Surveillance of Commensal Rat and Shrew Populations in the Bangkok Area with References to Flea Index as the Risk Indicator of Plague

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Abstract

Commensal rats and shrews were trapped from 47 fresh food markets in Bangkok during the two study periods in the same markets: 21st June to 28th December 1999 and 1st March to 31st May 2000. Trapping was performed using wire live traps on three consecutive nights in each period. The trapped animals were identified for taxonomic species and flea infestation. Fleas were collected, identified and counted. Four species of rodents: *Rattus norvegicus, Rattus rattus, Rattus exulans* and *Mus musculus*, and one species of shrew: *Suncus murinus* were trapped in comparable numbers during the two study periods. Among the 1177 animals trapped, 84.3 per cent were *R. norvegicus*. Regarding sex prevalence, a higher number of female animals were trapped compared to males. Almost all the fleas collected were *Xenopsylla cheopis*, and there were very few *Ctenocephalides felis-felis*. Flea index based on the number of *X. cheopis* was 0.65 for all over Bangkok. Based on the geographical area of Bangkok, the inner area had the highest rodent population and the highest flea index of 0.86. Therefore, the inner region should be the priority for sanitation improvement.

Key word : Commensal Rat and Shrew, Flea, Flea Index, Bangkok

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J Med Assoc Thai 2003; 86: 795-801

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Commensal rodents cause public health problems worldwide, because they can be carriers of viral, bacterial and parasitic pathogens. They can transmit diseases to man directly or indirectly through their ectoparasitic insects as the disease vectors. Rodent species living in various geographical areas may be different; and different species harbour different pathogens. Therefore, distribution of a rodent species in a geographic area may be indicative of human risk for certain endemic diseases[1]. In addition, with their nature to colonize human habitats, commensal rodents often disturb humans in such a way that they damage foodstocks and household belongings according to their biting and eating habits.

Rodents are little mammals which breed easily, and give birth to several litters in a year. Human diseases can emerge as a consequence of overpopulation of commensal rodents. The size of the rodent population is an important indicative marker for the sanitation status of a community. Surveillance for rodent populations and their ectoparasitic fleas especially *Xenopsylla cheopis* for the determination of the flea index (the average number of *X. cheopis* collected from one animal) can be used to indicate the risk for plague occurrence. A high rodent population and flea index ≥ 1 is suggestive of a plague outbreak[2].

Bangkok, the capital of Thailand is located on both sides of the Chao Praya River. The capital occupies 1, 568. 737 square kilometers of fertile land some parts of which are often flooded every rainy season. The city was overcrowded with a population of 5, 680, 380 by the year 2000. Despite extensive sanitizing, poor hygienic areas are easily found hidden behind tall buildings ; in those places, stray dogs, cats and commensal rodents can be found. Fresh food markets, where people go to shop for fresh food are under the control of the Bangkok Metropolitan Administration (BMA). The standard of cleanliness and sanitation of the markets can be evaluated partly from the animals living in the vicinity.

The present paper estimated the size of the commensal rodent and shrew populations trapped from fresh food markets in Bangkok, the species of parasitized fleas and flea index were also determined. Trapping of animals was performed twice in each market of each district and lasted from June 1999 to December 2000.

MATERIAL AND METHOD

Bangkok area

Based on the density of the population and location, Bangkok is divided into three regions which include 50 districts.

The inner region, the most crowdest area is composed of 21 districts, i.e., Sampantawong, Bang Rak, Huai Khwang, Pom Prap Sattru Phai, Phra Nakhon, Bangkok Yai, Thon Buri, Bang Su, Bang Kho Laem, Phaya Thai, Ratchathewi, Yan Nawa, Khlong San, Sathon, Bangkok Noi, Vadhana, Patum Wan, Chatuchak, Khlong Toei, Din Daeng and Dusit.

The middle region is composed of 18 districts, i.e., Sa Phan Sung, Bang Na, Phasi Charoen, Suan Luang, Phra Khanong, Rat Burana, Khan Na Yao, Chom Thong, Prawet, Bang Khen, Wang Thong Lang, Lat Phrao, Bang Phlat, Bung Kum, Don Muang, Sai Mai, Bang Kapi and Lak Si.

The outer region is composed of 11 districts, i.e., Nong Chok, Min Buri, Khlong Sam Wa, Latkrabung, Nong Kham, Bang Khun Thian, Thawi Watthana, Bang Bon, Bang Khae, Thung Khru and Taling Chan.

There are several fresh food markets in one district; however, three districts have no market i.e., Taling Chan, Khlong Sam Wa and Sa Phan Sung. Therefore, this study was carried out in 47 fresh food markets; each one was chosen as the representative market of the district.

Animal trapping

Rodents and shrews were caught alive by wire live trap. Trapping was performed twice in each market with an interval of about 5-8 months between the first and second trapping periods. Each trapping session was conducted on three consecutive nights using 20 cages per night. Bait prepared from roasted coconuts were put in the cages. After each night, the cages were thoroughly cleaned and boiled in hot water, and air dried before reuse. The first trapping session was performed from June to December 1999; and second trapping round was performed from March to May 2000.

Identification of the trapped animals and their ectoparasitic fleas

The trapped animals were anaesthesized individually by chloroform; weighed and measured for body length and tail length. Approximately 1-2 ml of heart blood was obtained by venipunctured. The fur was combed for fleas which would be enumerated and preserved in 70 per cent alcohol until identified.

Identification for animal sex and species followed the criteria described previously[3-6].

Fleas were mounted on slides with Hoyer medium using the same method as described by

Apiwathnasorn et al for identification of insect larvae (7). Identification for flea species followed the chart established by Cheong and Mahadevan(8).

Blood and animal carcasses were sent to the Division of Virology, Department of Microbiology, Faculty of Medicine Siriraj Hospital where sera were separated, and organs such as lungs and brains were harvested and frozen for determination of pathogenic agents : rabies virus, hantavirus, rickettsial and leptospiral bacteria.

Determination for flea index

More than one kind of flea was collected from the trapped animals. However, flea index was determined based only on the number of *Xenopsylla cheopis*. Flea index was defined as the average number of *X. cheopis* collected per one animal trapped according to the criteria of Bahmanyar and Cavanaugh(2).

RESULTS

Four species of rodents trapped in the 47 markets of Bangkok comprised : *Rattus norvegicus* (Norway rat or brown rat or sewer rat - หนูท่อ), *Rattus exulans* (Polynesian rat- หนูจี๊ด), *Rattus rattus* (Roof rat or black rat - หนูท้องขาว), *Mus musculus* (House mouse - หนูทริ่งบ้าน), and one species of shrew: *Suncus murinus* (House shrews - หนูผี, หนูปากแหลม), an insectivorous mammal. *R. norvegicus* rats were trapped in the highest frequency, i.e., 84.3 per cent , and the remaining four species were trapped in a comparable number (Table 1).

Regarding sex prevalence, a higher number of females were trapped, especially *S. murinus* of which the male to female ratio was 1 : 9 (Table 2).

Among 770 fleas collected from all the trapped animals, 766 were *Xenopsylla cheopis* and four were *Ctenocephalides felis-felis*. The Flea index as determined by the total number of fleas collected per total number of animals trapped from all over Bangkok was 0.65 (Table 3). Flea index in the inner region of Bangkok was the highest, followed by the outer and the middle region, i.e., 0.86, 0.62 and 0.39, respectively (Table 4). However, the number of fleas collected from the flea infested animals ranged from 1 to 59 (Table 5).

DISCUSSION

Rodents comprise some 389 genera which include about 1,700 species among 35 families living in different habitats ranging from rain forests to desert regions worldwide(9). Common rodents familiar to humans are rats, mice, squirrels, guinea pigs, beavers, and voles, etc. The family *Muridae* which includes rats (*Rattus, Bandicota*, etc) and mice (*Mus*) are the common rodents of South East Asia(3,4). This family has been known to transmit several diseases, e.g., plague, leptospirosis, rickettsial diseases, rabies and other viral, bacterial and parasitic infections(3,4). Approximately 200 species of all rodents can harbour the plague naturally with different degrees of susceptibility.

Rats and mice have an average life span of 1 year. Reproductive lives begin at two months of age; and during their lives, a female can give birth to 5-8 litters which comprise 5-14 offsprings per litter. Each pregnancy lasts about one month; and females can begin mating again after four days of delivery(10, 11). Rat and mice in Thailand are divided into com-

Table 1. Population of animals trapped in fresh food markets located in Bangkok.

Animal species	Number of animals trapped		Total	%
	First trapping	Second trapping		
Rodents				
Rattus norvegicus (หนูท่อ)	447	545	992	84.3
Rattus rattus (หนูท้องขาว)	57	1	58	4.9
Rattus exulans (หนูจี๊ด)	18	7	25	2.1
Mus musculus (หนูทริ่งบ้าน)	26	14	40	3.4
Shrews				
Suncus murinus (หนูผี)	33	29	62	5.3
Total	581	596	1,177	100

Table 2. Genders of the trapped animals.

Animal species	Number of animals trapped	Number of			
		Male	Female	Unidentified sex	M : F ratio
Rattus norvegicus	992	447	518	27	1 : 1.16
Rattus rattus	58	21	30	7	1 : 1.43
Rattus exulans	25	8	13	4	1 : 1.63
Mus musculus	40	11	23	6	1 : 2.09
Suncus murinus	62	6	56	0	1 : 9.33
Total	1,177	493	640	44	1 : 1.3

Table 3. Determination of flea index in the trapped animals.

Animal species	Number of animals trapped	Number of fleas		Flea index
		X. cheopis	*C. felis-felis*	
Rattus norvegicus	992	675	4	0.68
Rattus rattus	58	47	-	0.81
Rattus exulans	25	8	-	0.32
Mus musculus	40	27	-	0.68
Suncus murinus	62	9	-	0.15
Total	1,177	766	4	0.65

mensal and field animals by their natural habitats. The majority of commensal rats and mice previously found in Thailand were *Rattus norvegicus*, *Rattus exulans*, *Rattus rattus* and *Mus musculus*; and some field rats and mice were *Bandicota indica* (Great bandicoot rat - หนูพุกใหญ่), *Bandicota savilei* (Lesser bandicoot rat - หนูพุกเล็ก), *Mus caroli* (Ryukyu mouse-หนูหริ่งนาหางยาว), *Mus cervicolor* (Fawn colored mouse - หนูหริ่งนาหางสั้น), *Rattus argentiventer* (Ricefield rat - หนูนาใหญ่หรือหนูนาท้องขาว), *Rattus losea* (Lesser ricefield rat - หนูนาเล็กหรือหนูสวน), and some other *Rattus* spp[1, 3,12]. However, the present study was confined to commensal rats and mice living only in Bangkok.

The present study conducted animal trapping in fresh food markets in Bangkok. Most of the animals trapped included mice and rats; interestingly, shrews which are insectivores were also trapped. Our study found more females than males among all species of the animals trapped which reflects the possibility of an increase in animal population where there is poor sanitation. Fortunately, the animal population did not change since the number of animals trapped during the two trapping periods in the same area was not different (Table 1). Imvithaya et al also reported that 64.3 per cent of 1,104 animals trapped in 19 provinces along the border of Thailand were females[12].

Some studies previously conducted in different provinces of Thailand at different periods of time demonstrated different findings[12-15]. In Chanthaburi Province which is situated in the East of Thailand, 84.5 per cent of the animals trapped in rural areas were *R. exulans*[13]; while in Mae Hong Son and Chiang Rai Provinces which are located in the North where the climate is colder, 100 per cent of the mammals captured in houses were 100 per cent *R. Rattus*[14]. Regarding the studies in urban areas of Chanthaburi, 55.6 per cent of the captured animals were *R. norvegicus*, 29.8 per cent *R. exulans* and 14.6 per cent *S. murinus*[13,14].

There were three previous studies on animal trapping in Bangkok, the first one by Yabe et al in 1989[14], the second one by Imvithaya et al in 1995-1996 which included Bangkok and Nonthaburi, a nearby province[15] and the third one also by Imvithaya et al in 1996-1997[12]. Those studies reported that *R. exulans* were the most common animals captured followed by *R. norvegicus*, i.e., 53.8 *vs* 29.0 per cent by Yabe et al; 65.4 *vs* 16.4 per cent by Imvithaya et al

Table 4. Relationship between density of fleas and density of animal populations in different regions of Bangkok.

Bangkok area	Total animals trapped	Number of animals infested with fleas	%	Number of fleas collected	Crude flea index	Average number of fleas per infested animals
Inner	587	152	25.9	505	0.86 (505/587)	3.32 (505/152)
Middle	439	65	14.8	171	0.39 (171/439)	2.63 (171/65)
Outer	151	42	27.8	94	0.62 (94/151)	2.24 (94/42)
Total	1,177	259	22.0	770	0.65 (770/1177)	2.97 (770/259)

Note : One animal was infested with both *X. cheopis* and *C. felis-felis*

Table 5. Density of *X. cheopis* population in the infested animals.

Animal species	Number of flea infested animals	%	Number of animals infested with different ranges of flea number							
			1-4	%	5-9	%	10-19	%	≥ 20	%
R. norvegicus	219/992	22.1	176	80.4	30	13.7	12	5.5	1	0.5
R. rattus	15/58	25.9	13	86.7	1	6.7	0	0	1	6.7
R. exulans	5/25	20.0	5	100	0	0	0	0	0	0
M. musculus	13/40	32.5	12	92.3	1	7.7	0	0	0	0
S. murinus	4/62	6.5	4	100	0	0	0	0	0	0
Total	256/1,177		210	82.0	32	12.5	12	4.7	2	0.8

in 1995-1996; and 58.7 *vs* 15.2 per cent by Imvithaya et al in 1996-1997. These results were in contrast to the present study which showed that *R. norvegicus* was the most common among five species of animals captured, followed by the house shrews *S. murinus* and *R. rattus*, i.e., 84.3, 5.3 and 4.9 per cent , respectively. *R. exulans* took the fifth rank of all, i.e., 2.1 per cent (Table 1). The difference could be explained by location of trapping, but not by method of trapping and bait which were the same. The habitat of *R. exulans* may be inside houses, meanwhile *R. norvegicus* prefer to live in more dirty places, i.e., in fresh food markets. Regarding *S. murinus*, the house shrews which live on insects, were captured in urban areas of Chanthaburi, and also in all studies in Bangkok including the present report. We found that the number of animals captured was highest in Bangkapi Market, followed by Bang Su Market. From a total of 60 trapping cages per market, 83 animals were captured in Bangkapi Market, while 72 animals were captured in Bang Su Market (data not shown).

Plague is a zoonotic disease caused by *Yersinia pestis* bacteria which is transmitted from rodents to man by flea vector, *Xenopsylla cheopis*, the Oriental rat flea[16]. Fleas are infected by feeding on blood of the infected rodents. The bacteria multiply in flea gut, and bacterial burden will cause gut obstruction. Upon feeding on a new host, bacteria are regurgitated from the flea's gut and enters the blood stream of the host. Humans accidentally become infected by this means. The last case of plague in Thailand was seen in 1952, and the disease has not been seen since then. Nevertheless, the outbreak of plague in India in September 1994[17] alerted the public health authorities of several countries to the risk of a re-emergence of the disease if sanitary management broke down. The specific index for *X. cheopis* of over 1 is indicative of a risky situation for plague; and an outbreak can occur if the specific flea index is higher than 5[18].

Surveillance for plague carried out in 19 provinces along the Thai border demonstrated specific flea indices between 0.03 to 1.2. There were two provinces which had a flea index ≥ 1. The index of 1.2 was seen in Songkhla and of 1 in Nong Khai[12]. Fortunately, all animals'sera tested for specific antibodies did not give any positive results [12]. The average specific flea index of 0.65 for the Bangkok area was shown in the present study. However, the value of 0.86 in the inner area of Bangkok, especially

the market of Pom Prap Sattru Phai, is not a safe indicator (Table 4). There were 15 animals captured in the market of Pom Prap Sattru Phai district during the two trapping periods; however, one rat was infested with 59 fleas and the other one with 23 fleas (Table 5).

Among all species of the captured animals, the highest specific flea index of 0.81 was seen in *R. rattus*, followed by 0.68 for both *R. norvegicus* and *M. musculus* (Table 3). Flea infestation was more common in *R. rattus* than *R. norvegicus*; eventhough, the latter one has a bigger body size. *X. cheopis* may have a higher propensity for certain animal species. This explanation needs further elucidation.

From the present study, We could not conclude that there is no risk of plague at all. If *Yersinia pestis* is introduced into Thailand, the inner area of Bangkok will be at high risk for disease transmission because of its high density of animal population and high rate of flea infestation. Continuous control practices of rodent populations should be seriously carried out in Bangkok.

ACKNOWLEDGEMENTS

This project (project number SE/99/222694) received a grant from the World Health Organization. The authors wish to thank the Bangkok Metropolitan Administration and Mahidol University for supporting the entire project ; and Prof. Prasert Thongcharoen and Dr. Prayura Kunasol for their advice. We also thank Assist. Prof. Thongchai Deesin, Assoc. Prof. Somjai Leemingsawat and Mr. Samrerng Prommongkol from the Department of Medical Entomology, Faculty of Tropical Medicine, Mahidol University for flea processing and identification; and Mr. Sutthirak Singh-nok from the Department of Microbiology, Faculty of Medicine Siriraj Hospital for blood and tissue specimen processing.

We also wish to thank Mr. Somchai Chongchoo, Mr. Paithoon Rattanapaiboon and teams from the Department of Health, Bangkok Metropolitan Administration for the animal trapping throughout the entire project.

(Received for publication on March 18, 2003)

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การเฝ้าระวังหนูและค่าดัชนีหมัดหนูเพื่อแสดงความเสี่ยงต่อการเกิดกาฬโรคในเขตกรุงเทพมหานคร

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งานวิจัยนี้ได้ทำการดักจับหนู ในตลาดสดจำนวน 47 แห่ง ในกรุงเทพ ฯ โดยทำการดักจับสองครั้งในสถานที่เดิม ครั้งแรกในช่วงเวลามิถุนายน – ธันวาคม 2542 และครั้งที่สองในช่วงเวลามีนาคม – พฤษภาคม 2543 การดักแต่ละครั้งจะดัก 3 คืนติดต่อกัน และวางกรงคืนละ 20 กรงทุกคืน จากนั้นนำสัตว์ที่ดักจับได้มาทำการจำแนกสปีชีส์ และสางหมัดเพื่อตรวจนับจำนวนหมัดในสัตว์แต่ละตัว เพื่อคำนวณหาค่าดัชนีหมัดหนู การศึกษานี้สามารถดักจับสัตว์ได้ 5 ชนิด เป็นหนู rat 3 สปีชีส์ หนู mouse 1 สปีชีส์ ส่วนสปีชีส์ที่ 5 ไม่ใช่หนูแต่มีลักษณะคล้ายหนูเรียกว่า หนูผี (Shrew) ซึ่งเป็นสัตว์เลี้ยงลูกด้วยนมที่กินแมลงและของคาวเป็นอาหาร จากจำนวนสัตว์ที่ดักได้ 1,177 ตัว พบหนู *Rattus norvegicus* หรือหนูท่อมากที่สุดถึงร้อยละ 84.3 สัตว์ที่ดักได้มีจำนวนเพศเมียมากกว่าจำนวนเพศผู้ หมัดที่เก็บได้เกือบทั้งหมดคือ *Xenopsylla cheopis* ซึ่งเป็นพาหะนำโรคกาฬโรค ส่วนน้อยมากเป็น *Ctenocephalides felis–felis* หรือหมัดแมว ค่าดัชนีหมัดหนูจะคำนวณจากจำนวนของ *X. cheopis* เท่านั้น และได้ค่าเฉลี่ย เท่ากับ 0.65 ในจำนวนสัตว์ที่ดักได้ทั้งหมด อย่างไรก็ดีเมื่อพิจารณาแบ่งกรุงเทพ ฯ ออกเป็นเขตพื้นที่ชั้นใน ชั้นกลางและชั้นนอกแล้วพบว่า ชั้นในเป็นพื้นที่ที่มีหนูชุกชุมที่สุด และมีค่าดัชนีหมัดหนูสูงสุดถึง 0.86 ซึ่งแสดงว่าการปรับปรุงสุขาภิบาลของพื้นที่ชั้นในควรได้รับการปรับปรุงก่อนพื้นที่อื่น

คำสำคัญ : หนูบ้านและหนูผี, หมัด, ค่าดัชนีหมัดหนู, กรุงเทพมหานคร

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