear length 12.7 (11- 14.5): and forearm length 45.8 (45 -47).

Taxonomy and Distribution

No subspecies are recognized. It is widely distributed in the Maluku and also occurs in Sulawesi, Philippines, Borneo and Anambas.

Reproduction

This species was in active breeding condition during the Gag island survey. Six of the 10 adult females were pregnant with single fetus which, on average, had a crown to rump length of 7.9 (3.3 - 19.2) mm. Two had just given birth; they were lactating but still had uteri that had not completely regressed.

Ecology

Flannery (1995b) suspected that the sexes roost separately, but this is not the case on Gag island where both sexes were captured, in even numbers, from a series of small limestone caves opening into a well-lit cathedral cavern behind Turtle Beach. The only other bats roosting in this situation were *Dobsonia beauforti*, but they were in the cavern. Several hundred *E. alecto* were seen in the vicinity of these caves.

Lesser Sheathtail - bat, *Emballonura nigrescens*

Measurements

(An adult male): weight 4; snout to vent length 35.5; ear length 9; and forearm length 32.

Taxonomy

Perhaps this species should be placed in the genus *Mosia* Gray, 1843, but we agree with Flannery (1995b) that it is better to wait for a complete revision before adopting this generic name. Three subspecies are known. The single specimen collected on Gag island does not allow us to place this form with any confidence into a subspecies, but geographically it is probably a representative of *E. n. papuana* Thomas, 1914, which is known from Sulawesi, Maluku Utara, New Guinea, Schouten islands, Irian Jaya and Kai islands

Distribution

In addition to the above localities for *papuana*, the species occurs on adjacent islands of New Guinea including the central Maluku.

Reproduction

The single female had a near-term fetus, which had a crown to rump length of 18.4 mm.

Ecology

Single animal was captured. This was from a mistnet from the tall closed ultrabasic forest at Site C. This species is not frequently mist-netted and this single capture does not indicate that it has a low abundance on Gag island. Interestingly, it was not captured along with *E. alecto* in the caves on Gag island, although it is known to roost in the twilight zone of caves, as well as under the leaves of both *Heliconia* sp. and banana.

Indonesian Black Rat, *Rattus tanezumi*

Measurements

(N= 5 females and 5 males): weight 157.2 (112- 207) 10; snout to vent length 182.6 (162- 195) 8; head to body length 166.7 (118- 200) 10; ear length 21.3 (19- 24) 10; and hind foot length (without claws) 33.3 (30.0 - 36.5) 10.

Taxonomy

Previously placed in synonymy with *Rattus rattus*, but genetic studies indicate that it is a distinct species (Musser and Carleton, 1993).

Distribution

Indigenous in Southeast Asia from Afghanistan through the highlands of Nepal and North India into south and central China, Korea and mainland Indo China, south to the isthmus of Kra. It may have been introduced to Taiwan, Japan, Malay Peninsula and islands on the Sunda Shelf. It has been introduced to Philippines, Sulawesi and numerous islands throughout Maluku and Nusa Tenggara to west New Guinea and further east through Micronesia to Fiji and Samoa (Musser and Carlthon, 1993).

Reproduction

All 10 specimens were adult. All five males had large scrotal testes. All the females were parous and had, on average, 6.2 (4- 8) implantation scars, but none was actively breeding (pregnant or recently parturient).

Ecology

All captures on Gag island were in the ultrabasic habitats as follows: valley forest, 3; ridge scrub, 2; native grassland, 1; and Alang alang, 4. There were too few captures to comment on the distribution of the species on Gag island.

In the Timika region, this species was captured in all habitats that were very disturbed, including the lowland mangal, grasslands of the river meander belt, mid montane forests and secondary forests growing on the frequent scree slopes at high 3723 m altitude (Kitchener, Boeadi and Sinaga, 1997). Taylor *et al.* (1982) stated that in New Guinea it was mainly found near the sea ports and in the lowlands below 750 m.

Given the propensity for this *Rattus* to occur in disturbed situations, it is unusual to find that on Gag island it was not captured close to the village, which has been established for 50 years, or in disturbed forest situations on the volcanic substrates. This is particularly so because this species is known to quickly establish itself in areas following human settlement (Taylor *et al.*, 1982). It suggests that the Gag island Rat may be so well adapted on this island that it excludes the Indonesian Black Rat to the more peripheral habitats.There was, however, no significant negative association between the number of these two species captured in the major habitats (R^2 = 0.12; ns), although the data for such a comparison were rare.

Pacific Rat, *Rattus exulans*

Measurements

(An adult male): weight 45.5; tail length 146; snout to vent length 107; ear length 21; hind foot length (without claw) 30.

Taxonomy

A large number of subspecies have been described. A recent revision of many of these subspecies has been completed (Kitchener, unpublished data).

Distribution

Widely distributed throughout southeast Asia, the Sundaic region, Sulawesi, Philippines, Maluku, Nusa Tenggara, the New Guinea region, New Zealand and Polynesia and is present in specific habitats in New Guinea east to the Solomon islands (Musser and Carleton, 1993).

Reproduction

A single adult male with scrotal testes and two juvenile males with inguinal testes were captured on Gag island. Dwyer (1975) found that it bred in the wetter months and had the greatest mean litter size of any of the rodents studied by him in the eastern Highlands of Papua New Guinea over a period of 10 months.

Ecology

On Gag island, two were captured on volcanic substrates; one from a cage trap set by a villager next to his house and the other from primary rainforest. The other capture was in native grassland near the mangal.

This human commensal has been transported around Indonesia through the activities of man. It is basically an inhabitant of disturbed habitats from sea level to 3000 m, where it is mainly terrestrial and lives in holes of the ground.

Gag island Rat , *Rattus* sp. (Plate 10)

Measurements

Measurements are presented in Table 5 for the Gag island specimens and for *Rattus praetor coenorum* specimens from the Museum Zoologicum Bogoriense, Bogor, that were listed in the revision of Taylor *et al.* (1982) as being *R. praetor coenorum,* and for single specimen from Gebe island.

Table 5. Mean and standard deviation of external body, cranial, dentary and dental measurements (in mm) of adult *Rattus* sp. from Gag island, and *Rattus praetor coenorum* from Irian Jaya and Gebe island. Details of the measurement points are provided in Taylor *et al.* (1982). [*f*, females; and *m*, males. N, sample size].

Measurement	Gag (m,N=20) (f,-N=10)	New Guinea & Gebe (m,N=3) (f, N=3)	Gebe N=1 male
Snout- vent length	167.7 ± 12.26 176.2 ± 45.17	NA NA	206
Tail length	153.7 ± 10.75 151.0 ± 11.46	NA NA	NA
Hind foot length	33.9 ± 1.40 32.7 ± 0.86	NA NA	38.0
Skull occipitonasal l.	42.1 ± 1.18 41.4 ± 1.59	48.3 ± 1.85 46.2 ± 1.32	46.3
Condylobasal length	41.8 ± 1.22 41.8 ± 1.22	48.0 ± 2.03 45.8 ± 1.22	46.0
Basal length	39.8 ± 1.14 39.1 ± 1.34	45.9 ± 1.95 43.9 ± 1.27	44.1
Zygomatic width	20.6 ± 0.58 20.4 ± 0.73	22.3 ± 3.11 22.2 ± 0.82	22.9
Interorbital breadth	6.9 ± 0.24 6.9 ± 0.25	6.6 ± 0.48 6.6 ± 0.46	6.7
Interparietal length	6.2 ± 0.37 5.9 ± 0.49	6.9 ± 0.01 7.0 ± 1.17	6.7
Interparietal breadth	11.3 ± 0.82 11.5 ± 0.62	12.9 ± 0.12 11.9 ± 0.64	12.5
Braincase breadth	16.9 ± 0.36 16.8 ± 0.41	18.2 ± 1.21 17.3 ± 0.46	17.5
Mastoid width	16.0 ± 0.33 16.0 ± 0.56	18.2 ± 0.07 16.8 ± 0.83	16.9
Nasal length	15.6 ± 0.89 15.0 ± 0.71	16.5 ± 2.08 16.5 ± 1.39	17.8
Nasal breadth	5.4 ± 0.31 5.2 ± 0.31	5.5 ± 0.95 5.3 ± 0.55	5.9
Palatal length	23.7 ± 1.01 23.1 ± 1.12	25.5 ± 3.36 25.0 ± 1.66	25.9
Incisive foramen length	7.5 ± 0.35 7.2 ± 0.32	7.9 ± 0.96 8.0 ± 0.53	8.8
Incisive foramen width	2.9 ± 0.21 3.3 ± 1.49	3.2 ± 0.53 3.0 ± 0.09	3.5
Inside M1- M1 breadth	4.8 ± 0.33 4.8 ± 0.42	5.3 ± 0.86 5.3 ± 0.54	5.9
Outside M1- M1 width	8.8 ± 0.28 8.8 ± 0.37	9.6 ± 1.23 9.6 ± 0.44	9.5
Bullae length	6.0 ± 0.24 5.8 ± 0.23	6.5 ± 0.85 6.4 ± 0.21	6.3
M1-3 length (crown)	6.4 ± 0.39 6.6 ± 0.28	6.7 ± 0.49 6.5 ± 0.15	7.6
M1-3 length (alveoli)	7.0 ± 0.24 7.0 ± 0.25	7.7 ± 0.54 7.7 ± 0.38	7.6
M1-2 length (crown	4.9 ± 0.26 5.0 ± 0.21	5.1 ± 0.30 5.4 ± 0.21	5.8
Palate length post. M3	1.2 ± 0.26 1.0 ± 0.22	1.6 ± 0.40 1.6 ± 0.48	2.7
Mesopt. fossa breadth	2.5 ± 0.26 2.6 ± 0.23	3.2 ± 0.62 3.0 ± 0.16	3.0
Zyg. plate breadth	4.3 ± 0.24 4.3 ± 0.37	4.5 ± 0.49 4.8 ± 1.10	4.1
Weight	140.2 ± 19.7 128.3 ± 20.0	NA NA	240

Remarks: except for three measurements. These were: palate length post. M3, which is the length of the palate projecting posterior to the posterior crown surface of the last upper molar: mesopt. fossa breadth, which is the maximum breadth of the mesopterygoid fossa; and zyg. Plate breadth, maximum breadth of zygomatic plate. The molar lengths refer to the upper teeth (M).

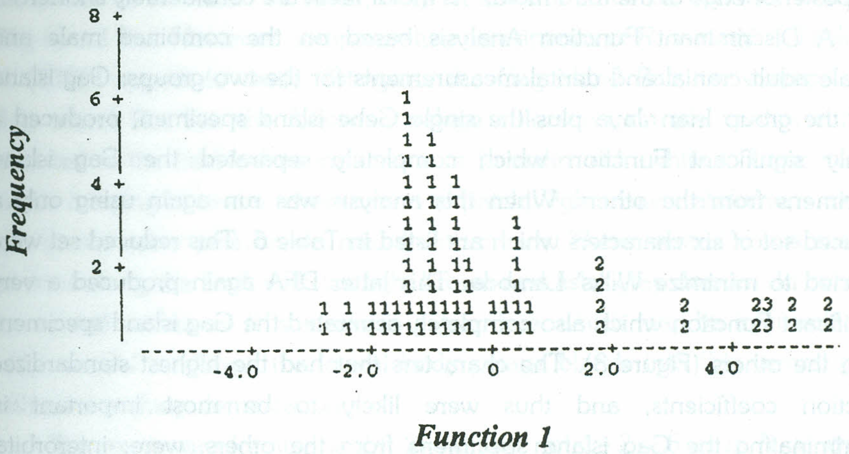

Figure 3. Discriminant Function 1 Canonical based on a reduced set of cranial and skull measurements (see text) and the two groups: first, *Rattus* sp. From Gag island (1) and second, *Rattus praetor coenorum* from Irian Jaya (2) and Gebe island (3).

Taxonomy

The Gag island Rat is closely related to the very variable subspecies *Rattus praetor coenorum* Thomas, 1922, but not to *R. p. praetor sensu* Taylor *et al.* (1982). Measurements recorded by us for adult Gag island Rats and *coenorum* from both Irian Jaya and single specimen from the nearby Gebe island (Table 5) indicated that the Gebe island specimen is indeed closely allied to *coenorum* but that the Gag island specimens are morphologically different.

The Gag island Rat, compared to *R. p. coenorum,* has a generally smaller body length and hind foot length [our measurements, unlike those of Taylor *et al.* (1982) do not include the claws- which average 2.5 mm in length]; generally broader skull in the posterior cranial, particularly mastoid region, and in the interorbital regions; shorter incisive foramen length; shorter bulla length; narrower and more rounded anterior edge to the mesopterygoid fossa;

narrower zygomatic plate and the palate terminates generally much closer to the posterior edge of the third molar. Its molar teeth are considerably shorter.

A Discriminant Function Analysis based on the combined male and female adult cranial and dental measurements for the two groups: Gag island and the group Irian Jaya plus the single Gebe island specimen, produced a highly significant Function which completely separated the Gag island specimens from the others. When this analysis was run again using only a reduced set of six characters which are listed in Table 6. This reduced set were selected to minimize Wilks' Lambda. This latter DFA again produced a very significant Function which also completely separated the Gag island specimens from the others (Figure 3). The characters that had the highest standardized function coefficients, and thus were likely to be most important in discriminating the Gag island specimens from the others, were: interorbital breadth; distance of palate behind the posterior surface of the last upper molar; and mesopterygoid fossa breadth (Table 6).

Table 6. Standardized and unstandardized canonical discriminant function coefficients (in brackets) from DFA based on a reduced subset of cranial and dental characters (see text) for the *Rattus* sp. specimens from Gag island and a grouping of *Rattus p. coenorum* from Irian Jaya and Gebe island.

Character	Function 1
Outside M1 - M1 width	0.4144 (0.9776)
Palatal length post. M3	0.5162 (1.8238)
Mesopteryg. fossa breadth	0.4610 (1.6361)
Interorbital breadth	-1.2753 (-4.7162)
Nasal breadth	0.2981 (0.7545)
Zygomatic plate breadth	0.3291 (0.8117)
Constant	0.5623

As noted by Taylor *et al.* (1982: 245), *R. praetor* is most readily confused with *R. steini* and that "young *R. praetor* can be distinguished from *steini* only with great difficulty". Furthermore Taylor *et al.* (1982) recognized four subspecies of *R. steini*. Of those, only *R. s. steini* could be confused with the Gag island Rat. However, compararative descriptions of *R. s. steini* in Taylor *et al.* (1982) appear to easily distinguish the Gag island Rat. For example, the Gag island Rat has the following pelage coloration on the ventral surface recorded in the field before immersion in formalin: chin-white to base; throat-rufous merging to tawny; chest-brown to patchy light brown; abdomen- cream; and scrotal area- pale brown mixed with cream. These ventral colors sharply contrast along the flank with the light brown and ashy gray dorsum. In contrast the ventral surface of *R. s. streini* is a gray hue, which may be interrupted by white ventral markings; the lateral body pelage blends into this ventral gray, without any sharp demarcation.

The mammary formula is 2+ 2= 8 and not 1+2= 6 as in *R. s. streini.* The tail scales are 8-9 per cm and not 10 per cm as in *R. s. steini.*

Comparison between cranial, dental and external measurements of the Gag island Rat in Table 5 with those in Taylor *et al.* (1982: Table 16) for *R. s. steini* shows that the hind foot of The Gag island rat in average is longer, as do most cranial measurements except: braincase breadth; incisive foramen length and breadth; and bulla length and lengths of M1-3 and M!-2 - which relative to measures of the length of the skull are proportionally smaller.

Direct comparison from live specimens of *R. s. steini* need to be carried out to confirm these above differences.

In summary, the morphology of the Gag island Rat differs from its nearest described taxa. It would appear to be an undescribed taxon, possibly a subspecies of *R. praetor.*

Distribution

The Gag island Rat is known only from that island. *Rattus p. coenorum* is known from Irian Jaya (the north and east coasts of the Vogelkop region, Etna Bay on the south coast and between sea level to 1525 m north and south of the central cordillera) and the northern lowlands of Papua New Guinea.

Reproduction

Male Gag island Rats showed a steady increase in the size (length) of their right testes in relation to their body weight up to a weight of about 100 gm. Below 80 g testes were not scrotal but were inguinal or abdominal in position. Between 80 g and 86 g body weight, most testes were scrotal and were of a length similar to that of much heavier males that were obviously adult, or were slightly below the mature testes length; one animal of 84 g had small inguinal testes that were probably immature (Figure 4). Several clearly adult males, on the basis of their body weight and extent of their tooth wear, had abdominal or inguinal testes; these were thought to be males that were either approaching senility or had seasonally regressed testes. In this study, males with body weight less than 80 g were considered juvenile; between 80-100 g adult, if they also had scrotal testes; and adult, if their body weight was greater than 100 g.

All female specimens examined with body weight above 96 g (N= 19) were in active reproductive condition (pregnant or lactating). Those with body weight below 55 g (N= 5) were juveniles and showed no indication (they had 'thread uteri" and tiny teats) of having reached sexual maturity.

Ten of the 17 adult females (59%) were in active breeding condition; that is they were pregnant (N = 4) or had uterine horns that were not fully regressed and were lactating (N = 6). There was no significant difference in breeding activity of adult females in the volcanic or ultrabasic habitats (χ^2 = 0.2). As expected, there was no significant difference (χ^2 = 0.1) in the proportion of juveniles in the population captured in the volcanic (29%) or ultrabasic (22%) habitats.

The five pregnant females had, on average, 3.8 (2-5) fetuses. Interestingly, the 14 other adult females averaged 3.5 (1-7) uterine fetal implantation scars, sited approximately equally on both the right and left uterine horns. This suggests that the species gives birth to only a single litter, or that implantation scars disappear rapidly.

Clearly the Gag island Rat was, at the time of the survey, widely distributed and actively breeding over much of the island.

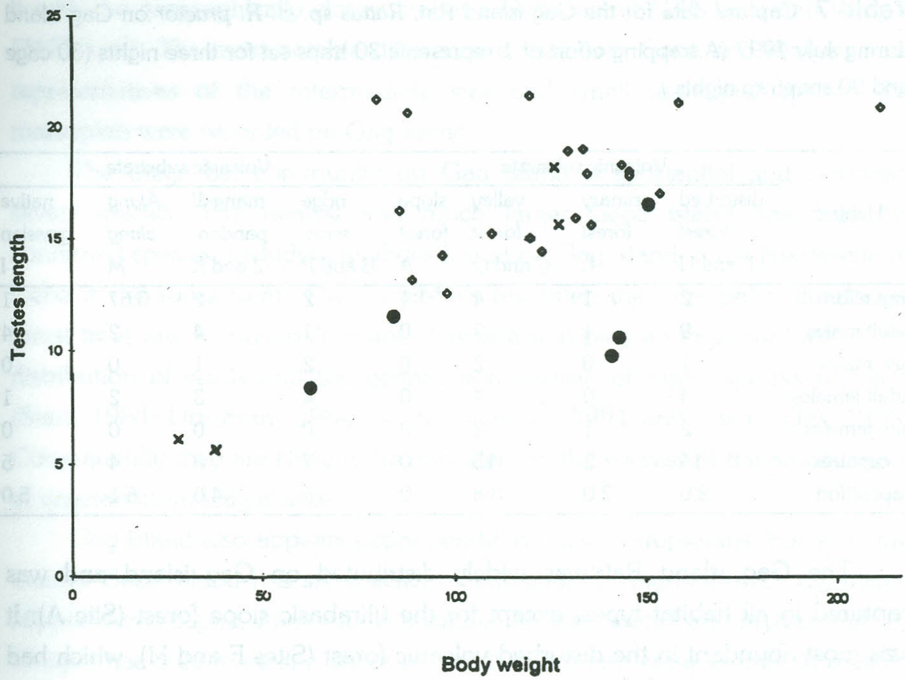

Figure 4. Bivariate plots of right testis length (mm) *versus* body weight (g) for *Rattus* sp. from Gag island. Position of testis: ◊, scrotal; •, inguinal; and **x**, abdominal

Ecology

The number of individuals captured at each collecting site on Gag island during the survey are presented in table 2. For each habitat type, numbers of male and female adults and juveniles captured during comparable periods of trapping (the first three nights trapping, except for the Alang alang site which had only two nights of trapping) and abundance (number of individuals captured over a period of three days in each standard trapline of 30 traps per trap effort) are in presented in Table 7.

Table 7. Capture data for the Gag island Rat, *Rattus* sp. cf. *R. praetor* on Gag island during July 1997 (A trapping effort of 1 represents 30 traps set for three nights (30 cage and 90 snaptrap nights).

Habitat	Volcanic substrate					Volcanic substrate		
	disturbed forest F and H	primary forest L	valley forest C and O	slope forest A	ridge scrub B and P	mangal/ pandan. J and K	*Alang alang* M	native grasslan I
trap effort	2	1	4	1	2	2	0.67	1
adult males	9	1	7	0	1	4	2	4
juv. males	1	0	2	0	2	1	0	0
adult females	4	0	4	0	4	3	2	1
juv. females	2	1	2	0	0	0	0	0
# captures	16	2	15	0	7	8	4	5
capt./effort	8.0	2.0	3.8	0	3.5	4.0	6.1	5.0

The Gag island Rat was widely distributed on Gag island and was captured in all habitat types, except for the ultrabasic slope forest (Site A). It was most abundant in the disturbed volcanic forest (Sites F and H), which had a relative abundance value of 8.0. This represents, however, a low trapping return at that site, with only of 8.9 % of traps set each night capturing a Gag island Rat. Overall the trapping return for all sites for these Rats was 4.6 %. The Rat also had moderate values of abundance in Alang alang and native grassland near the mangal (5.0 and 6.1, respectively); in the mangal / pandanus (4.0); in the ultrabasic valley forests (3.8) and in the ultrabasic ridge scrub (3.5). Their abundance was surprisingly low in the primary volcanic forest (2.0). There was no significant difference overall between captures in relation to trapping effort in habitats on volcanic and ultrabasic substrates ($\chi^2 = 3.1$; df = 1; ns).

Discussion

The assemblage

The number of species on Gag island was about what one would expect in the region for an island the size of Gag (56 km^2). An interesting comparison is with the geographically close ultrabasic Gebe island (145 km^2) and Waigeo (3155 km^2). The most notable difference is that both Gebe and Waigeo have representatives of the intermediate size and small marsupial species. No marsupials were recorded on Gag island.

The mega bat community on Gag island is substantial and comprises seven species. The nearby and much larger Gebe island has only five confirmed species, including all those found on Gag island- if the *Nyctimene* on Gebe is the same form. These fruit-bats are often the principal pollinators of forest trees and shrubs in Asia and Australia and play an important role in the distribution of seeds and the germination success of many species of plants (Start, 1984; Utzurrum, 1984; Kitchener *et al.*, 1991 and refs in Eby, 1996). Consequently they are likely to be important to the success of the rehabilitation of vegetation on Gag island.

Gag island also appears depauperate in micro chiropterans. For example, nearby Gebe island has six species of microbat (*E. nigriscens, E. raffrayana, Hipposideros papua, Miniopterus australis, M. schreibersii* and *Myotis stalkeri)*. Waigeo has only three species of microbat, but considering its area, it must be very under-collected for bats (it also has only a single recorded megabat, *Dobsonia beauforti*).

The paucity of microbats on Gag island may in part be due to the general absence of large caves. Only *Emballonura alecto* was collected from the small limestone caves, despite a reasonable attempt to collect in these caves and mist-net around them. The only other microbat collected was a single specimen of *Emballonura nigrescens.* This specimen, from the ultrabasic valley forest, was trapped as a result of the largest mist-netting effort (729 m^2, see Table 1) carried out in any of the habitats.

It would appear that there is no shortage of insects on Gag island for microbats to feed on; Dr Mike Bangs (personal communication) considers the island to have a diverse insect fauna and was somewhat surprised to record the large number of 25 species of mosquito on the island. It could be expected that more systematic collection over a longer period of time would undoubtedly reveal a larger microbat community on Gag island.

color and teat number from *R.s. steini* from Irian Jaya. Whether it is an undescribed subspecies of *R. p. coenorum* or *R. s. steini*, or is a new species of rat, requires further investigation.

The taxonomic status of the *Nyctimene* on Gag island also needs further examination. From our preliminary examination, it appears to be morphologically distinct from all other close forms of this species.

Reproduction

The period of the survey on Gag island and immediately preceding it was one of intense breeding activity for most, and probably all species of bat on the island and for *Rattus* sp. A high percentage of adult female bats of all species were pregnant or were lactating. Because lactating females, in particular, require a most nutritious diet, the habitat selected by these species at the time of the survey may well be their optimum one.

Habitat utilization

Mist-netted bats indicated that at the time of the survey the habitats on the ultrabasic substrates were richer in species and diversity and had a higher overall relative abundance than those on the volcanics. This is despite the fact that the introduced coconut plantations that were mist - netted were found only on the volcanics - and that these plantations had extremely high rates of capture for *Macroglossus* and *Dobsonia*. If natural vegetations only were sampled, then the habitats on the ultrabasic substrates, compared to those on the volcanics, would have shown even higher values of bat richness, diversity and abundance.

On the ultrabasic substrates, the valley forests were clearly the most important areas for the community of bats.

Several species were captured in sufficient numbers to allow for a statistical comparison between their relative abundance in habitats on the ultrabasic and the volcanic substrates. These are summarized as: significantly higher on volcanics (*Dobsonia beauforti* and *Macroglossus minimus*); significantly higher on ultrabasics (*Nyctimene* sp. and *Syconycteris australis*); and no significant difference between volcanics and ultrabasics (*Rattus* sp.).

Clearly all habitats on the island, both on the ultrabasic and volcanic substrates are important for the ecology of the mammal fauna on the island, but particularly the ultrabasic valley forests. It must be stated though, that the bat community, particularly the larger fruit-bats have the flight capacity to traverse an island of this size in a single night in search of fruit. Their distribution pattern in the various habitats may alter considerably in a different season. It may also be that in some seasons the larger pteropodids may leave Gag island for nearby islands in search of fruiting trees.

Acknowledgements

We were indebted to the BHP Gag island Manager, Warwick Alliston, for his impressive organizational skills which made the entire period on Gag island not only fruitful biologically, but also a most pleasant experience.

Thanks are extended to our escort, Bapak Kamis A., who in addition to driving the mammal group around our traplines each day, assisted in general management and aspects of the field work, and generally made things function well. Particular thanks are due to our main field support technician, Bapak Syraif, who labored beyond the expected to assist us; and who showed a great deal on initiative in assisting us develop the trapping procedures adopted in the field.

References

Andersen, K. (1912). *Catalogue of the chiroptera in the collections of the British Museum. 2nd ed. 1. Megachiroptera.* (British Museum of Natural History: London).

Dwyer, P. D. (1975). Observations on the breeding biology of some New Guinea murid rodents. *Australian Wildlife Research* 2: 33-45.

Eby, P. (1996). Interactions between the Grey - headed flying fox *Pteropus poliocephalus* (Chiroptera: Pteropodidae) and its diet plants- seasonal movements and seed dispersal (*PhD Thesis, University of New South Wales* .

Flannery, T. F. (1995a). *Mammals of New Guinea, revised and updated ed.*(Australian Museum and Reed Books: Chatswood, New South Wales).

Flannery, T. F. (1995b). Mammals of the South -west Pacific and Molluccan islands (Reed: Sydney)..

Gillison, A. N. and K. R. W. Brewer, (1985). The use of gradient directed transects or gradsects in natural resource surveys. *Journal of Environmental Management* 20: 103- 127.

Gunnell, A.; Yani, M. and D. J. Kitchener, (1996). Field observations of *Macroglossus minimus* (Chiroptera: Pteropodidae) on Lombok island, Indonesia. Pp. 127-145. *In* D. J. Kitchener and A. Suyanto (eds), *Proceedings of the First International Conference on Eastern Indonesian Australian Vertebrate Fauna, Manado, Indonesia, November 22- 26, 1994* (Western Australian Museum: Perth).

Hall, L.S. (1983). *In* R Stahan (ed.), *The Australian Museum Complete Book of Australian Mammals* (Angus and Robertson: Sydney).

Heaney, L. R., P. D. Heideman, E. A. Rickart, R. B. Utzurrum and J. S. H. Klompen, (1989). Elevation zonation of mammals in the central Philippines. *Journal of Tropical Zoology* 5: 259-280.

Heideman, P. D. and L. R. Heaney, (1989) . Population biology and estimates of abundance of Fruit Bats (Pteropodidae) in Philippine submontane rainforests. *Journal of the Zoological Society of London* 218: 565- 586.

Hill, J. E. (1983). Bats (Mammalia : Chiroptera) from Indo-Australia. *Bulletin of the British Museum of Natural History (Zoology)* 45 : 103 - 208.

Koopman K. K. (1982). Results of the Archbold Expeditions. No. 109. Bats from eastern Papua and the east Papuan islands. *American Museum Novitates* 2747.

Kitchener, D. J., A. Gunnell and Maharadatunkamsi, (1991). Aspects of the feeding biology of fruit bats (Pteropodidae) on Lombok island, Nusa Tenggara, Indonesia, *Mammalia* 54: 561- 578.

Kitchener, D. J.; Boeadi; and M. Sinaga, (1997). The mammals of the Freeport Contract of Work Region, Irian Jaya : results from the survey of 14 February - 6 March 1997. Unpublished report to Freeport, Jakarta.

Kitchener, D. J., W. C. Packer and I. Maryanto, (1993). Taxonomic status of *Nyctimene* (Chiroptera: Pteropodidae) from the Banda, Kai and Aru islands, Maluku, Indonesia- implications for biogeography. *Records of the Western Australian Museum* 16 : 399 - 417.

Kitchener, D. J., W. C. Packer and Maryanto, (1994). Morphological variation in Maluku populations of *Syconycteris australis* (Peters, 1867) (Chiroptera: Pteropodidae). *Records of the Western Australian Museum* 16: 485- 498.

Kitchener, D. J., W. C. Packer and A. Suyanto, (1995). Systematic review of *Nyctimene cephalotes* and *N. albiventer* (Chiroptera: Pteropodidae) in the Maluku and Sulawesi regions, Indonesia. *Records of the Western Australian Museum* 17: 125- 142.

Kitchener, D. J. and A. Suyanto, (1996). Intraspecific morphological variation among island populations of small mammals in southern Indonesia. Pp. 7- 13. *In* D. J. Kitchener and A. Suyanto (eds), *Proceedings of the First International Conference on Eastern Indonesian-Australian Vertebrate Fauna, Manado, Indonesia, November 22- 26, 1994* (Western Australian Museum: Perth).

Krebs, J. C. (1972). *Ecology: the experimental analysis of distribution and abundance* (Harper and Row Publishers: New York).

Lawrence, M. A. (1991). Biological observations on a collection of New Guinea *Syconycteris australis* (Chiroptera: Pteropodidae) in the American Museum of Natural History. *American Museum Novitates* 3024.

Lyman. M. L. (1980). Line-intercept sampling for attributes other than coverage and density. *Journal of Wildlife Management* 44: 530- 533.

Mc Kean, J. L. (1983). Northern Blossum- bat. P.290. *In* R. Strahan (ed.), *The Australian Museum Complete Book of Australian mammals*. (Angus and Robertson: Sydney).

McKenzie, N. L., A.C. Gunnell, M. Yani and M. R. Williams, (1995). Correspondence between flight morphology and foraging ecology in some palaeotropical bats. *Australian Journal of Zoology* **43**: 241- 257.

Menzies, J. I. and E. Dennis, (1979). Handbook of New Guinea rodents (Wau Ecology Institute Handbook No.6).

Musser, G. G, and M. D. Carleton, (1993). Muridae. *In* D. E. Wilson and D. M. Reeder (eds), *Mammal species of the World: a taxonomic and geographic reference* (Smithsonian Institution Press: Washington D. C.).

Proctor, J. (1992). The vegetation over ultramafic rocks. Pp. 249 - 279 *In* B. A. Roberts and J. Proctor (eds), *The ecology of areas with sepertinized rocks. A world wide view* (Kluwer Academic Publishers: The Netherlands).

Simpson, E. H. (1949). Measurement of diversity. *Nature* **163**:688.

Start, A. N. (1974). The feeding biology in relation to food sources of nectarivorous bats (Chiroptera: Macroglossinae) in Malaysia. (*Doctoral Dissertation, University of Aberdeen, Scotland*).

Suyanto, A. (1995). Genetic and morphological variation in the Blossum Bat, *Macroglossus* (Chiroptera : Pteropodidiae) in South East Asia.(*MSc Thesis, University of Western Australia*).

Taylor, J., J. H. Calaby and H. M. Van Deusen, (1982). A revision of the genus *Rattus* (Rodentia, Muridae) in the New Guinean region. *Bulletin of the American Museum of Natural History* **173**: 177 - 336.

Utzurrum, R. C. B. (1984). Fig fruit consumption and seed dispersal by frugivorous bats in the primary tropical rainforest of Lake Balinsasayao, Negros Oriental, Philippines (*MSc Thesis, Silliman University, Negros*).

Whittaker, R. H. (1975). Direct gradient analysis: techniques. Pp. 9- 31 *In* R. H. Whittaker (ed), *Ordination and classification of communities. Handbook of vegetation Sciences No. 5* (Junk: The Hague).

Ziegler, A. C. (1982). The Australo- Papuan genus *Syconycteris* (Chiroptera: Pteropodidae) with descriptions of a new Papua New Guinea species. *Occasional Papers of the Bernard P. Bishop Museum* **25**: 1 - 22.