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The Population Size of the Lesser bandicoot (*Bandicota bengalensis)* in Three Markets in Penang, Malaysia

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Abstrak: Satu kajian mengenai saiz populasi tikus *Bandicota bengalensis* telah dijalankan di tiga buah pasar di Pulau Pinang iaitu Pasar Taman Tun Sardon (TTS), Pasar Batu Lanchang (BTLG) dan Pasar Bayan Lepas (BYNLP). Sebanyak enam sesi persampelan telah dijalankan di setiap pasar selama empat hari berturut-turut bagi setiap sesi. Di ketiga-tiga kawasan kajian, sebanyak 92%, 73% dan 89% daripada keseluruhan tikus yang ditangkap terdiri daripada jenis *B. bengalensis*. Jumlah anggaran populasi tikus *B. bengalensis* di TTS sebanyak 265.4 (dengan 95% selang keyakinan di antara 180.9–424.2), 69.9 (dengan 95% selang keyakinan di antara 35.5–148.9) di BTLG dan 134.7 (dengan 95% selang keyakinan di antara 77.8–278.4) di BYNLP. Secara amnya, tikus jantan paling banyak ditangkap di setiap kawasan kajian (55.19%), diikuti tikus betina (31.69%), tikus juvenil jantan (9.48%) dan tikus juvenil betina (3.27%). Hasil kajian menunjukkan terdapat perbezaan signifikan dalam bilangan tangkapan tikus berdasarkan nisbah jantina dan kematangan (χ^2 = 121.45, df = 3, p<0.01) di setiap kawasan kajian. Hasil dari keputusan kami berpendapat bahawa saiz populasi daripada kajian ini berkemungkinan tidak menggambarkan saiz populasi yang sebenar untuk setiap pasar, kerana hasil tangkapan semula tikus yang rendah. Ini berkemungkinan disebabkan oleh kelimpahan makan yang pelbagai yang terdapat di pasar tersebut.

Kata kunci: *Bandicota bengalensis*, Jumlah Tangkapan, Anggaran Populasi, Nisbah Jantina

Abstract: A study of the population size of *Bandicota bengalensis* rats in three markets in Penang was conducted from April 2004 through May 2005. Taman Tun Sardon Market (TTS), Batu Lanchang Market (BTLG) and Bayan Lepas Market (BYNLP) were surveyed. Six sampling sessions were conducted in each market for four consecutive nights per session. The total captures of *B. bengalensis* in TTS, BTLG and BYNLP were 92%, 73% and 89% respectively. The total population of *B. bengalensis* in TTS was estimated as 265.4 (with a 95% confidence interval of 180.9–424.2). The total population at BTLG was estimated as 69.9 (with a 95% confidence interval of 35.5–148.9). At BYNLP, the total population was estimated as 134.7 (with a 95% confidence interval of 77.8–278.4). In general, adult male rats were captured most frequently at each site (55.19%), followed by adult females (31.69%), juvenile males (9.84%) and juvenile females (3.27%). The results showed that the number of rats captured at each site differed significantly according to sex ratio and maturity (χ^2 = 121.45, df = 3, p<0.01). Our results suggest that the population sizes found by the study may not represent the actual population size in each market owing to the low numbers of rats recaptured. This finding might have resulted from the variety of foods available in the markets.

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Keywords: *Bandicota bengalensis*, Total Captures, Population Estimation, Sex Ratio

INTRODUCTION

Commensal rats are commonly regarded as pests because they can tolerate many habitats, especially habitats associated with man. Commensal rats cause great losses to the economy and affect both individuals and companies. The main economic effect of rodent pests is the loss of agricultural production. Rats also act as a vector for many harmful diseases of humans and livestock. The commensal rodents most commonly found in urban areas are *Rattus norvegicus* (the Norway rat) and *Rattus rattus* (the house rat). However, in Penang, *Bandicota bengalensis* can also be classified as a commensal rodent because it is present in most human settlements. In Penang, rats have been reported to be the fourth major pest after cockroaches, mosquitoes and ants (Yap *et al.* 1999). The Penang Municipal Council receives reports from the public every month about the nuisance caused by the rats.

The natural habitat of *B. bengalensis* rats is reported as thick forests and bushes. These rats have now become pests in urban areas. The species found in Penang is *Bandicota bengalensis varius* and is a sub species of the *Bandicota* genus. It is a larger-bodied animal than typical *B. bengalensis* (Aplin *et al.* 2003).

B. bengalensis has short coarse hairs. The dorsal side of the body is dark grey and brown, whereas the ventral side is light grey or brownish. The wide front teeth, yellowish in colour, distinguish *B. bengalensis* from other rat species. The width of the teeth in adult rats is approximately 4 mm. Like other rat species, *B. bengalensis* has poor eyesight, but it has a keen sense of smell, hearing and taste (Medway 1983; Aplin *et al.* 2003). The reproductive characteristics of the species are similar to those of the Norway rat. *B. bengalensis* is a ground dweller and a good swimmer, and it prefers to stay near wet environments. Studies of the food habits of young *B. bengalensis* found that the diet of these animals consists of rice and yeast (Sridhara 1978). In the field, adult rats have a different diet. It includes wheat, rice, other grains, sugarcane, beans, fruits, vertebrates, molluscs and crabs (Parshad & Jindal 1991; Aplin *et al.* 2003). However, as a result of their adaptation to the urban environment, rats eat a variety of food items from food storage warehouses, restaurants, bazaars and residences. *B. bengalensis* is also known for its aggressive behaviour and its harsh sound when disturbed (Meehan 1984).

The objective of this study was to determine the population of *B. bengalensis* in three markets in Penang; Taman Tun Sardon Market (TTS), Batu Lanchang Market (BTLG) and Bayan Lepas Market (BYNLP). This species has been studied frequently in other countries, especially in India and Bangladesh (Kaur & Guraya 1950; Greaves & Rehman 1977; Sahu & Maiti 1978; Fulk *et al.* 1981; Sahu 1984; Deobhankar 1985; Bryce 1994; Rajab *et al.* 2003). However, to the best of our knowledge, no quantitative studies of *B. bengalensis* in markets in Penang have previously been conducted. Although this study did not include all areas of Penang, the study provides some information and understanding about the population of *B. bengalensis* in markets in Penang. We

consider this information essential for developing a more efficient and cost-effective integrated management strategy.

MATERIALS AND METHODS

The market areas chosen for this study were TTS, BTLG and BYNLP. TTS is located approximately 2 km from the Universiti Sains Malaysia (USM) campus in Taman Tun Sardon, in the Gelugor area (5° 22' 9.34' N, 100° 18' 20.27' E). The double-storey market building consists of a public hall on the first floor and a sales area on the ground floor. The area around the market consists of low-cost residential flats in front of the market, a school on the hill immediately adjacent to the market and a food court to the left of the market. Outside the market on the right-hand side is an open area suitable for *B. bengalensis*. The market is busy only in the morning, and human activity decreases in the afternoon. Owing to inefficient waste collection, strong odours are present in the area near the garbage bins, and discarded chicken heads, feathers and entrails are scattered on the floor.

Located in a busy area, BTLG is a two-storey market (5° 23' 25.12' N, 100° 18' 21.64' E) surrounded by low- and medium-cost flats. A food court is located in front of the market. The market has a public hall on the first floor and a sales area on the ground floor. The market faces the main road. A large car park is located between the market and the road. Behind the market, a large skip (open-topped container) is located near an area of bushy vegetation. The areas around the market are occupied primarily by a Chinese population. The market is open during the day and closes by 1900. Many dogs are found around the market. Some of these dogs are pets, and the others are strays.

BYNLP is a single-storey building built in 1930 and located in the centre of Bayan Lepas town (5° 18' 3.53' N, 100° 16' 23.81' E). It is relatively small compared with the other two markets. The interior of the market is relatively narrow, and the number of traders does not exceed 20. The market is surrounded by old shops, terrace houses and a village. Activity at the market begins in the early morning and continues until the afternoon. The market closes in the evening. The villagers near the market allow their chickens and ducks to roam freely around the residential areas. The animals eat rice strewn on the ground. In addition, many stray cats are found at the market.

Sampling Procedures

The study was conducted from April 2004 through May 2005 using mark-recapture techniques. Six sampling sessions were conducted at each market. Rats were trapped for four consecutive days and nights at the three sampling locations. Wire traps measuring 25 x 15 x 11.5 cm and baited with ripe bananas were used for the study. A total of 50 traps were placed randomly around the market each night. The traps were usually placed near rat holes, in areas that included potential travel routes of the rats, and around garbage bins. The distance between the traps varied among areas according to the size of the sampling sites. Traps were placed inside the BYNLP but not inside the TTS and

the BTLG because these two markets were locked at night. The traps were set at approximately 1800 each evening during the sampling period and checked at 0200. Each rat captured was identified using the methods of Medway (1983) and Yasuma and Andau (1999). Additional information, such as the sex and the maturity of rats, was also collected (Chew & Butterworth 1964). The pregnancy status and lactating condition of the females were recorded. The males were recorded as having scrotal or abdominal testes. The captured rats were ear-tagged for identification and released at the point of capture.

Data Analysis

Trapping success was calculated as the number of rats captured divided by the total number of traps set, multiplied by 100 (Nelson & Clark 1973). The population estimate for each market was calculated using the Schnabel method (Ecological Methodology software, Exeter Software, Setauket, New York) or according to Krebs (1999). Because the number of recaptures in each sampling session was very low, the population estimate for each session was calculated using the method for determining the minimum number of individuals alive (Krebs 1966). Chi-square tests were used to examine the significance of the differences in sex ratio and maturity among the markets. The statistical analyses were performed with SPSS version 15.0.

RESULTS

A total of 225 *B. bengalensis* were trapped during the 14 months of the study at TTS, BYNLP and BTLG. In addition to *R. norvegicus* and *R. rattus*, *B. bengalensis* was the dominant species captured. The overall numbers of individuals captured varied significantly among the sampling sites (χ^2 = 45.49, df = 2, p<0.01). The numbers of *B. bengalensis* captured also varied significantly among the sites (χ^2 = 53.83, df = 2, p<0.01). Approximately 6.25% trapping success was recorded at all 3 sites for the 3600 trap-nights of sampling. The recapture rate was 17.78%.

The overall capture success at TTS was 10.42%. The capture success varied among sampling sessions. The capture success for the first session was 17.5%. The values in the subsequent sessions were 5.0%, 13.0%, 11.5% and 3.5%. The number of individuals captured was significantly different for each sampling session (χ^2 = 26.48, df = 5, p<0.01). The overall mean percentage of recaptures was 17.6%. BTLG showed an overall capture success of only 3.17%, with a declining percentage from the first session to the sixth session (χ^2 = 23.6, df = 5, p>0.05). Only the first and third sessions showed high percentages of recaptures, 29.41% and 33.33%, respectively. An overall capture success of approximately 5.17% was recorded at BYNLP. The number of individuals captured did not vary significantly across sampling sessions (χ^2 = 7.22, df = 5, p>0.05). The overall percentage of recaptures was 17.74%. Table 1 shows the percentages of captures and recaptures at each market.

The overall estimates of the rat population were 265.4 individuals (with a confidence interval of 180.9 to 424.2) for TTS, 69.9 individuals (with a confidence

interval of 35.5 to 148.9) for BTLG and 134.7 individuals (with a confidence interval of 77.8 to 278.4) for BYNLP. Figure 1 shows the population estimates for each session at the three sites. TTS and BYNLP showed similar patterns, with decreasing numbers of individuals alive across the sampling sessions. BYNLP showed the opposite pattern, with increasing numbers of individuals alive from the first session to the fifth session.

Table 1: Number of *B. bengalensis* captured at each site for every sampling session, with percentages of trapping and recapture success.

Session	TTS		BTLG		BYNLPS	
	Overall captured	Recaptured	Overall captured	Recaptured	Overall captured	Recaptured
1	35	7	17	5	8	0
2	10	3	3	0	10	3
3	26	2	6	2	7	2
4	23	5	4	0	13	0
5	24	4	6	0	16	2
6	7	1	2	0	6	2
Total	125	22	38	7	62	11
Number of trap-nights	1200		1200		1200	
Trapping success (%)	10.42		3.17		5.17	
Recapture success (%)		17.6		18.42		17.74
χ^2	26.48		23.6		7.22	
df	5		5		5	

The sex ratio of *B. bengalensis* at TTS deviated significantly from unity (χ^2 = 17.96, df = 1, p<0.01), with a 2.43:1 ratio of males to females. At BYNLP (χ^2 = 0.34, df = 1, p>0.05) and BTLG (χ^2 = 2.65, df = 1, p>0.05), the sex ratio did not deviate significantly from 1:1. Table 2 shows the numbers of rats captured according to sex in each session at all sites. The sex ratios by level of maturity are shown in Table 3. In general, adult male rats were captured most frequently at each site (55.19%), followed by adult females (31.69%), juvenile males (9.84%) and juvenile females (3.27%). The number of rats captured varied by sex ratio and maturity (χ^2 = 121.45, df = 3, p<0.01) at each site. The relative excess of males may result from their greater activity and larger home range, which would tend to produce a higher probability of capture than that of the females. At TTS, approximately 26.92% of the females were found to be pregnant, and an additional 23% of the females were lactating during the study. A similar finding was obtained at BTLG, where 27.27% of the females were found to be pregnant. In contrast, a higher pregnant female population of 76.19% was recorded at BYNLP, but no females were found to be lactating. An error-free analysis of

female reproductive condition based on external inspection is difficult to achieve because reproductive condition is difficult to determine during early adulthood. However, the reproductive status of multiparous female rats is easier to determine. Figure 2 shows the numbers of adult female rats, pregnant rats and lactating rats for each session at each site.

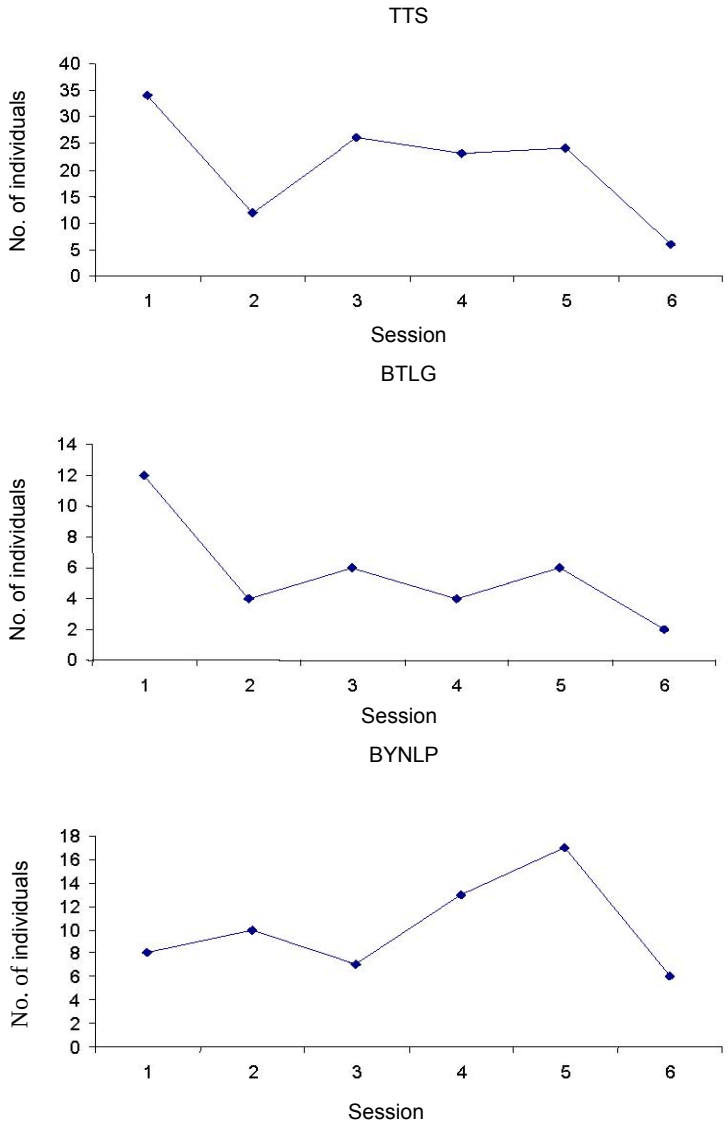

Figure 1: Estimates of minimum number of individuals alive for each session at each site.

Table 2: Number of *Bandicota bengalensis* captured according to sex at each site.

Site	Session	No. captured		
		Male	Female	χ^2
TTS	1	27	1	24.1786
	2	4	3	0.2857
	3	14	10	0.6667
	4	11	7	0.9444
	5	12	8	0.85
	6	5	1	2.8333
	Total	73	30	29.8**
	χ^2			17.96**
BTLG	1	6	2	0.0834
	2	2	5	3.25
	3	4	1	0.25
	4	7	6	2
	5	7	7	2.8333
	6	2	2	0.5
	Total	28	23	8.92*
	χ^2			2.64
BYNLP	1	6	6	2.125
	2	2	0	1.4286
	3	2	2	1.25
	4	3	1	0.1538
	5	5	1	0.0714
	6	1	1	0.25
	Total	19	11	5.28
	χ^2			0.34

Notes: **Significantly different by χ^2 test (p<0.01)
*Significantly different by χ^2 test (p<0.05)

Table 3: Numbers of individuals and maturity percentage by sex at each site.

Site	No. of individuals	Maturity	% total
TTS	61	Male – adult	59.22
	12	Male – juvenile	11.65
	26	Female – adult	25.24
	4	Female – juvenile	3.88
BYNLP	25	Male – adult	49.02
	3	Male – juvenile	5.88
	21	Female – adult	41.18
	2	Female – juvenile	3.92
BTLG	16	Male – adult	51.72
	3	Male – juvenile	10.34
	11	Female – adult	37.93
	0	Female – juvenile	0

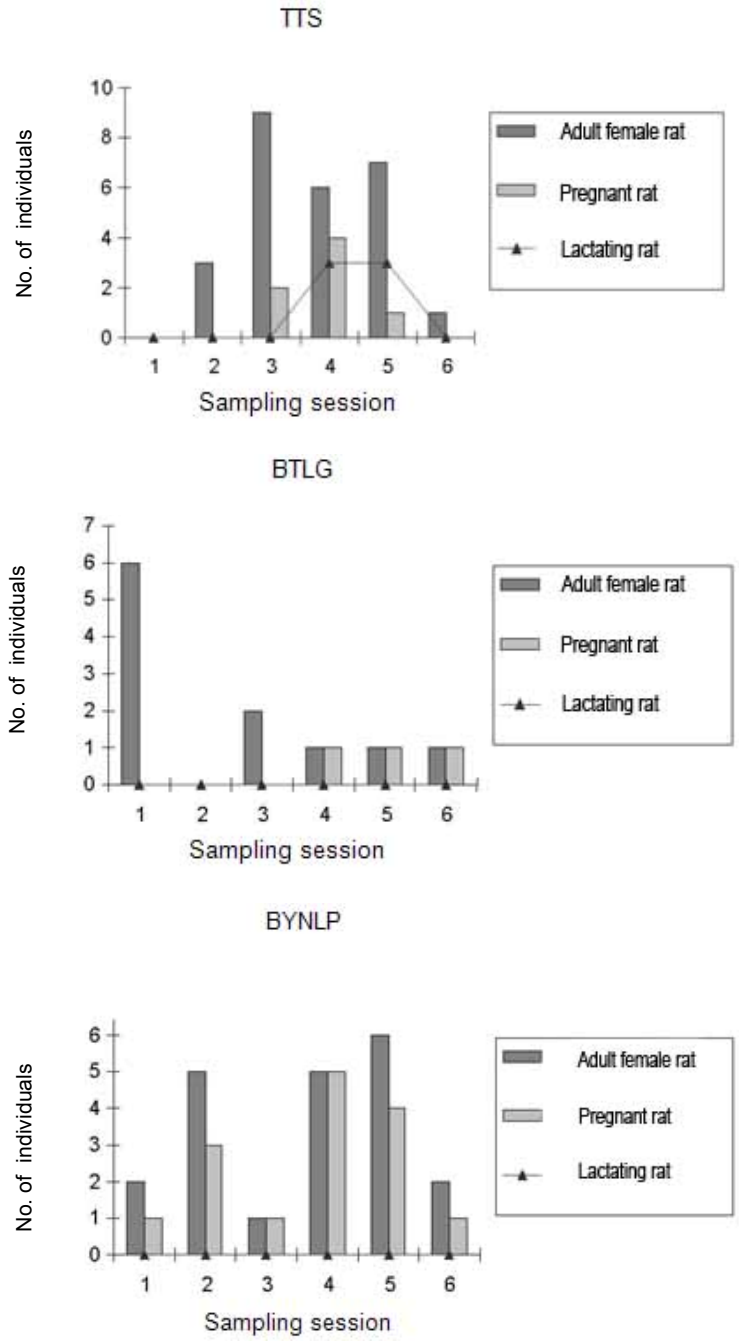

Figure 2: Numbers of adult female rats, pregnant rats and lactating rats for each session at each site.

DISCUSSION

The population estimates of *B. bengalensis* in this study based on total captures did not represent the actual populations of these rats in the markets. Overall captures and recaptures in each session were relatively low compared to the numbers of trap-nights. The main reason for this outcome may be the availability of abundant food in the market areas. If the baits were contaminated or rotten, the rats were not attracted to the traps. Moreover, the activity patterns of the rats influenced the capture rates (Aplin *et al.* 2003).

Several sampling sessions were conducted to confirm the above hypothesis in additional areas of Penang. These additional areas were Bayan Baru Market, Campbell Market, Prangin Market, Nusantara areas, Taman Free-School flats, jetty areas, King Street, Hutton Road and Delima Road. Various types of bait were used, including ripe banana, fried chicken feet, fried fish, salted fish, shrimp paste, bread, papaya and toasted bread with butter. The use of various types of bait was suggested by Aplin *et al.* (2003). Although rats were observed in the additional sampling areas, especially the area of Campbell Market, the number of captures was still low. In some areas, no rats were captured. Another factor that influences the number of captures is the neophobic behaviour of *B. bengalensis*. A study of *R. norvegicus* showed that rats from areas with abundant food resources tend to be more neophobic (Priyambodo & Pelz 2002). This study may also demonstrate the neophobic behaviour of *B. bengalensis* at the three study sites. This behaviour is believed to be one of the reasons that only a relatively small number of rats were captured. Inheritance, experience and environmental stability all tend to influence the level of neophobia (Priyambodo & Pelz 2002). When moving or eating, rats normally prefer to stay in safe, covered places and in proximity to the walls (Meehan 1984). Sheltered or hiding areas also influence rat behaviour towards baits or traps (Jacob *et al.* 2003). A study of *Microtus domesticus* shows that this rodent tends to eat bait from a well-hidden trap rather than from more exposed traps. This behaviour is related to the rodent's reactions towards its prey (Jacob *et al.* 2003). In our study, it was our intention to place all the traps in covered places. However, the covered areas were limited. Therefore, the traps were placed near rat holes or next to walls. The presence of traps in exposed areas was believed to be one of the reasons that the number of captures was low. Another factor affecting the low numbers of rats captured was that the total number of missing and destroyed traps was high. This high rate of trap loss was the result of disturbance by humans and animals. The loss of a large number of traps decreased the total sampling effort and thus influenced the number of rats captured.

Although there are conflicting opinions on using the population estimation method involving the minimum number of individuals alive (Jolly & Dickson 1983; Efford 1992), this method is the most appropriate for use if the Jolly-Seber or the Schnabel method cannot be used owing to a small population size or small numbers of recaptures (or no recaptures at all) (Krebs *et al.* 1986). Consequently, the population estimate for each sampling session was calculated using this method because very few rats or no rats were recaptured in several sampling sessions. Although the population estimate calculated using this method includes

some amount of error, this estimate is generally near the actual population size (Krebs *et al.* 1986). The percentage of recaptures found in other studies in Southeast Asia was also low, generally below 1% (Aplin *et al.* 2003). Consequently the mark-recapture method did not provide sufficient information on the rat population size in the field (Aplin *et al.* 2003).

Probably, the total number of rats captured in this study does not represent the actual population owing to the availability of abundant food. This result appears to contradict the findings of Sherman and Runge (2002). These authors claimed that their observed abrupt decrease in the total rat population resulted from a lack of food resources. We assume that the amount and variety of food in our sampling areas made the traps less attractive and produced a smaller number of captures. Therefore, the population estimates obtained using the mark-recapture method were not accurate. Population density is generally influenced by the quantity and quality of food (Agrell *et al.* 1992).

Small mammal responses to traps also depend on the social hierarchy of the species. Individuals that are more active have a higher probability of being caught. A study of wild European rabbits, *Oryctolagus cuniculus,* showed that several sampling techniques can produce estimation errors in the sex or age ratios in a population (Sullivan & Sullivan 1983). These findings are consistent with the results of the present study. We found that adult males were captured more frequently than adult females, followed by juvenile males and juvenile females. Presumably, the adult males were more frequent in the sample because they were more dominant, were more active and tended to move farther than the adult females. In addition, a previous study reported that larger rats are more likely to be captured than smaller rats and that the capture rates of females and males did not differ significantly (Davis & Emlen 1956). Similarly, the relative proportions of females and males were not significantly different in the samples taken at the BTLG or at the BYNLP. However, at the TTS the number of male rats captured was much higher than the number of female rats. In contrast to the study of Krebs *et al.* (1976), the results of our study shows that the capture probabilities of male and female rats can vary but are generally similar. Adult rats were trapped more often than juvenile or subadult rats because juveniles and subadults have smaller home ranges than adults. Other factors that would cause juveniles and subadults to be captured less frequently are a tendency to explore areas nearer their nests or a tendency to disperse to other areas.

CONCLUSION

The estimates obtained by this study may not represent the actual population numbers of *B. bengalensis* in the three markets studied in Penang, but the study does provide some rough information in the form of the numbers of individuals captured at each site. Further study is recommended to develop a better understanding of the size of the *B. bengalensis* population in Penang. These data can be used to plan better pest management control strategies that do not rely solely on rodenticides.

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