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Movements and home range of a common species of tree-shrew, *Tupaia glis*, surrounding houses of otoacariasis cases in Kuantan, Pahang, Malaysia

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ABSTRACT

Objective: To document movement patterns, home range, nesting behaviour and social organization of 5 individuals (3 males and 2 females) of a common species of tree-shrew, *Tupaia glis* (*T. glis*) surrounding houses of otoacariasis cases. **Methods:** Each shrew was fitted with a transmitter chip radio-collar which operates between the frequencies of 154.13 MHz to 154.21 MHz. Each transmitter was then tracked with a Portable Telemetry Receiver (Sirtrack, New Zealand) fitted with a 3-element Yagi antenna. Collared shrews were located using standard methods of ground-based triangulation. Each location was taken from at least 2 directional fixes and a minimum of 3 compass bearings. Fixes were taken hourly for each collared individual from the time of emergence from nest (beginning of activity) till time of entry into the nest (end of activity) every day for 5 to 7 continuous days. Three series of radio telemetry observations were carried out. The bearings, time and positions of an observer were recorded and later plotted on a graph paper in order to derive coordinates of the collared animal. [These coordinates then analyzed using Ecological Software Solutions (Biotas Version 1.03)]. **Results:** Nests were found in a jack fruit tree, long bushes, and 2 houses. Daily telemetry detections demonstrated 2 individuals of different sex having nests (or a nest) in the same house. All shrews emerged from and returned to their nests between 0601 to 0659 hours and 1901 to 1959 hours, respectively. Both the time of exit from and entry into nest were the same between sexes ($P>0.05$). Their average total active period was 4.90 to 7.00 hours with a total daily travel distant of 270 m to 382 m. A male and a female shrew can move as far as 3 285 m and 4 591 m, respectively. Active movements of *T. glis* were during daytime. They regularly entered some houses in the area during day and night except for one individual which visited during daytime only. The sizes of home range and core area for the shrews were 2.00-3.40 ha and 0.05-0.42 ha, respectively. Generally, the mean home range size of females was 20.8% larger than that of males. Females covered a 15.4% slightly higher daily movement range compared to males. **Conclusions:** This is the first radio telemetry study in Malaysia to monitor movements and home range of shrews carrying ticks on their body. It demonstrates that shrews are potential carriers of ticks from wild into the houses and their compounds based on their total active periods spent moving around from fruit orchards, secondary forest, plantations and other vegetations to trees in compound of 4 to 7 houses and vice versa. There are also evidences showing shrews have close contact with humans.

1. Introduction

Cases where ticks have entered the external auditory canal of humans had been reported in Malaysia[1-5]. However, there is an uncertainty on the source of tick infestation because human otoacariasis is not a natural occurrence but rather accidental[6]. Humans may be infested when living, working or conducting activities in close contact with tick-infested animals or close to the environment where ticks naturally occur. There is the possibility that animals may introduce the ticks into houses and compounds. Tree-shrews and rodents were identified as two common small animals caught inside houses and compounds of affected humans[7]. These animals usually have ticks on their body.

There is a need to collect information for spatial

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distribution of shrews with ticks for public health research. It is important to understand spatial distribution and movements within their habitat, so as to interpret ecological processes and to formulate control plans.

There were few radio telemetry studies conducted on shrews, because of high cost[8]. A field study on 6 species of shrews was conducted in Sabah[9]; while the common shrew, *Tupaia glis* (*T. glis*) which is also present in Sabah, was not included. The first radio telemetry study of *T. glis* was conducted in Gunung Jerai, Kedah[8]. Unfortunately, it was not clear whether the shrews were infested with ticks or not. There is no published report of telemetry study on monitoring movements of *T. glis* carrying ticks on their body.

Thus, this study was designed to obtain information on activity and movement patterns, home range, nesting behaviour and social organization of 5 individuals of a common species of tree-shrews, *T. glis* caught surrounding houses of otoacariasis cases in Kuantan, Pahang.

2. Materials and methods

The study was conducted in Lorong Bukit Goh 3/1, Felda Bukit Goh, Kuantan, Pahang (N03°54′ E103°15′) (Figure 1), an area with high number of new and repeat otoacariasis cases (adult & children), and presence of small animal hosts and wild boars with ticks that may be the cause of otoacariasis. Present too are supporting ecology for survival of hosts such as oil-palm plantations, fruit orchard and secondary forest. Moreover, vast sources of food are available, including trees fruiting throughout the year, poultry feed inside their pens that can be easily shared, and discarded food in rubbish bins that were not properly closed and maintained. Majority of people in the area works in oil-palm plantations. They also reared cows, goats, chicken, ducks and goose in the compounds or near their houses.

Figure 1. Location of study site in Felda Bukit Goh, Kuantan, Pahang.

There are altogether 17 houses in the study area, most of which are single units built from wood and bricks. Compounds around the houses were generally not well maintained; small bushes and scrub grow everywhere. Fruit trees such as durian (*Durio zibethinus*), banana (*Musa sapientium*), starfruit (*Averrhoea carambola*), langsat (*Lansium domesticum*), rambutan (*Nephelium lappaceum*), jackfruit (*Artocarpus heterophyllus*), snakefruit (*Salacca zalacca*), water apple (*Syzygium samarangense*), pineapple (*Ananas comosa*) and mangosteen (*Garcinia mangostana*) were grown either in the compound or back yard of most houses. Almost every house has coconut trees (*Cocos nucifera*) in the compound. Bamboo, Bambusa spp. was also abundant in the area.

2.1. Population study

A population sampling of shrews using Mark-Recapture Techniques was carried out 3 times in a period of 3 months from April to June 2008. A total of 130 traps were laid 10 m apart and baited with banana. Trapping period was done for 5 consecutive nights (14-19 April 2008) with an interval of 1 to 3 weeks before the second (27 April-4 May 2008) and third trapping (2-7 June 2008). The second and third trapping lasted for 7 and 5 consecutive nights, respectively. The captured shrews were placed in cloth bags to restrain their mobility. The animals were then anaesthetized intramuscularly with Zoletil (Virbac, Carros, France) at a dosage of 0.02 mL. A toe nail-clipping method[10] was used to mark the animal. Each animal was released at the point of its capture.

2.2. Radio-tracking

Shrews caught in the population study that have ticks on their body were selected to be radio-collared. Only adults and sub-adults were considered to be fitted with radio-collars due to a limitation that each transmitter should not be more than 4% of the weight of the animal so as not to affect or restrict movements of the animal[11]. In this study, 5 shrews (3 males and 2 females) were monitored. In the first trapping, only one male shrew was selected, followed by another 2 pairs in the second trapping. The shrews were placed individually in a cloth bag to restrain their mobility. The animals were then anaesthetized intramuscularly with Zoletil (Virbac, Carros, France) at a dosage of 0.02 mL. The mean induction time with Zoletil was approximately 3 to 4 minutes. The animals were then weighed and their reproductive condition recorded.

Each animal was then fitted with a radio-collar around its neck (Figure 2) and placed in a wire trap for approximately 30 minutes to ensure full recovery of the animal and to confirm that the collar was fitted well before release at its capture point. The transmitter chip radio-collar (Sirtrack, New Zealand) operates between the frequencies of 154.13 MHz to 154.21 MHz. The whole collar weighs about 5.2 g and the life span for each battery in the transmitter was about 3 months. Each transmitter was then tracked with a Portable Telemetry Receiver (Sirtrack, New Zealand) fitted with a 3-element Yagi antenna. Prior to trapping of the animals, range and accuracy tests with the transmitters were

Figure 2. A tree-shrew, *T. glis* fitted with a radio-collar around its neck.

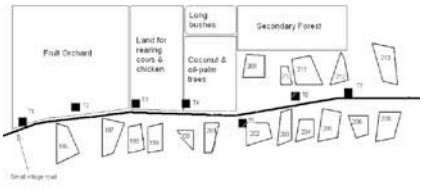

Figure 3. Layout of houses (numbered 196 to 213; house # 207 was no longer exist during study) and designated points (T1 to T7) for taking compass bearing for telemetry.

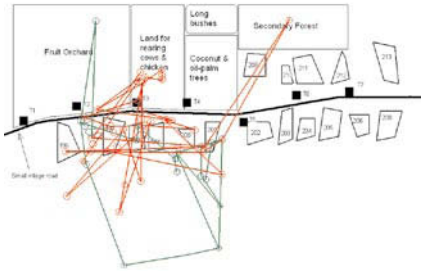

Figure 4. Movements made by a male tree-shrew, *T. glis* (ID#13) in the first period (green line) and second period of observation (red line), respectively.

conducted to improve the overall accuracy of radio tracking. Transmitters were placed at designated points (labeled T1 to T7) within the area so that signals can be heard at varying distances from known locations (Figure 3). Although faint signals were heard as far as 150 m, a signal clear enough for taking a compass bearing was obtained at a maximum distance of approximately 80 m with an average error of ±2°. Since the animals did not wander far off from the study area, a distance of 20 to 30 m between receiver and collared tree-shrews can be maintained without disturbing the animals.

Collared shrews were located using standard methods of ground based triangulation. Each location was taken from at least two directional fixes which were spaced out to be at least 90° between angles. To minimize error, attempts were made to obtain a minimum of three compass bearings. Fixes (the bearings, time and positions of the observer) were taken hourly for each collared individual from the time of emergence from nest (beginning of activity) till each individual retired to the nest (end of activity) every day for 5 to 7 continuous days, 24 hours a day. The 1-hour interval between fixes was set arbitrarily to avoid problems of auto-correlation mainly because the hourly interval time was deemed as sufficient to allow an individual to move across its home range. All fixes were then plotted on graph paper in order to derive location coordinates of the collared animal. These coordinates were analyzed using Ecological Software Solutions (Biotas Version 1.03).

2.3. Analysis of data

2.3.1. Activity and movements

Onset of activities or time of exit from nest was determined as the time of first movement outside the shrew´s nest. End of activity or time of entry into nest was defined as the beginning of the inactive (non-movement) period when the shrew returned to its nest after dusk and at which point, signals were detected from the same compass bearing for several hours until it moves again the next day. Model times (Mode of the time recorded) were used to compare time of emergence and end of activity between sexes[9]. Total active period was crudely derived by calculating the hours between time of emergence from nest and time of entry into nest.

Total daily distances moved on each day were calculated by measuring the linear distances between consecutive 1-hour locations on each day using the Ecological Software Solutions (Biotas Version 1.03). Daily movement rate of a shrew was crudely derived by calculating the total daily distances moved each day divided by the total active period for that individual on that particular day. Differences between sexes and sites for total active period, total daily distance moved, and movement rate were tested using the Mann-Whitney U Test with the number of days being the sample size (n). It is important to note that differences between sexes (3 males and 2 females) were possible because sample size was based on the number of days of each sex monitored and not individuals.

Activity profile was plotted out for each shrew by using average percentage of activity derived from 5 to 7 consecutive days according to each hour. Percentage of activity according to each hour was derived by calculating the distances moved for each hour divided by the total distances moved on each day, and multiplied by 100%. This indirect method of plotting an activity profile was developed by Palomares & Delibes[12,13].

2.3.2. Home range and associate analysis

Cumulative area curves were plotted for each collared shrew to determine the minimum number of radio locations that was needed for home range computations. The cumulative curves were plotted out using the Ecological Solutions Software (Biotas Version 1.03). In this study, 3 types of methods namely the 100% Minimum Convex Polygon (MCP100%), 95% Minimum Convex Polygon (MCP95%) and the 95% Harmonic Mean (HM95%) were used to estimate home range size. Two types of estimators namely the 50% Harmonic Mean (HM50%) and 50% Minimum Convex Polygon (MCP50%) were used to estimate core area. Daily movement range for each shrew was calculated as the percentage of daily movement range over the overall total home range[14]. The percentage of daily movement range is used to assess the amount of area transverse in relation to total home range on a daily basis. Home range estimates and graphical distribution of home ranges derived from radio-tracking and trapping data were done based on the MCP100% in order to standardize and compare results generated from both types of data. All estimates and

graphical distribution were computed using the Ecological Solutions Software (Biotas Version 1.03).

3. Results

A total of 56 *T. glis* were captured in the population study including 49 new captures and 7 (12.5%) recaptures (Table 1). The maximum estimated population size of shrews in this area was 142 individuals per hectare. Detailed description and monitoring periods of 5 collared individuals are shown in Table 2. Throughout the study, all collared shrews (except for individual with ID#17) were recaptured; three of them were recaptured (ID#13, 19, 21), ID#15 was recaptured twice.

The nest of each shrew was located the night prior to each day of tracking in order to precisely record the beginning of activity and also to collect data on nest use. The location of nests was based on physical presence of nests via daily fixes readings. Time of exit from nest and time of entry into nest was able to be precisely noted to the exact hour by observing the shrew directly. Besides a jack fruit tree and long bushes, nests were found in 2 houses, of which nests of 2 individuals of different sex were found in the same house (Table 3); they were suspected to be a mating couple.

Average total active period for all shrews ranged from 4.90 to 7.00 hours and their average total daily distance traveled ranged from 270 to 382 m (Table 4). In general, total lengths of daily active periods for males were 4.90 to 6.30 hours and 5.00 to 7.00 hours for females. A male and female shrew can move as far as 3 285 m and 4 591 m, respectively (Table 5). Based on mean daily rate of movement, females moved at a rate of 12.7% faster than males (Table 6).

3.1. Movement patterns and direct observations

In the study, *T. glis* was observed to spend whole of their total active periods moving around their ranges, i.e., from trees in fruit orchards or a nearby secondary forest to trees in compound of 4 to 7 houses and vice versa (Table 7). The exact manner in which they covered their ranges was peculiar to each individual. Generally, shrews were active during daytime. They were observed to be regular ´visitors´ of the houses day and night except for one individual (ID#15) which visited the houses only during the day time throughout the 2 observation periods. On most days, shrews were found to focus their activity in small areas where they returned repeatedly.

Direct observations on routes and movement patterns of a male shrew, ID#13 showed that it had moved inside compounds of 5 houses in the first and 7 houses in the second observation period (Figure 4). That shrew thus spent most of the day on trees inside compounds and backyard of houses rather than trees in the fruit orchard and made less movement at night (Figure 5). On 19th April 2008, the shrew was seen jumping around a brick drainage system opposite house # 202, then crossed the road to backyard of house # 200. This particular shrew which has nest in house # 197 also seems to be a regular visitor of house # 198 where on 28th April 2008, it entered kitchen of the house and ate a banana placed on a table while the lady owner was

Table 1
Number of captures, number of individuals and percentage of *T. glis* recaptured at Bukit Goh, Kuantan, Pahang in 3 periods of trapping.

Parameters	Trapping period		
	1	2	3
Catch effort*	650.00	910.00	650.00
Captures	17.00	25.00	14.00
Capture rate**	0.03	0.03	0.02
Percentage of captures success	2.62	2.75	2.15
Recaptures	0.00	3.00	4.00
Percentage of recaptures	0.00	12.00	28.57
Radio-collared	1.00	4.00	0.00

*Catch effort = Number of traps × Number of sampling nights, ** Capture rate = Number of individuals caught÷Catch effort.

Table 2
Morphological measurements, duration of monitoring period and number of locations obtained for each radio-collared *T. glis*.

ID#	Sex	Weight (g)	Head-body length (mm)	Tail (mm)	Hand-foot length (mm)	Ear (mm)	Monitoring period (day)	Number of radio locations
13	Male	192	200	160	45	14	8	74
15	Male	165	183	140	42	13	13	116
17	Female	189	183	165	46	15	6	54
19	Female	164	186	152	43	26	12	141
21	Male	180	186	172	45	13	11	93

Table 3
Modal (mode) time of exit and entry into nest for *T. glis* in Bukit Goh.

ID#	Sex	Nest	Modal time of exit from nest (hour system)	Modal time of entry into nest (hour system)
13	Male	House No. 197	601 – 659	1901 – 1959
15	Male	Jack fruit tree with bushes around	601 – 659	1901 – 1959
17	Female	House No. 197	601 – 659	1901 – 1959
19	Female	House No. 211	601 – 659	1901 – 1959
21	Male	Long bushes and scrubs behind house No 211	601 – 659	1901 – 1959

Table 4
Total active period and total distance traveled for all individuals for 2 consecutive days in fieldwork 1 (FW1), 7 consecutive days in fieldwork 2 (FW2) and 5 consecutive days in fieldwork 3 (FW3).

Individual ID#		13		15		17		19		21	
FW	Day	Total active period (h)	Total distance travelled (m)	Total active period (h)	Total distance travelled (m)	Total active period (h)	Total distance travelled (m)	Total active period (hour)	Total distance travelled (m)	Total active period (h)	Total distance travelled (m)
1	1	10	673.05	Not yet started		Not yet started		Not yet started		Not yet started	
	2	1	144.73								
2	1	6	344.94	6	138.20	3	161.97	6	285.45	4	106.36
	2	6	500.82	6	329.35	9	669.54	10	1117.95	3	275.38
	3	6	300.78	3	287.38	6	663.09	4	235.29	5	478.83
	4	7	491.73	8	332.48	8	361.07	9	429.99	6	318.96
	5	6	396.63	5	343.17	5	228.39	7	551.47	7	400.19
	6	4	123.37	5	195.76	3	260.27	4	397.46	6	486.28
	7	Detection failed		1	18.84	1	105.63	1	91.18	1	125.97
3	1	Detection failed		1	247.82	Subject dead		1	72.15	3	167.44
	2	Detection failed		8	314.88	Subject dead		8	246.89	7	199.85
	3	Detection failed		10	493.00	Subject dead		12	732.49	6	146.72
	4	Detection failed		12	365.63	Subject dead		11	248.05	6	265.26
	5	Detection failed		11	218.81	Subject dead		11	182.80	Detection failed	
Average		5.75	372.01	6.30	273.78	5.00	349.99	7.00	382.59	4.90	270.11
SD		5.69	185.72	3.62	102.19	2.89	213.19	3.83	281.68	1.92	137.12

Table 5
Total length of active period, mean and range of total daily distances moved by every individual *T. glis*.

ID#	Sex	Number of days	Mean total active period (h)	Mean total daily distances moved (m)	Range of total daily distance (m)
13	Male	74	5.75	372.01	2976.08
15	Male	116	6.30	273.78	3285.36
17	Female	54	5.00	349.99	2449.93
19	Female	141	7.00	382.59	4591.08
21	Male	93	4.90	270.11	2971.21

Table 6
Mean daily rate of movement and maximum observed rate of movement by each individual *T. glis*.

ID#	Sex	Number of days	Mean daily rate of movements (m/h)	Maximum observed rate of movement (m/h)
13	Male	74	64.69	113.11
15	Male	116	43.46	136.12
17	Female	54	69.99	174.09
19	Female	141	54.66	201.31
21	Male	93	55.12	197.73

preparing food for the family.

Unlike ID#13, male shrew ID#15 exhibited movements only in the fruit orchard during the first observation period of study. Few movements inside compound of 2 houses adjacent to the orchard were only shown during the second observation period (Figure 6). Besides the orchard, it also moved to compound of houses during the day. However at night, movements were only in the fruit orchard, inside chicken coop and land planted with coconut and oil-palm trees (Figure 7). ID#15 was observed to hide in fronds of an oil-palm tree where a lot of coconut fruits dropped from a higher tree stuck in between the fronds. The shrew was seen to eat flesh of the cracked coconut. During the period of study, the coconut tree has been observed to provide shelter and food for this particular shrew.

Movements made by a female shrew, ID#17 were only from 27 April to 4 May 2008 as it died before the next observation period. Its movements were mainly in the compounds of 4 houses with its nest located in house # 197 (Figure 8). More movements were made during the day compared to night time (Figure 9). Both front and back yard of the houses were visited during the day but not at night. Another female shrew, ID#19 made very wide movements from the fruit orchard towards 3 houses (# 209, 210 & 211) and another two houses across the road (# 201 & 202). The same three houses were also visited during the second observation period (Figure 10). These houses were frequently visited during the day. However, movements of the shrew at night were concentrated in the compound of houses on the same side of the fruit orchard, poultries, coconuts and oil-palm trees (Figure 11).

Movements made by a male shrew, ID#21 were different from the others. During first period of study, the movements were only in the orchards and towards the lateral 4 houses. However, the movements changed to mainly inside compounds of houses # 210 and 211; and once into compound of house # 212 (Figure 12). Comparison of movements during day and night have showed that ID#21 started its activity from its nest in long bushes and scrubs behind house # 211 towards trees in the same side of area and never across the road (Figure 13).

3.2. Home ranges and core areas

For all individuals, the HM95% consistently generated much larger home ranges than the MCP100% and the MCP95% (Table 8). The HM95% generated home range size for *T. glis* was from 4.7 to 56.4% higher than the MCP100% estimates. Generally, the mean home range size of females was 20.8% larger than that of males. Although it was apparent that females had larger home ranges and core areas than adult males, sample size was too small to test for any statistically significant differences between sexes. Females covered a 15.4% slightly higher daily movement range compared to male shrews.

3.3. Predation/Natural death

Only one shrew was still observed alive at the end of study. One individual was found dead in a water-pool in bathroom of a house. Status of the other 3 individuals was unknown due to exhaustion of battery energy in the transmitter, thus resulted in failure of detection. These shrews were never recaptured in traps despite numerous efforts to set traps near their nesting sites.

Table 7

Number and the list of houses visited by each individual *T. glis* during 3 field work conducted in Felda Bukit Goh, Kuantan, Pahang.

ID#	Sex	No. houses visited by tree-shrew in period of fieldworks			List of houses visited	Time visited
		1	2	3		
13	Male	5	7	undetected	196, 197, 198, 199, 200, 201, 209	Day & night
15	Male	–	0	4	196, 197, 198, 199	Day only
17	Female	–	4	undetected	196, 197, 198, 199	Day & night
19	Female	–	5	2	201, 202, 209, 210, 211	Day & night
21	Male	–	4	4	209, 210, 211, 212	Day & night

Table 8

Home range, core area estimation and mean percentage of daily movement range for each individual *T. glis*.

ID#	Sex	Home range estimates (m^2)			Core area estimates (m^2)		Mean daily movement range (%)
		MCP100%	MCP95%	HM95%	HM50%	MCP50%	
13	Male	22 133.50	10 729.50	23 182.62	3 410.40	4 380.50	13.45
15	Male	15 788.50	12 553.50	20 314.71	516.00	532.99	20.81
17	Female	15 844.00	10 119.50	22 885.05	4 233.74	3 273.50	15.46
19	Female	22 324.00	15 773.00	34 911.40	1 431.16	2 569.50	20.57
21	Male	23 888.00	16 940.50	28 251.67	2 435.24	2 878.00	12.44

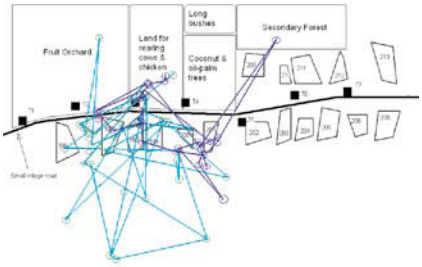

Figure 5. Movements made by a male *T. glis* (ID#13) during day (aqua line) and night (blue line) time within the two periods of observation.

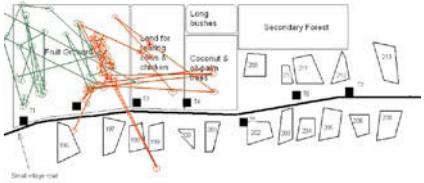

Figure 6. Movements made by a male *T. glis* (ID#15) in the first period (green line) and second period of observation (red line), respectively.

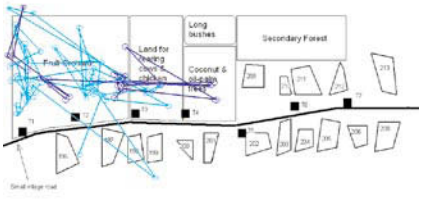

Figure 7. Movements made by a male *T. glis* (ID#15) during day (aqua line) and night (blue line) time within the two periods of observation.

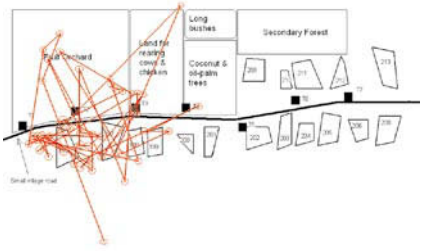

Figure 8. Movements made by a female *T. glis* (ID#17) during period of observation (27 April – 4 May 2008). The tree-shrew was found dead before starting of the next observation.

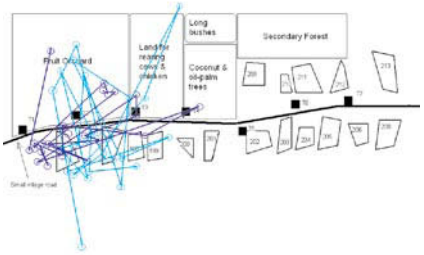

Figure 9. Movements made by a female *T. glis* (ID#17) during day (aqua line) and night (blue line) time within the period of observation.

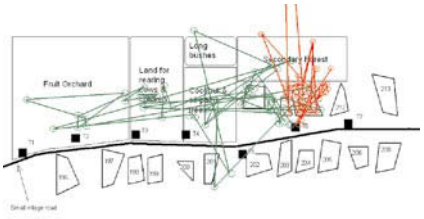

Figure 10. Movements made by a female *T. glis* (ID#19) in the first period in the first period (green line) and second period of observation (red line), respectively.

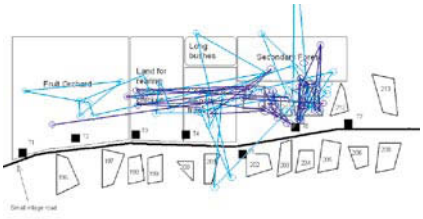

Figure 11. Movements made by a female *T. glis* (ID#19) during day (aqua line) and night (blue line) time within the periods of observation.

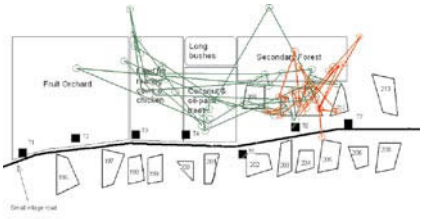

Figure 12. Movements made by a male *T. glis* (ID#21) in the first period (green line) and second period of observation (red line), respectively.

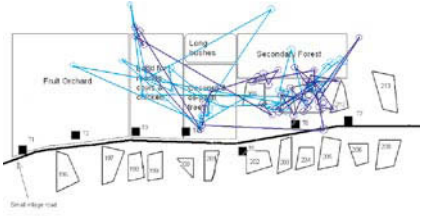

Figure 13. Movements made by a male *T. glis* (ID#21) during day (aqua line) and night (blue line) time within the periods of observation.

4. Discussion

All the 5 shrews emerged from and return to their nests between 601 to 659 hours and 1901 to 1959 hours, respectively. The onset and cessation activity was agreeable with that reported by Darmaraj[8] and Emmons[9], respectively. Both times of exit and entry into nest were the same between sexes (P>0.05). This is in contrast with a telemetry study of *T. glis* in a highland forest where males were reported to enter into their nests later than the females[8].

In this study, female shrews move greater distances compared to males and this contradicts to the findings by Darmaraj[8]. Total length of daily activity periods may have been over-estimated because the calculations do not take into consideration the shrews´ inactive time between recordings. Time needed to rest was undetectable because fixes for the radio-tracking were taken at 1-hour intervals and that more or less affected estimation of their movements. It is emphasized that daily distances moved as stated in this report, refers to the cumulative straight line distances measured between consecutive locations with 1-hour intervals each day.

The front and back yard of most houses in the area provided good shelter and food for the shrews. There were a lot of trees with fruits available in the front yard (such as banana, starfruit, papaya and coconut) and back yard of the houses (such as sapodilla fruits, *Manikara* spp.). Piles of fiber and husk of coconuts; cuttings of tree branches; and unattended dried leaves surrounding the house are some examples for offering shelter. Some of the shrews were observed feeding on the coconuts that were kept in the compound for domestic use.

Consecutive fixes between intervals were not spaced apart, which indicated that shrews focused their activity in small patches although their straight line movements had less obvious beeline patterns. A beeline movement made by an animal is referred as having a focused or revolving movements in a small area to which an individual returned repeatedly[9]. In general, all shrews would visit house and/or orchard on most days. The beeline movements made around the house indicated that they visited these houses at least twice on each particular period of observation.

In this study, females have larger home and daily movement ranges probably because of differences in energetic requirements and different resource limitations[15]. Females moved a farther distance probably to avoid competition in getting food. They might have gone to food sources that were widely dispersed.

The study has proved that shrews are potential carriers of ticks from wild into the houses and their compounds based on their total active periods spent moving around from fruit orchards, secondary forest, plantations and other vegetations to trees in compound of 4 to 7 houses and vice versa. There were also evidences of shrews having close contact with human in this area such as the presence of nest for 3 shrews in houses; detection of a shrew in kitchen of a house and a dead drowned shrew in water pool of a house.

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Conflict of interest statement

We declare that we have no conflict of interest.

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