CHAPTER 5 – Ranging Patterns, Analysis and Modeling

5.1 Ranging Patterns of *Nycticebus c. coucang*

5.1.1 Introduction

Twelve individuals were radio tracked, providing a total of 1748 fixes (ranging from 39 to 316 fixes) for the individuals tracked. Eight adults were captured and radio collared (4 female, 4 male) 2 sub-adults (male and female) and two (2) infant males, and these were monitored for periods lasting from one to eight months (in the period from June 2006 to January 2007). Results of continuous monitoring were obtained for a total of 158 days of 12-hour shifts from dusk to dawn. (Table 5.1) (Figure 5.1).

Interruptions of specific monitoring periods were due to the following circumstances, although the number of locations for these particular individuals was still greater than 70:

(a) Two infant individuals (Adopt and Little) had their collars removed by the mother. This is shown by the fact that the cable-ties were found broken with signs of having been bitten through, this being a behavior that was also observed in captivity. These infants could not be recaptured, although they were visually observed later on within the area;
(b) One adult male (Aggressive, or AG) managed to remove his collar, but he was recaptured just two days later, re-collared to enable successful subsequent tracking; and
(c) One sub-adult male (Gent, or GE) died after approximately two months of tracking (refer below causes of mortality).

At the end of the field study all the individuals tracked were successfully re-trapped to retrieve their collars, and they were then released back into the wild.

5.1.2 Causes of Mortality and Interruption

One radio-collared sub-adult male known Gent (GE) was found dead due to physical attacks perpetrated by other *Nycticebus c. coucang*. The signal from the collar was transmitting from the ground where it was found dead. The radio-collar was recovered from the remains of the carcass which was partially buried under leaf litter.

Table 5.1 Number of GPS Readings (Fixes) recorded and the Monitoring Period for twelve radio-tracked *Nycticebus c. coucang* in Bukit Boloh and Cempaka, Pahang, Malaysia.

	Number of	2006							2007	
	Fixes	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb
Males										
Aggressive (AG) [b]	257									
Cop (CO)	71									
ECA	73									
KRO	39									
Females										
Bonita (BO)	213									
Fala (FA)	40									
Linda (LI)	316									
Timida (TIM)	215									
Subadults										
Hermosa (HE)	250									
(GE) [a]	72									
Infants										
Adopted [c]	126									
Little (LIAG) [c]	76									
Total	1748									

Note: Circumstance/fate of individuals that caused abrupt termination of monitoring: (a) Individual attacked upon (carcass and collar found on the ground); (b) Adult managed to remove the collar but was recaptured (collar found on the ground); (c) Infants collars removed by females.

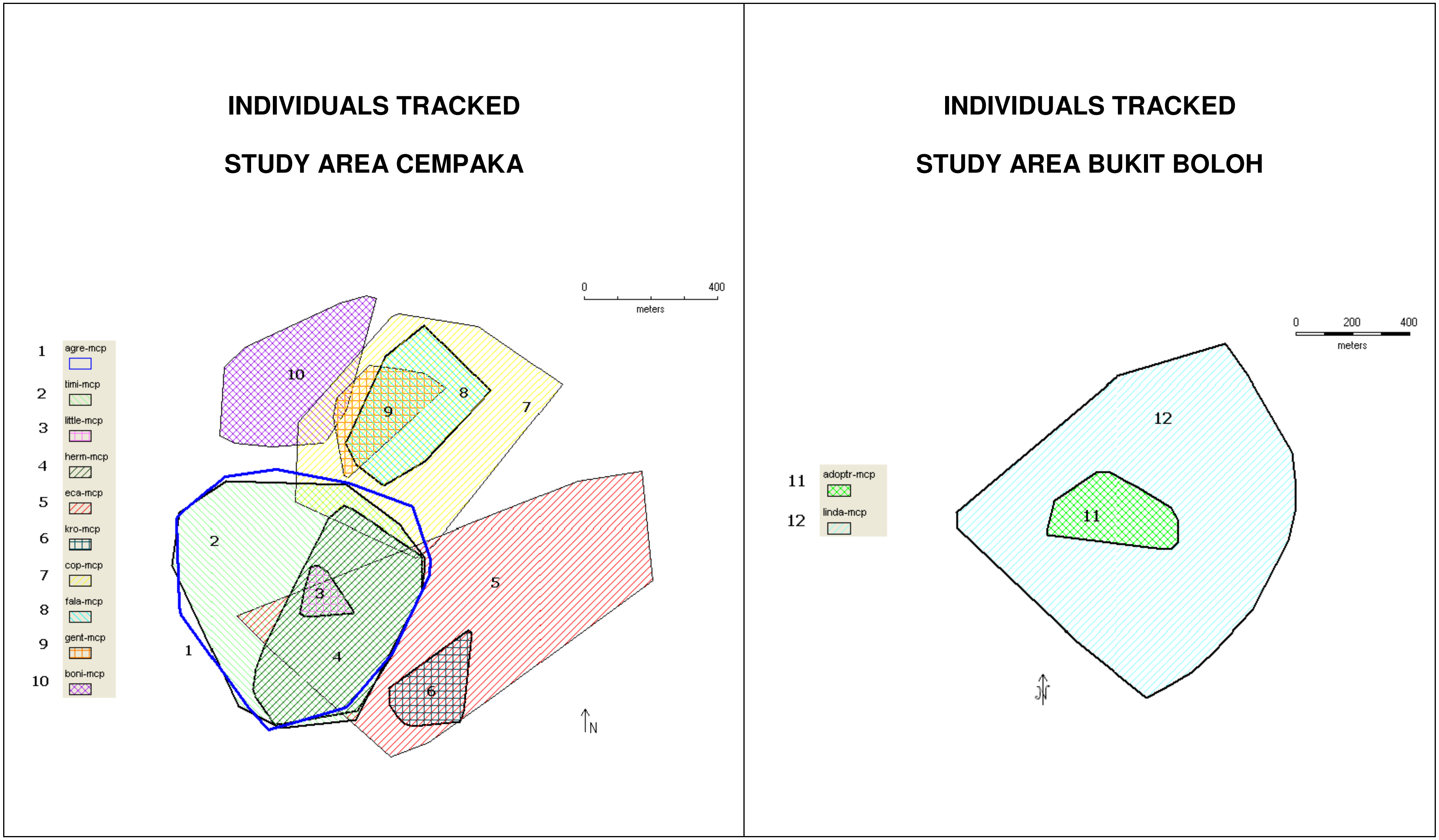


Figure 5.1 Study Areas and MCP % for individual *Nycticebus c. coucang*.

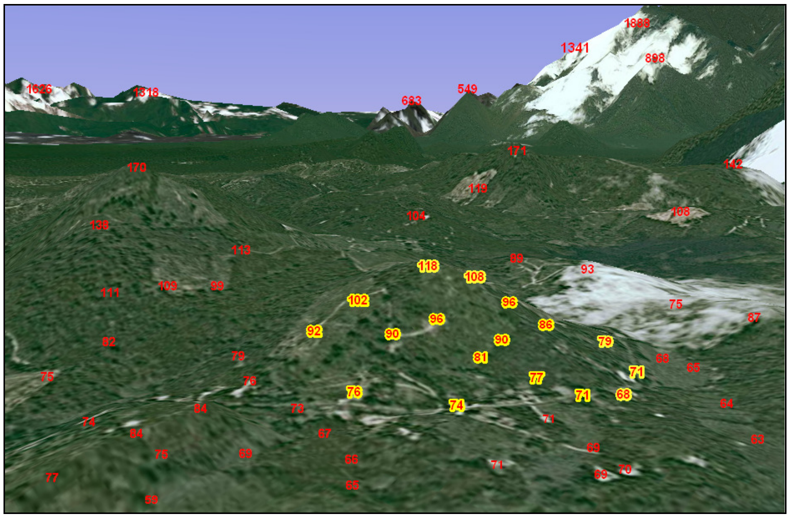
5.1.3 Home Range Elevation Analysis

Elevations detected for those individuals tracked within the two study areas ranged from 68 to 118 meters in altitude in Bukit Boloh, and from 56 to 89 meters in altitude in the Cempaka area. There was no observed discernible difference by gender or age concerning elevation, or among the movement patterns of individuals (Table 5.2 below) (and Figure 5.2).

Table 5.2 Elevations (in meters above mean sea level) detected for those individuals tracked in Chempaka and Bukit Boloh

Bukit Boloh	68	71	74	76	77	79	81	86	90	92	96	102	108	118
Cempaka	56	59	60	61	62	63	64	67	74	76	77	78	79	89

A



B

Figure 5.2 Elevations plotted on Satellite Images of the Study Areas. Yellow color represents elevations where tracked individuals moved. Red color represents land marks around the study areas: (A) Bukit Boloh, and (B) Cempaka.

5.1.4 Summary of Spatial Statistics

Table 5.3 summarizes the spatial statistics of *Nycticebus c. coucang* tracked during the study period in the Cempaka and Bukit Boloh areas.

Table 5.3 Spatial Statistics

A)

Movement Analysis	Linda	Adopt	Aggressive	Little	Timida	Hermosa
Minimum X	102.15689	102.1582	102.16356	102.1669	102.16344	102.16562
Minimum Y	3.546996	3.5491	3.52555	3.5286	3.5256	3.52569
Maximum X	102.1618	102.1612	102.17044	102.1684	102.17031	102.17022
Maximum Y	3.55205	3.5518	3.53258	3.53	3.53227	3.53161
Sample Size	316	126	257	76	215	250
Mean of X	102.15963	102.1592	102.16662	102.1674	102.1668	102.16788
Mean of Y	3.54952	3.54978	3.52952	3.52939	3.52962	3.52869
X Variance	11646.3	3797.25	38150.4	1393.04	36676.4	10061.6
Y Variance	13457.7	717.592	39158.8	1830.52	36637.8	25387.7
XY Variance	12552	2257.42	38654.6	1611.78	36657.1	17724.7
Maximum distance	468.747	189.095	749.819	160.513	766.708	584.32
Total distance	45185.1	5474.2	87531.5	3800.86	63284.6	48213.8
Mean distance	144.361	46.788	344.612	52.0666	298.512	195.197
Number of bearings	305	115	253	73	211	244
Mean bearing	192.05	333.609	168.238	105.374	265.793	47.6367
R Concentration of angles	0.04477264	0.026847	0.0326121	0.07652	0.0499671	0.0306004
Angular deviation	142.807	154.116	149.915	129.904	140.261	151.303
Rayleigh's z for angles	0.6114	0.082889	0.269078	0.427433	0.526806	0.228478
Linearity	0.00125233	0.054149	0.00437066	0.019223	0.0006138	0.0006227
r2	25104	4514.84	77309.2	3223.55	73314.2	35449.3
T2/R2 ratio	1.27856	0.825965	1.89342	1.4942	1.69049	1.60088
Primary axis length	605.847	302.506	1043.87	224.431	1014.36	809.402
Secondary axis length	484.345	129.198	873.563	163.969	853.3	440.958
Primary axis angle	54.9539	21.8769	-48.0917	-58.8538	45.9088	71.3943
Eccentricity	1.1193	1.36864	1.09339	1.17122	1.09034	1.35741
MCP area	187638.636	17978.1	435874.482	15679.71	417172.9	207787.59
95% Ellipse Area	230466.258	30695.86	716196.468	28902.54	679802.43	280318.06

B)

Movement Analysis	Bonita	Cop	Gent	Fala	Eca	Kro
Minimum X	102.1647	102.1668	102.16779	102.1682	102.16517	102.16931
Minimum Y	3.5332	3.53021	3.53236	3.53215	3.5248	3.52565
Maximum X	102.16897	102.174	102.17088	102.1721	102.1765	102.17157
Maximum Y	3.53731	3.53682	3.5354	3.53648	3.53253	3.52824
Sample Size	213	71	72	40	75	39
Mean of X	102.16716	102.1696	102.16869	102.17	102.17077	102.17014
Mean of Y	3.53521	3.53283	3.53429	3.53445	3.52753	3.52627
X Variance	12639.5	23757.4	7874.56	9324.68	51587.3	4859.48
Y Variance	9179.06	42053.9	5187.82	11875.6	41319.8	4382.76
XY Variance	10909.3	32905.6	6531.19	10600.1	46453.6	4621.12
Maximum distance	465.122	736.529	356.344	345.418	878.162	292.116
Total distance	23140.5	17594.1	7596.49	5618.65	21612.2	3769.06
Mean distance	110.193	258.736	110.094	151.855	300.17	104.696
Number of bearings	194	68	68	37	70	36
Mean bearing	207.187	80.5163	5.16307	311.304	296.905	349.052
R Concentration of angles	0.04675888	0.027896	0.10296418	0.039634	0.1456877	0.0796523
Angular deviation	141.806	153.297	122.172	145.582	112.46	128.886
Rayleigh's z for angles	0.42416	0.052919	0.72091	0.058123	1.48574	0.228401
Linearity	0.00356533	0.027382	0.00746034	0.051117	0.0051399	0.0140902
r2	21818.6	65811.3	13062.4	21200.3	92907.1	9242.23
T2/R2 ratio	1.01364	1.56917	1.66583	1.38644	1.48225	1.75784
Primary axis length	650.042	1110.84	502.639	582.252	1288.76	390.744
Secondary axis length	316.777	585.88	245.775	411.177	752.137	262.331
Primary axis angle	37.5618	59.7616	35.2302	55.7278	38.5846	41.2495
Eccentricity	1.43161	1.37858	1.42892	1.19101	1.30828	1.22006
MCP area	141162.499	364615	61536.824	113398	539662.02	44416.599
95% Ellipse Area	161727.922	511153.3	97025.2584	188031	761303.29	80506.623

Note: Refer to Appendix 2a for the definitions of Movement Analysis

5.1.5 Analysis of Activity Patterns

Nycticebus c. coucang showed greater preference for tree heights less than 15 m (56.7 %), and the least preference for tree heights over 20 m (8.4 %) (Figure 5.3). Insect foraging was carried out mainly at 0-10 m (48.6 %) and they rarely foraged for insects above 20 m (4.5 %). Fruit feeding occurred in all the height ranges, but mainly at 0-10 m (49.1 %). Travel was mostly at the 10-15 m (43.2 %) height range, resting at 15-20 m (43 %) and sleeping at 5-10 m (49 %) characterized by thick and thin branches covered with leaves. Twenty eight species of fruits were identified in the tracking areas (Table 5.4).

The *Nycticebus c. coucang* were most active at dusk, leaving their sleeping sites at 18:55-19:25 hours (pm) and reentering at 6:57-7:27 hours (am). The average time when they were away from their sleeping site was 12.2 hours. The main activities observed during that period were insect foraging, flower and fruit feeding, travel and resting. Reproductive behaviors were only seen during the dry season from the months of August to October.

The first feeding activity was dependent on which biotope in which they had slept in, for instance, fruit feeding if they slept in the orchards. Fruit feeding usually had three periods of intensity; between 18:55-21:00 hours (pm), 23:00 -01:00 hours (pm-am) and most intensively, between 3:00-6:00 hours (am). Insect foraging was most frequently seen during the same periods, and, therefore, fruit and insect foraging often occurred simultaneously.

Fruit and insect feeding lasted longer in the dry season than in the wet seasons due to scarcity of fruit within the orchards during the rainy season. There were two distinct peaks during the observed travelling time.

It was more intensive in the night (22:00- 24:00 hours) and in the early morning (3:00-5:00 hours), when the *Nycticebus c. coucang* showed greater displacement to feeding areas than in the morning. Resting was observed to be most intense between 1:00 and 3:00 hours (am).

Table 5.4 Feeding Trees from where *Nycticebus c. coucang* consumed Fruits, Flowers or Young Tree Leaves.

Feeding Trees	**Malay Name**
Barringtonia racemosa	Putat
Durio Zibethinus Murray	Durian Paya
Mallotus macrostachyus	Balik angina
Parkia speciosa	Petai
Dialum indum	Keranji paya
Nephelium maingayi	Redan
Pimelo dendron griffithianum	Perah Ikan
Vitex Pinnata	Leban
Pithecellobium clyperia	Petai belolang
Baccaurea Lour	Rambai
Calophyllum molle King	Bintangor
Fagraea racemosa	Mepulih
Willughbeia	Joloh hantu
Psidium guajava	Jambu biji
Anthocephulus indicus	Pulasan hutan
Magnifera odorata	Kuini
Zalacca edulis	Salak
Mangifera foetida	Bachang
Bridelia stipularis	Kenidai
Cinnamomum iners	Medan teja
Mangifera caesia	Binjai
Musa paradisiaca	Pisang
Garcinia mangostana	Mangis
Nephelium lappaceum	Rambutan
Averhoa bilimbi	Blimbing asam
Artocarpus champeden	Cempedak
Carica papaya	Betek
Eucalyptus cornuta	Yate

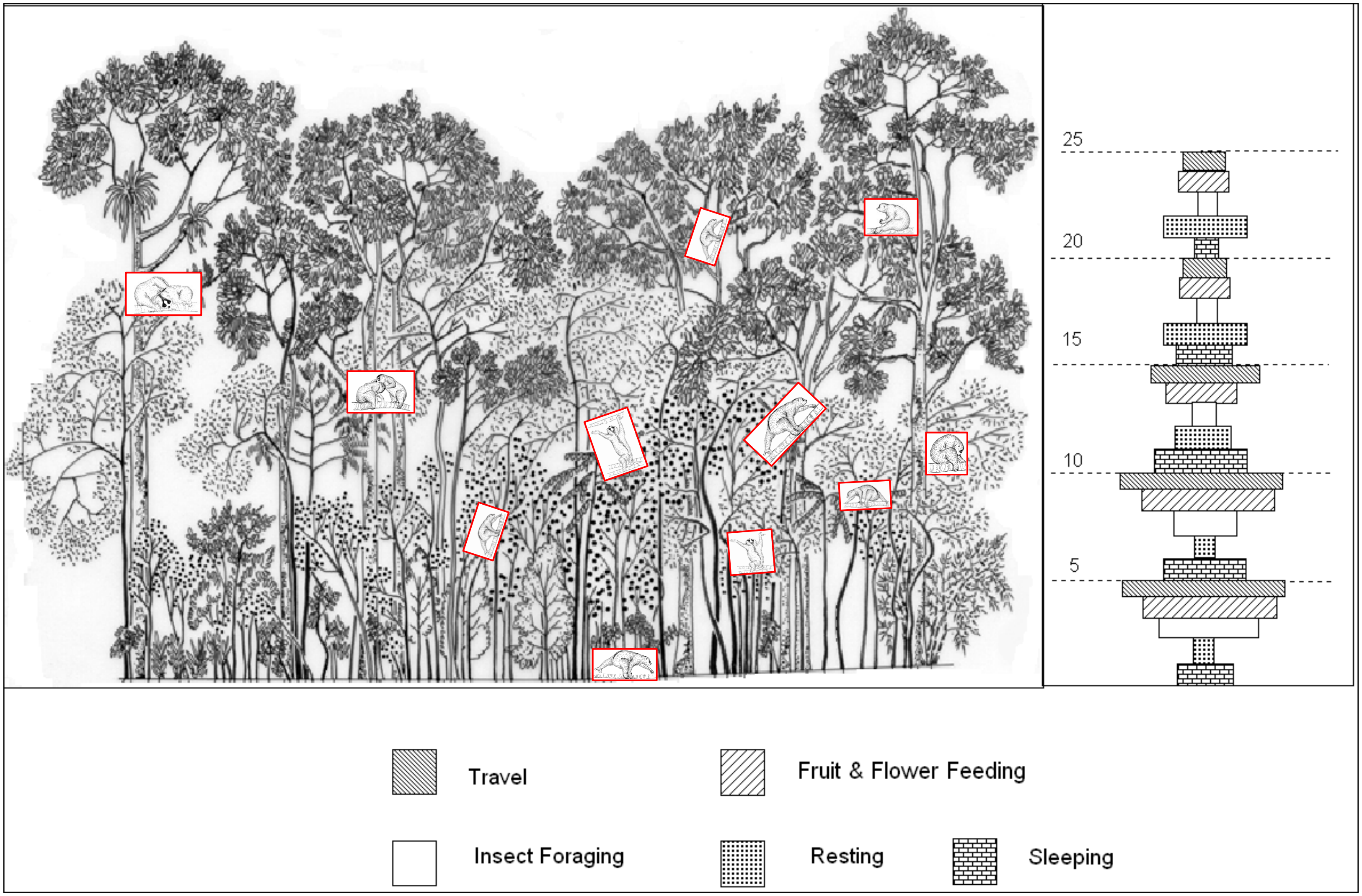


Figure 5.3 Vertical use of the Forest shown by the Distribution of Main Activities (%) across Height Ranges

5.1.6 Analysis of Daily Movement

By tracking individuals for a total of eight (8) nights consecutively, it was found that the mean daily distance traveled by adult males during single a night ranged from 280.05 -1077.06 m, for adult females from 311.15-978.63 m, for sub-adults, from 76.17-568.11 m, and for the two infants from 50.5-158 m (Table 5.5 and Figure 5.4). The maximum distance traveled in a straight line within a single night (between dusk and dawn) was 1562.48 meters by the adult male “Aggressive” moving between the biotope IMA/Orchard and the Belukar forest (Figure 5.5). The shortest recorded distance traveled in a 12-hour shift was 100m by an adult male. It was recorded on several occasions that adult females in their daily movement followed adult males from their group. In other cases, one sub-adult female followed an adult female in her daily movement. These daily follows were recorded in Group B and C.

Table 5.5 Summary and Average Daily Distances Traveled/Night of 12 radio tracked *Nycticebus c. coucang* in Bukit Boloh and Cempaka,

Daily Distance Traveled / night (m)

Individual	Sex	Mean	Range
Aggressive	male	977.64	392.81-1562.48
Cop	male	593.67	248.46-1001.29
Eca	male	856.67	378.17-1464.89
Kro	male	233.51	100.79-379.6
Timida	female	536.2	218.09-1377.14
Linda	female	414.05	183.99-840.09
Bonita	female	813.02	680.23-1024.05
Fala	female	684.62	162.3-673.24
Hermosa	sub-adult	369.71	91.38-897.29
Gent	sub-adult	167.84	60.96-238.94
Adopt	Infant	100.13	55-180
Little	Infant	85.25	46-136
Total		486.02	218.93-806.25

The female “Timida” followed within a distance of approximately 40 to 130 meters to the same locations where an adult male had moved minutes or hours earlier. Exactly the same behavior was observed in the Group C between adult female “Fala” and adult male “Cop”, but with longer distances these being approximately 100 to 200 m. In the case of the daily following movements of the sub-adult female Hermosa, she followed closely the adult female Timida crossing Biotopes Orchards towards Belukar forest using electrical wire connections along the Main Road, following at a distance of approximately 1 to 2 meters for a period of approximately 3 hours.

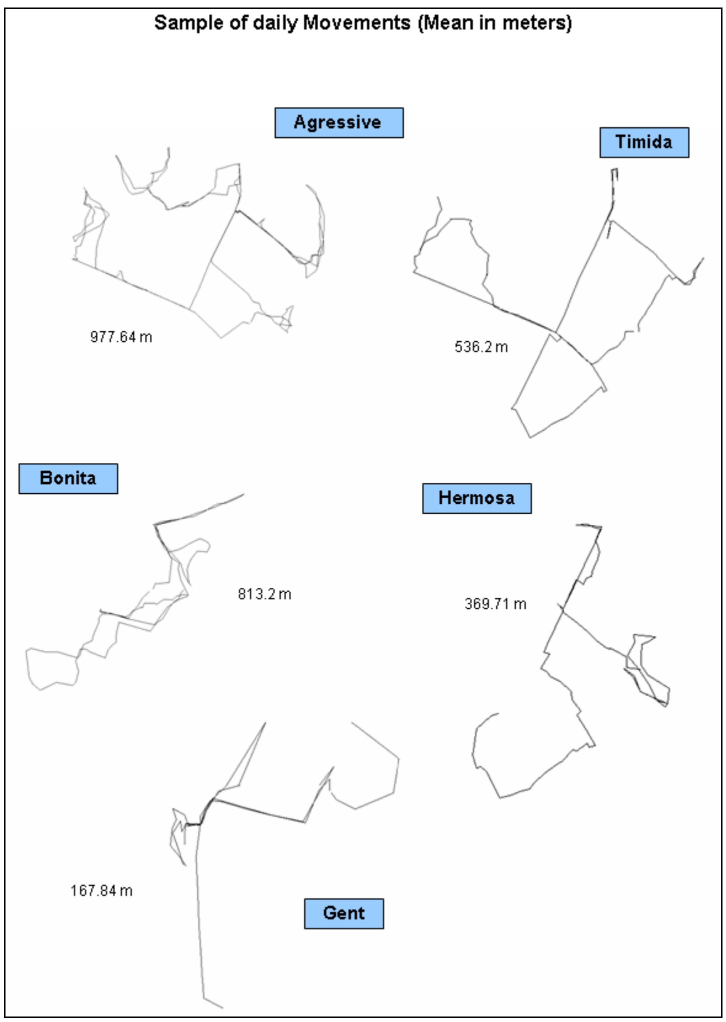


Figure 5.4 Shown here are examples of Individual Nightly Movements of (A) One adult male “Aggressive”, (B) Adult female “Timida”, (C) Adult female “Bonita”, (D) Sub-adult female “Hermosa,” and (E) the Sub-adult male “Gent”.

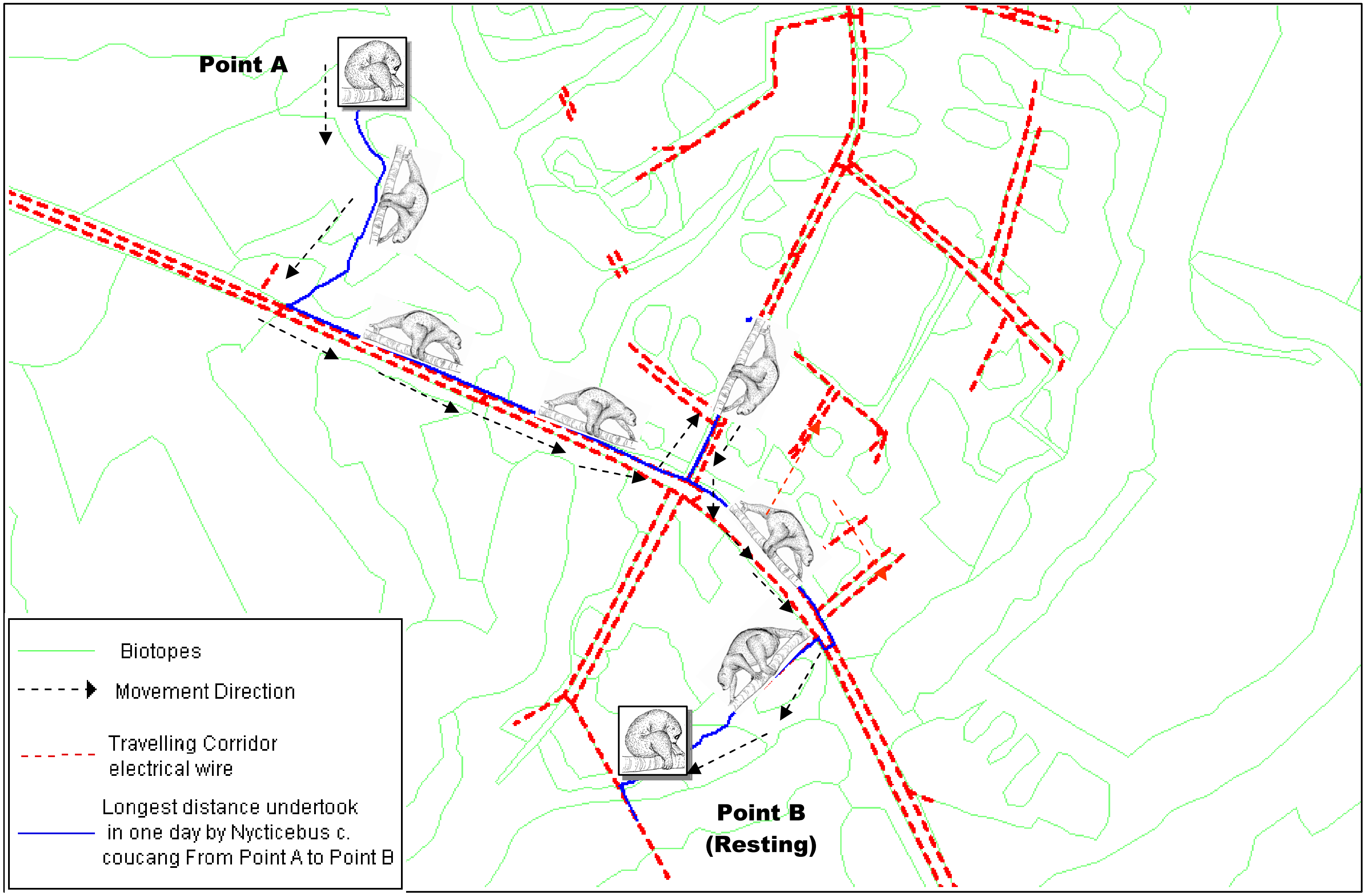


Figure 5.5 Longest Horizontal Movement in One Day recorded by the Adult Male “Aggressive,” from Point A to Point B.

5.1.7 Sleeping Associations

During the dry season (approximately the months of June to October) *Nycticebus c. coucang* typically left their sleeping site at 18:55-19:25 hours (pm) and entered these again at 6:57-7:27 hours (am). During the wet season (approximately November to January), individuals abandoned their sleeping site at around 19:20-19:30 hours (pm) and reentered them at 6:40-6:50 hours (am). Rainfall also caused them to leave their sleeping site later than usual (observed times, 19:25-19:50 hours (pm)), and caused them to arrive at their sleeping site earlier than usual (6:30-6:45 hours (am)). Heavy winds also caused them to travel less (Table 5.6 Photo 5.1).

Photo 5.1 Minutes after a Rain Event "Hermosa" is getting Warmth and Drying out while sleeping underneath a Street Light. This shows adaptation to the physical surroundings (Picture taken by Jaime Castillo G).

Table 5.6 Averaged Leaving and Entering Nest Times during the Study Period

PERIOD	**LEAVING (SUNSET)**	**ENTERING (SUNRISE)**
Dry season	18:55-19:25 hours (pm)	6:57-7:27 hours (am)
Wet season	19:20-19:40 hours (pm)	6:40-6:50 hours (am)
Rainfall	19:25-19:50 hours (pm)	6:30-6:45 hours (am)

Observations were made mainly on the night behavior of the Slow Loris but some data were collected on other aspects of their sleeping behavior, such as the species of trees that the group slept in (Table 5.7). One individual could usually be sleeping among medium or large bushy trees/palms and shrubs around 5 m to 30 height when one, or more, *Nycticebus c.coucang* were in an adjacent tree. However, on a few occasions they were observed sleeping at 3 m heights in small shrubs near the orchards cover by foliage shrubs (see picture 5.2). Within some Belukar biotopes individuals slept on 3 to 4 m high trees surrounded by Rattan Palm. In Cempaka daily sleeping trees were evenly dispersed throughout biotopes, however those individuals in Bukit Boloh primarily used sleeping trees within Belukar biotopes (see Figure 5.6 A, B).

Photo 5.2 Showing adult "Timida" sleeping near the orchards covered by foliage shrubs

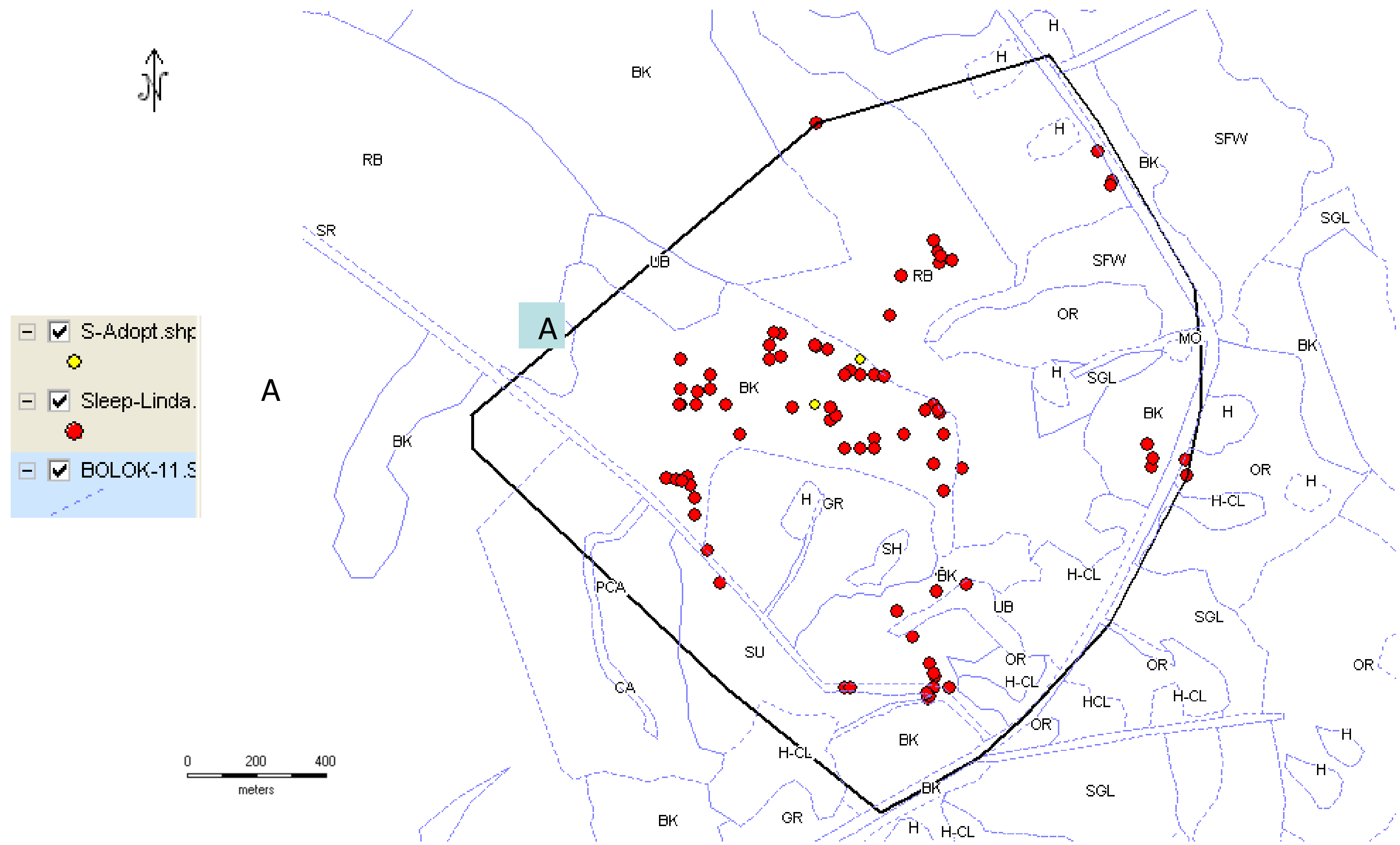


Figure. 5.6 A Individual Sleeping Sites within the Bukit Boloh Area superimposed onto the Biotope-Map of the Area (Right Brace represents defined group). Area enclosed by black line legend in a form of a geometric shape represents a group.

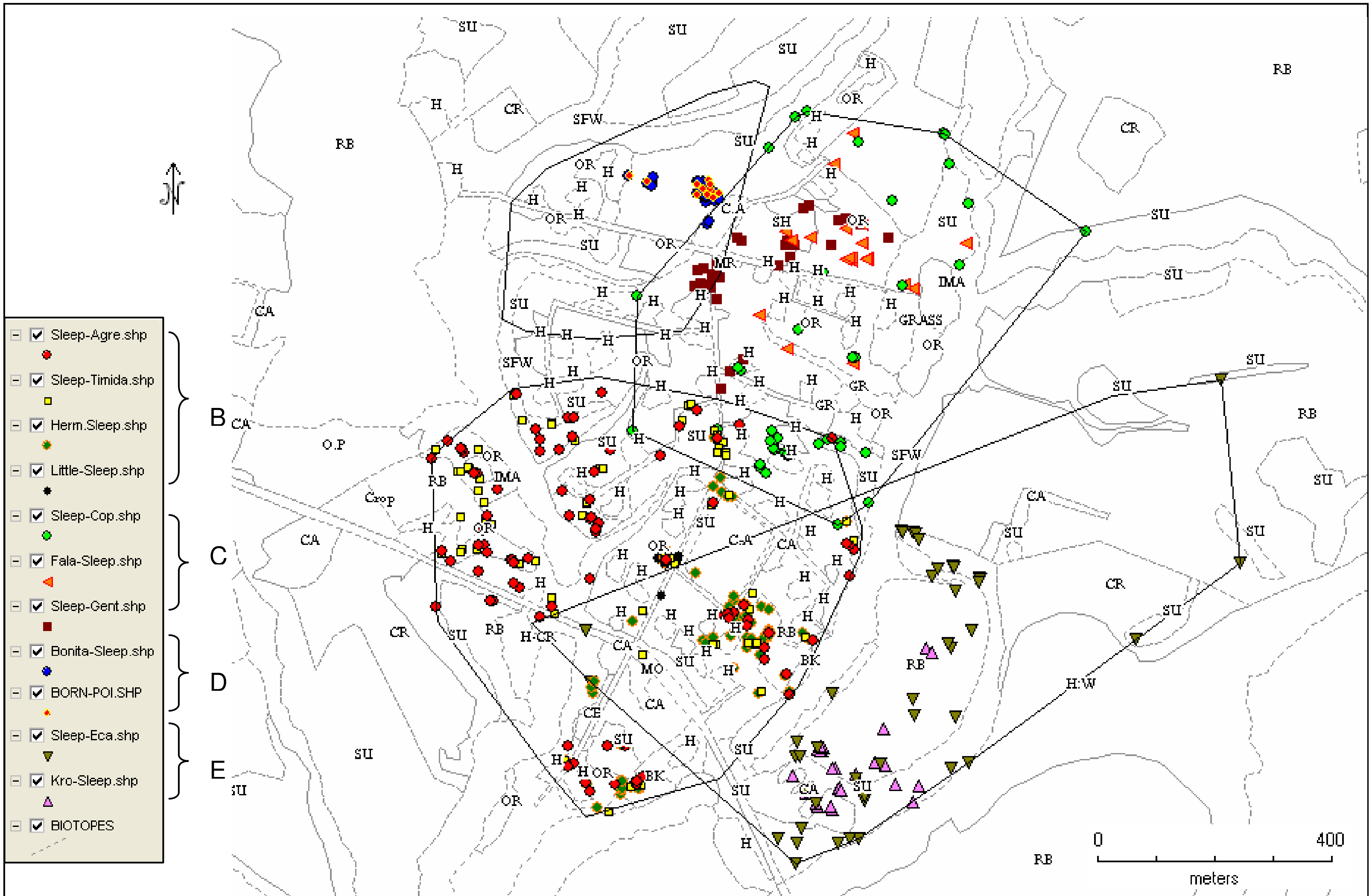


Figure 5.6 B Groups Individual Sleeping Sites within the Cempaka Area superimposed onto the Biotope-Map of the area (Right Brace shows defined groups). Areas enclosed by black line legend in a form of a geometric shape represent a group.

Table 5.7 Sleeping Trees and their Malay Names for the Focal Groups in the Cempaka and Bukit Boloh Study Areas.

Plant Species serving as Sleeping Trees	**Malay Name**
Alstonia angustilaba	Pulai
Bouea oppositifolia	Kundang
Elaterios permum tapos	Perah
Archidendrun Clypearia	Jering monyet
Archidendrun ellipitikum	Jering hutan
Microcos tormentosa	cenderai
Rhodamnia cinerea jack	Mempoyan
Vitex Pinnata	Leban
Shorea acuminate dyer	Meranit rambai daun
Scaphium Macropodum	Kembang semangkok Jantung
Cocos nucifera	Kelapa
Citrifolia marinda	Mengkudu
Hevea brasiliensis	Pokok Getah
Artocarpus heterophyllus	Nangka
Gironniera nervosa	Hampas tebu
Koompassia malaccensis Maingay	kempas
Abrus Precatorious	Saga
Arthrophyllum diversifolium	Susun dahan
Garcinia mangostana	Manggis
Artocarpus champeden	Cempedak
Arenga pinnata	Kabung

The number of sleeping sites used by each tracked individual, varied; "Adopt" recorded 12 sleeping sites; "Aggressive" 52 sites; "Timida" 46 sites; "Hermosa" 25 sites; "Bonita" 10 sites; "Cop" 44 sites; "Eca" 42 sites; "Fala" 21 sites; "Gent" 19 sites; "Kro" 29 sites; "Linda" 39 sites; and "Little" 11 sites, with a total of 339 individual sleeping identified for all individuals tracked. These comprised: Trees 52.6 %; Shrubs 31.1 %; and Palms 16.3 %. A total of 676 sleeping sites were recorded as visited during the study period.

Occasionally, observations during the day showed individuals were almost totally inactive while sleeping, aside from sleeping and resting; the latter was characterized by the animal scanning its surroundings without moving away from its sleeping site. Nevertheless several observations recorded of the infant “Baby-Born” (“Bonita’s” offspring born in captivity) revealed exploration behavior by the little one on its own while it was located on a branch. This infant did not, however, move farther away than 2 meters from where its mother “Bonita” was sleeping. This behavior was observed in the afternoon day time and when the day was clear and sunny.

In general, individuals within the same group used the same sleeping site. Nonetheless, only one adult female “Bonita” with a newborn Infant was consistently observed sleeping close together in the same tree on the same day and throughout the tracking period. Other females such “Timida” and “Linda” (with an adopted infant) did not consistently sleep with their infants (non-newborn).

Conversely, the other individuals (Aggressive and Timida), (Aggressive and Hermosa), (Hermosa and Timida), (Gent and Fala) and (Cop and Fala) were seen sleeping together, or in proximity, at least 3 times a week; this behavior was part of the consistent results obtained during the study period, providing empirical evidence that the *Nycticebus c. coucang* does not live completely in solitude. Individuals looked for known sleeping trees in order to look for the member of the group. This pattern of behaviour was observed in all most 75 % to 80 % of the events recorded.

Individuals were observed sleeping in twos (duo), but three animals (trio) or more were not recorded sleeping on the same tree. One remarkable case was observed which is important to mention it being a rare case of two adult males sleeping on the same tree (ECA and KRO). The distance estimated between the nearest individuals within the same group some occasion at the time of sleeping in proximity was between 0 to 25 m (Figure 5.7). For further analyses of each individual sleeping site refer to Appendix 2B and 2C.

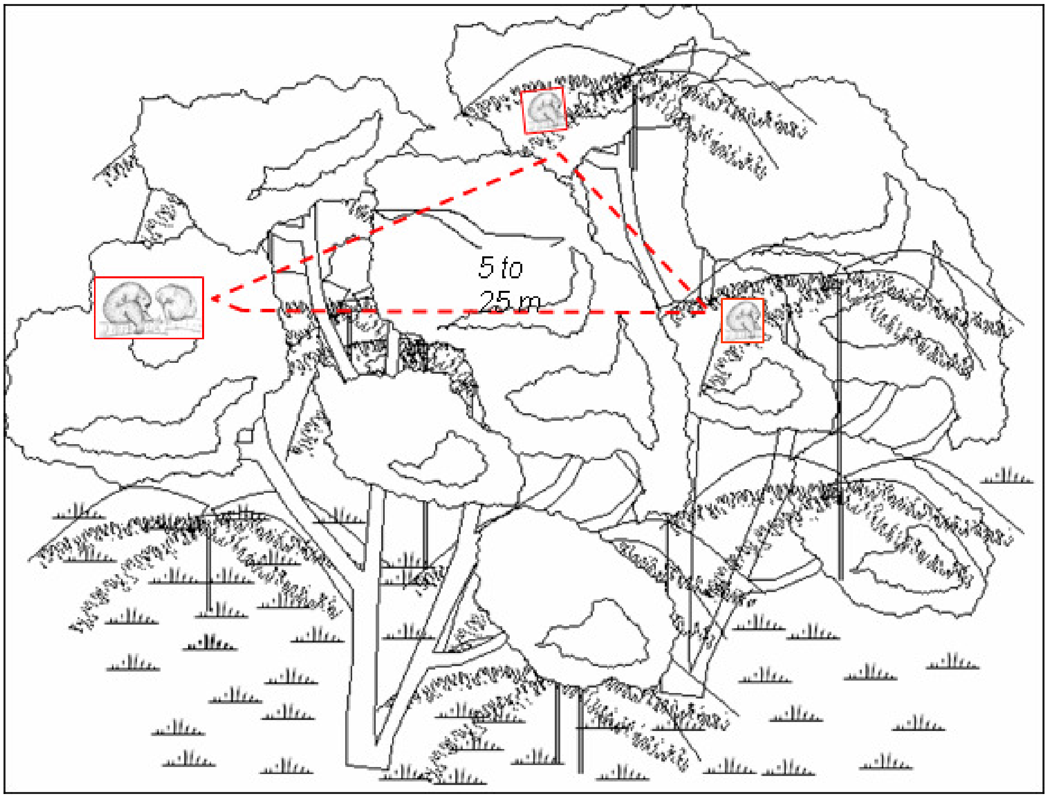


Figure 5.7 Schematic representation of Sleeping Proximity between Individuals from the Same Group

Nycticebus c. coucang tended to sleep a few meters away from the immediate vicinity of night activity. The distance between sleeping trees for consecutive nights depended on two factors, (A) whether the individual was infant, sub-adult or adult, and (B) or whether there was a female adult with a neonatal recently delivered or young infant.

Table 5.8 Distances between Sleeping Trees on Consecutive Nights

Individual	**Distance Ranges between Sleeping Trees on Consecutive Nights (m)**
Infant (F/M)	0 (Sleeping on the same tree the consecutive night) to 92 m
Sub-adult (F/M)	0 – 367m
Adult (F/M)	50m to 1562 m
Female with Neonatal delivered	0 to 20 m (using the same sleeping trees)

The adult female Bonita with an infant always returned to the same sleeping tree where the baby was left by her after sunset (Table 5.8).

Temporary shifts in sleeping sites were observed on some occasions, to be more specific in the area of Group A and B, responding to actual or potential disturbance within their home range such, the cutting of trees for agriculture or clearing land for other purpose.

A particular case of sympatry was observed within the sleeping sites used by *Nycticebus c. coucang*. Other primates species, specifically *Macaca fascicularis* and *Presbytis femolaris,* also shared sleeping sites or slept near to palms and trees used by the *Nycticebus c. coucang* which were being tracked. There was no observed aggression by those diurnal species towards the nocturnal *Nycticebus c. coucang* individuals at the time of sun rising when the former started their daily activities.

It is noteworthy to mention the special behavior of sleeping site recognition by the adult male ECA after his collar was removed and he was released into the wild. Regardless of the place he was captured and released, ECA was seen to move back exactly backto the same tree he was observed sleeping several times before. This shows that ECA clearly remembered the route to reach this tree and the distance for him to reach these were as far as 100 meters away from the point where he was released. A video of his movement was recorded and pictures were also taken as evidence of this spatial remembering ability.

5.1.8 Traveling Corridors Analysis

Twelve (12) Slow Loris, comprising 4 females, 4 males, 2 sub-adults (one male and one female) and 2 infants male, had their movement paths mapped in the study area, and they were each monitored for at least 10 consecutive days. Inter-biotope movement detected by radio tagging was very high. 11 of 12 individuals moved between biotopes. 10 individuals made inter-biotope moves originating in a central biotope, and thus this researcher was able to access whether corridors influence movements of the individuals (Figure 5.8).

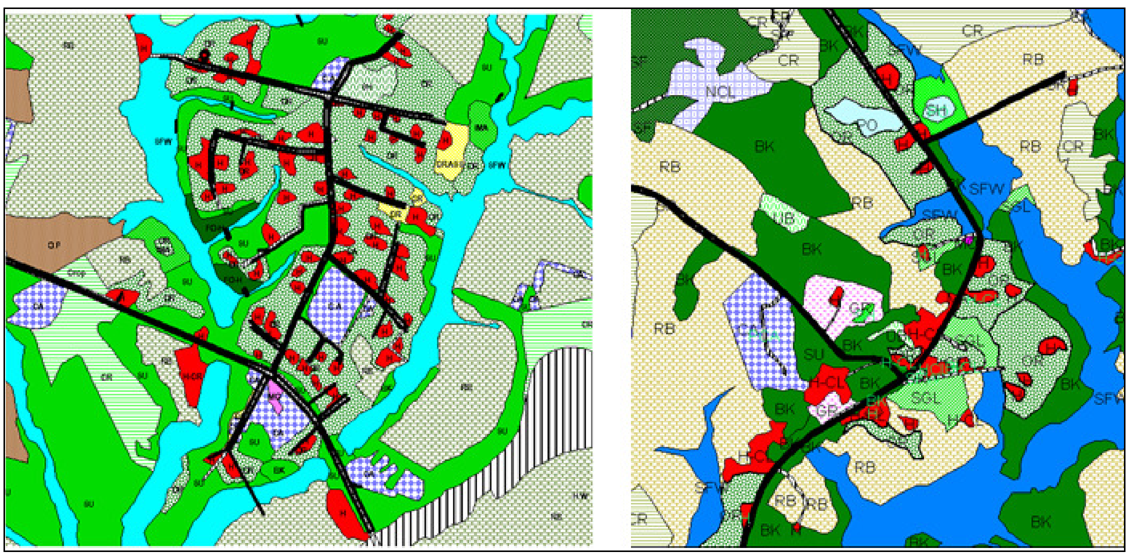


Figure 5.8 Superimposed Corridors Structures (black color) and Biotopes in the Cempaka Area (left) and the Bukit Boloh Area (right)

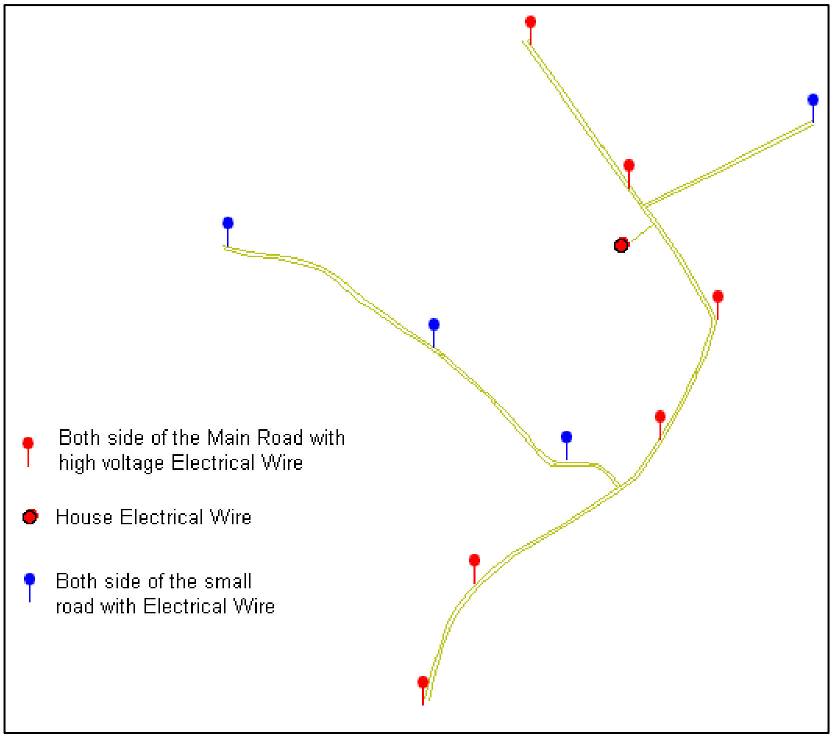
Records of animals when moving on both sides of roads within the biotopes indicated that crossing occurred, making possible to know for certain that the Slow Loris utilized a particular crossing structure. The Slow Loris studied used structural types such as electrical wires, house electrical wire, trees along ponds and bamboos as movement corridors (see Figure 5.9A and B). 10 individuals clearly utilized more electrical wire corridors when making inter-biotope moves.

Movement around corridors structures were found primarily along the electrical wires, although some extended across swamp fresh water such as bamboos used as bridge. The most prominent structural corridor was electrical wires that run around both sides of the main road and the small road within Cempaka Village (Photo 5.3).

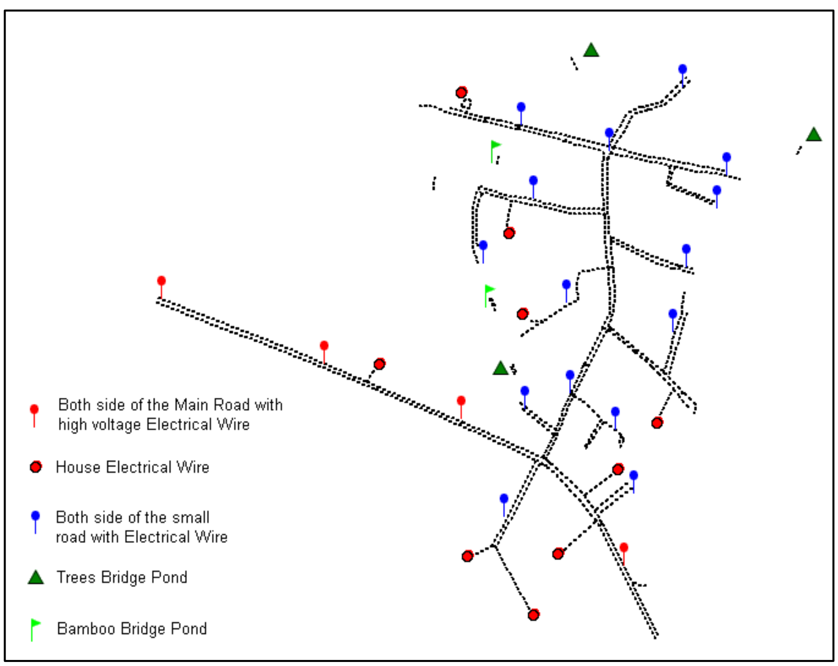
Photo 5.3 Use of the Electrical Wires as Traveling Corridors. A. Individual about to reach the electrical wire while still on the tree. B, C, E Individual Aggressive, moving

along the electrical wire; sometimes this was done at low speed but sometimes at high speed. D. "Hermosa" and "Timida" walking alone the electrical wire (Pictures taken by Jaime Castillo G.)

5.9 A. Corridors in the Bukit Boloh Study Area



5.9 B. Corridor in the Cempaka Study Area



Figures 5.9 A and B. Showing the Structure of Traveling Corridors used in both Study Areas

For the complete illustration of all 12 individuals movement paths refer to Appendix 2B and 2C. Traveling corridor characteristics were similar among sex classes. The primary difference was that adult females without young born had more corridor biotopes and total corridor patch area (see habitat analysis). Only one female had a baby born during the monitoring period. This adult female (Bonita) did not move with its young for the entire time that she was tagged, this being due to the fact that this female parked her baby in a single biotope while foraging at night during the entire tracking period (Figure 5.10).

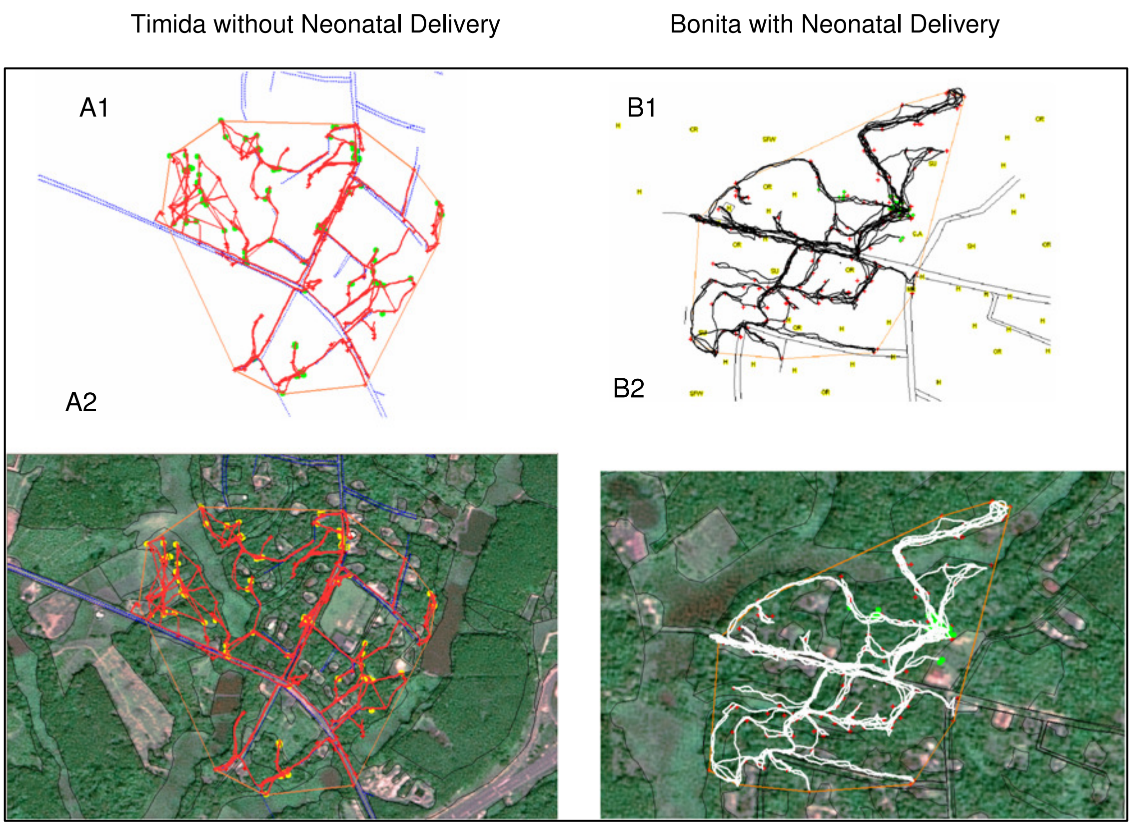


Figure 5.10 Comparison of Traveling Corridors of two females with, and without, neonatal born in the Cempaka study area. A1: Red color represents traveling corridor of the adult female Timida and its actual movement within its home range. A2: Shows superimposed tracking corridor (red) with satellite image of the study area. B1: Black color represents traveling corridors of the adult female Bonita within its home range. B2: Showing superimposed traveling corridor (white) and satellite image.

The figure below illustrates examples of the movement paths for a single animal (adult male Aggressive); one that ranged over Cempaka, showing as well biotopes and movement corridors of tagged Aggressive combined (Figure 5.11).

Figure A.

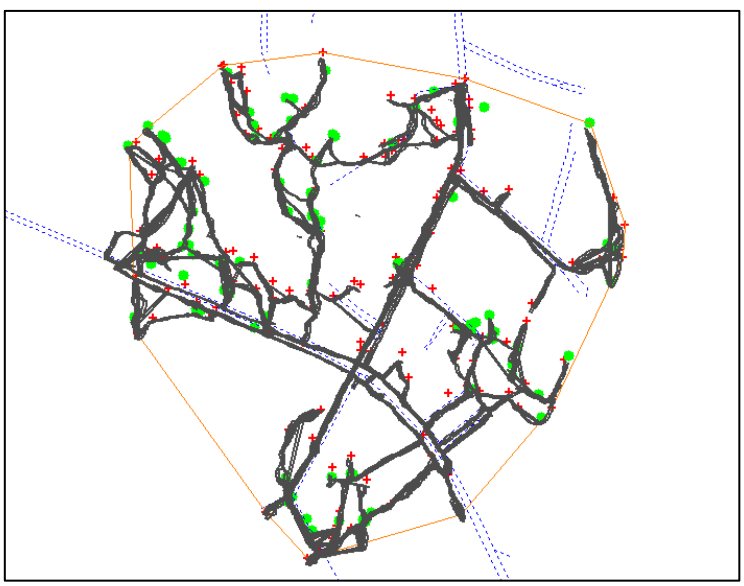


Figure B.

Figure 5.11 (A) Superimposed biotopes and Traveling Corridors (light grey) of an individual adult male "Aggressive" and satellite image. (B) Showing Traveling Corridors (dark grey) and Corridors Structures of adult male "Aggressive", light green color represents sleeping sites.

For further analysis of all the tracked animal corridors refer to Appendix 2B and 2C.

5.2 Analysis of Groups Home Ranges

Every individual *Nycticebus c. coucang* in the analysis had a location data set that had overlapping sessions. There was no adult *Nycticebus c. coucang* poly-territorial and none moved their territory during the study period (Figure 5.12).

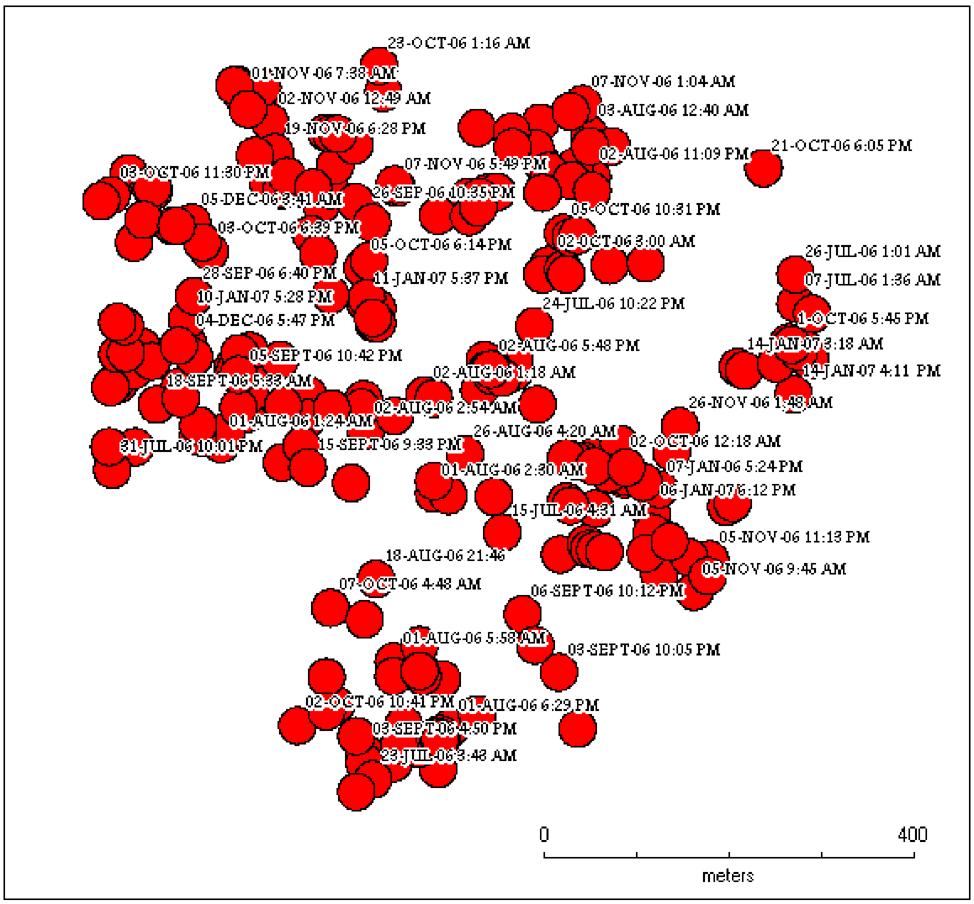


Figure 5.12 Example of locations collected for the individual adult male AG (Aggressive) during the sampling period. Note that the locations occur over a consistent area and showed obvious overlap during the study period, suggesting fidelity to this area during the sampling period.

Individuals were identified as a group A, B, C, D and E due to the movement patterns, spatial distribution and proximity. Five (5) individual *Nycticebus c. coucang* were not tagged but some points locations were recorded and proposed home ranges were suggested (Table 5.9) (Figure 5.13 A & B).

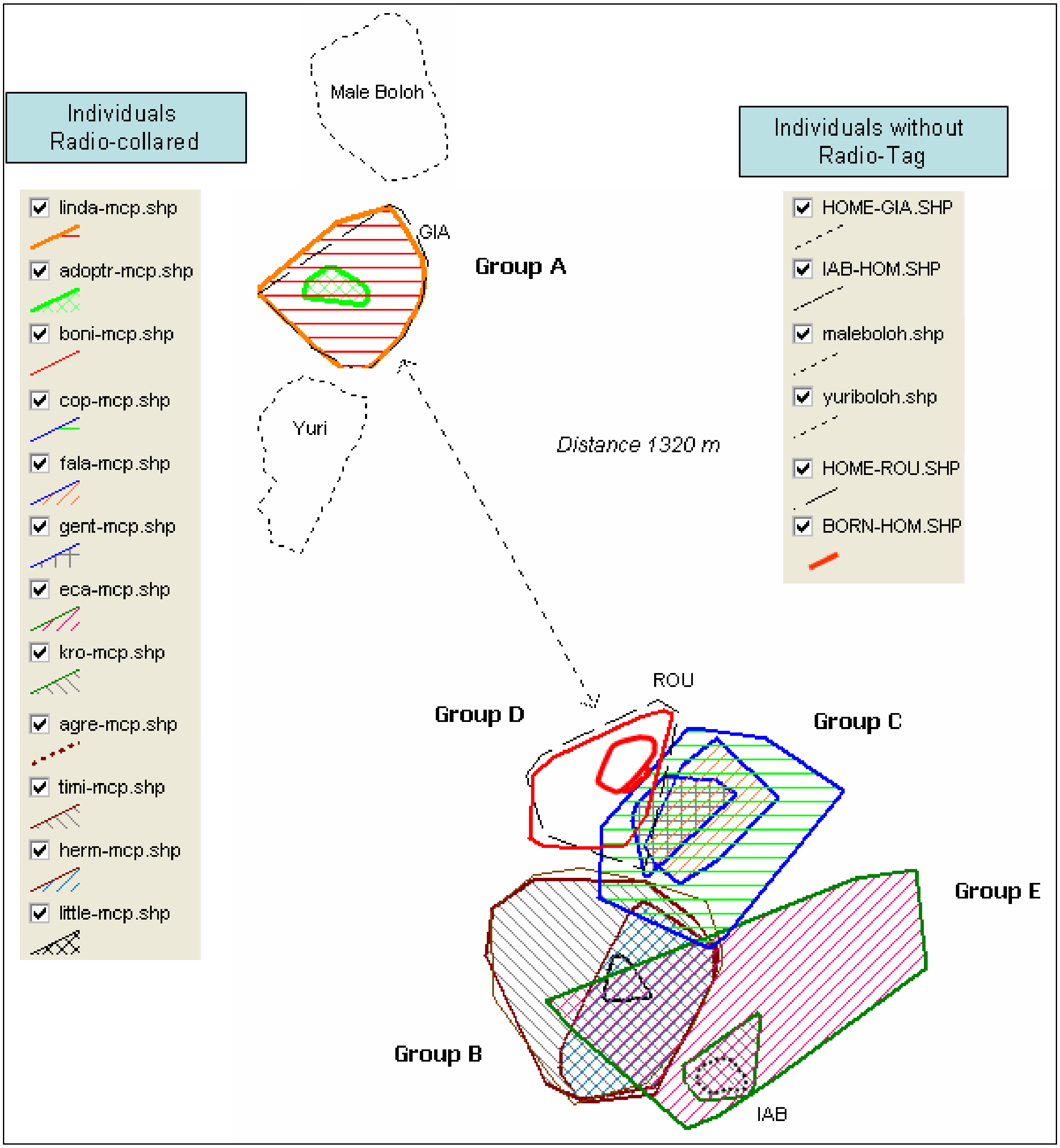


Figure 5.13 A. Spatial Distribution and Distance among Group A (Bukit Boloh) and Cempaka Groups (B, C, D and E) using Minimum Convex Polygons of individuals. Dash lines describe adult Male-Boloh, adult Female Yuri and sub-adult male IAB captured but not tracked whereas individual, GIA, ROU was never captured, but several locations were obtained when tracking those closer individuals within the group, hence, it is proposed as a home range for those individuals.

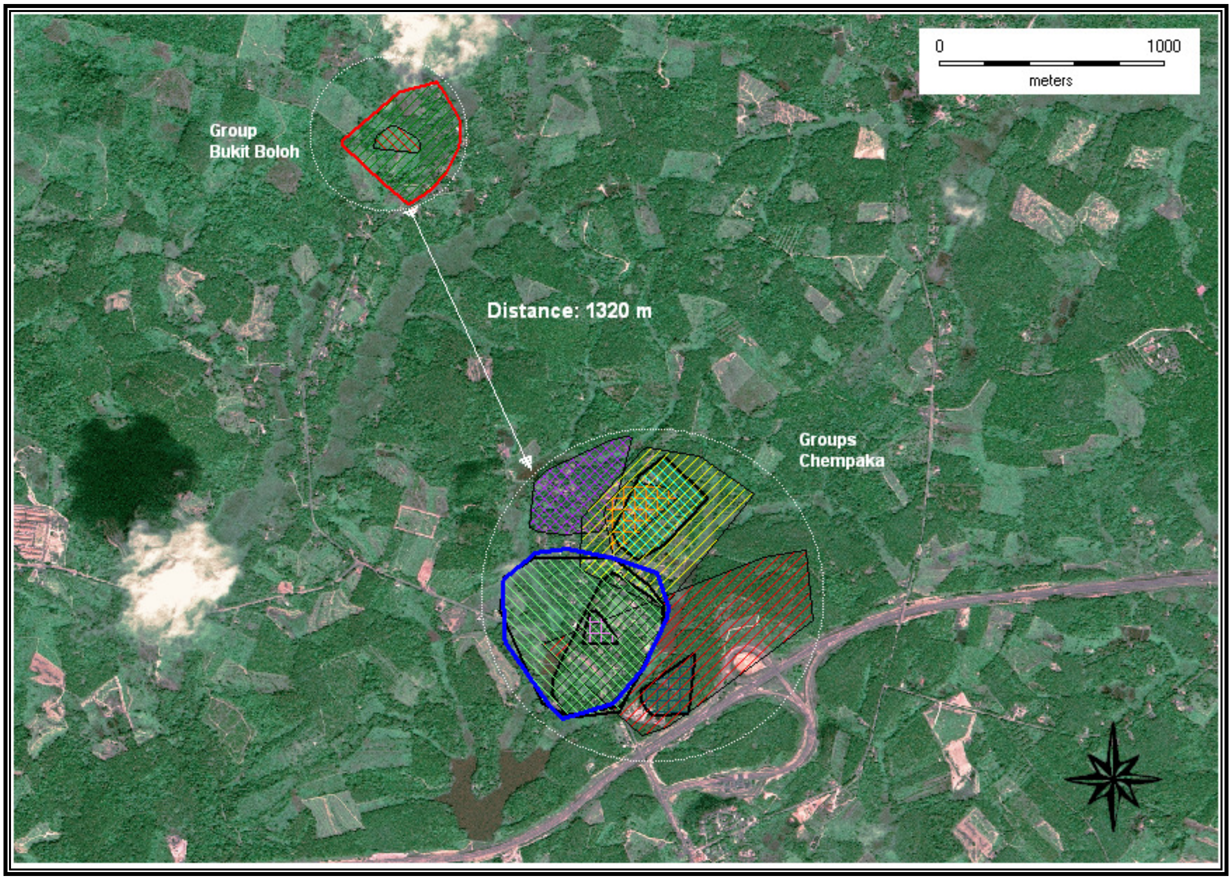
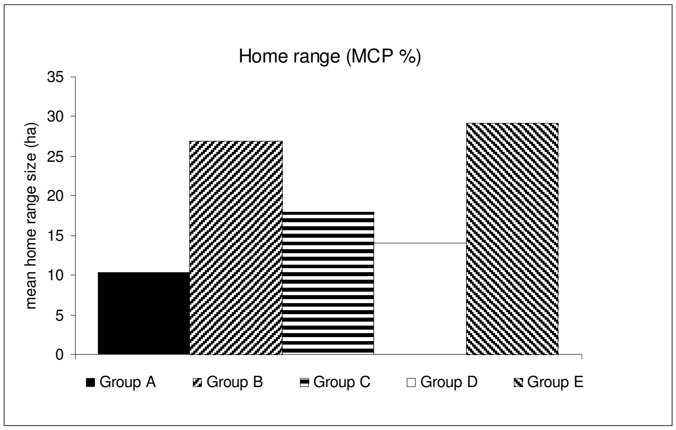


Figure 5.13 B. Representing the Home Ranges of those individuals tracked superimposed with the satellite image obtained from MACRES. The distance between the study areas is 1320 meters.

5.2.1 Home Range Estimators: 1) MCP % 2) KDE h_{ref} 95 % Fixed Contours and Core Areas Using 50 % of Fixes.

Home range values of the estimator MCP % produced the greatest results for the group E followed by group B, C, D and A. However, the estimator Kernel 95% with smoothing factor "h_{ref}" shows that values increases and higher results are given by group B followed by group E,C , A and D (Figure 5.14). The overall home ranges of adult males were significantly higher than females (T-test; $t=11.2$, $df=7$, $p<0.05$).

A)



B)

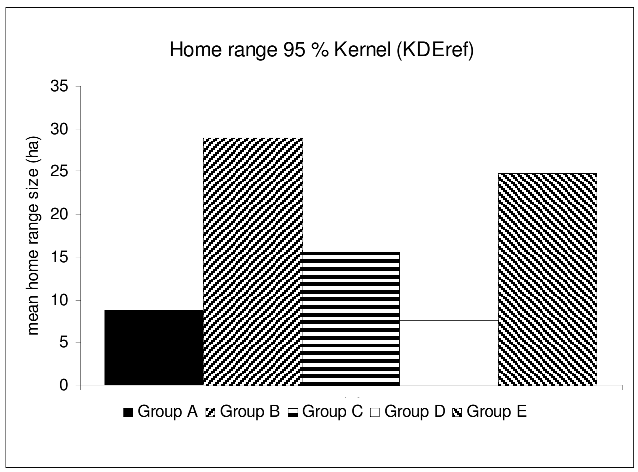


Figure 5.14 Mean (Minimum, Maximum) Size of *Nycticebus c. coucang* Adult, Subadult and Infant individual Home Ranges for 5 different Spatial Groups, (A) Minimum Convex Polygon MCP % (B) 95 % Kernel Density Estimation KDE h_{ref}.

Table 5.9 *Nycticebus c. coucang* Home Range Estimates calculated for Minimum Convex Polygons (MCP), Kernel Density Estimation probability from 95 % to 50 % (KDE $_{ref}$) determined by radio-telemetry locations. (See illustration in color Figure 5.17 for complementary information).

	Radio-tracking											
Group and Individuals	**Tracking period**		**Kernel Density Estimation (KDE) Home range (HR) with smoothing factor HDE(href) (ha)**									
		MCP % (ha)	**95%**	**90%**	**85%**	**80%**	**75%**	**70%**	**65%**	**60%**	**55%**	**50%**
Group A (Bukit Boloh)												
Male Adult (GIA)	seen- not caught											
Female Adult (LI)	8/06-27/11/06	18.7638	14.99	11.6	8.3	6.405	4.93	3.72	2.737	2.314	1.951	1.652
Male Infant (Adopted-ADOPT)	8/06-14/07/06	1.7978	2.393	2.05405	1.7744	1.4258	1.1534	0.91231	0.7337	0.5804	0.4361	0.3191
Group B (Cempaka)												
Male Adults (AG)	6/07/06-18/01/07	43.5874	51.3267	45.1871	39.6528	35.034	31.6119	28.4037	24.2877	20.7234	14.9635	11.7865
Female Adult (TIM)	1/08/06-18/01/07	41.717	45.164	36.7168	29.882	22.807	16.856	12.1631	8.9506	6.634	5.014	3.9573
Female Subadult (HE)	6/07/06-16/01/07	20.778	18.022	13.136	10.369	8.424	6.339	5.382	4.615	3.954	3.339	2.797
Male Infant (Little)	1/11-29/11/06	1.5679	1.1631	0.717	0.3902	0.2413	0.1839	0.1572	0.138	0.1215	0.1071	0.0939
Group C (Cempaka)												
Male Adult (CO)	9/11/06-16/01/07	36.4614	28.7878	12.2828	6.12	4.408	3.568	3.078	2.696	2.376	2.1001	1.8475
Female Adult (FA)	12/12/06-18/01/07	11.3397	13.2492	8.3288	5.1772	3.4911	2.4617	1.9211	1.5842	1.2836	1.0902	0.9308
Male Subadult (GE)	10/11/06-6/01/07	6.1536	4.5738	3.0958	1.8942	1.344	0.966	0.73	0.57	0.499	0.436	0.3811
Group D (Cempaka)												
Male Adult (ROU)	seen-not caught											
Bonita Adult (BO)	17/09/06-16/01/07	14.1162	7.547	2.863	1.3469	0.7992	0.701	0.6196	0.5495	0.4876	0.4316	0.3799
Infant Born (B.B) (Delivered by Bonita)	caught , not radio Collared											
Group E (Cempaka)												
Male Adult (ECA)	6/11/06-18/01/07	53.966	45.233	32.548	27.47	23.655	20.8182	18.41	16.1	13.969	11.606	9.696
Male Adult (KRO)	26/11/06-15/01/07	4.441	4.409	3.3804	2.699	2.08	1.5856	1.3226	1.1398	1.006	0.8783	0.7478
Male Subadult (IAB)	caught, not radio Collared											

Using all valid locations (MCP 100%), the home ranges of adult males varied from 4.44 to 53.96 ha, adult females from 11.33 to 41.17 ha, sub-adults from 6.15 to 20.77 ha, and infants from 1.56 to 1.79 ha. For KDE h_{ref} (Kernel 95 %) analysis the results for adults males were from 4.40 to 51.32 ha, adult females from 7.54 to 45.16 ha, sub-adults from 4.57 to 18.02 ha (Figure 5.15). The home range values for both MCP and KDE methods were significantly well correlated (Pearson Test: N=12, 0.97, $p<0.05$) (Figure 5.16).

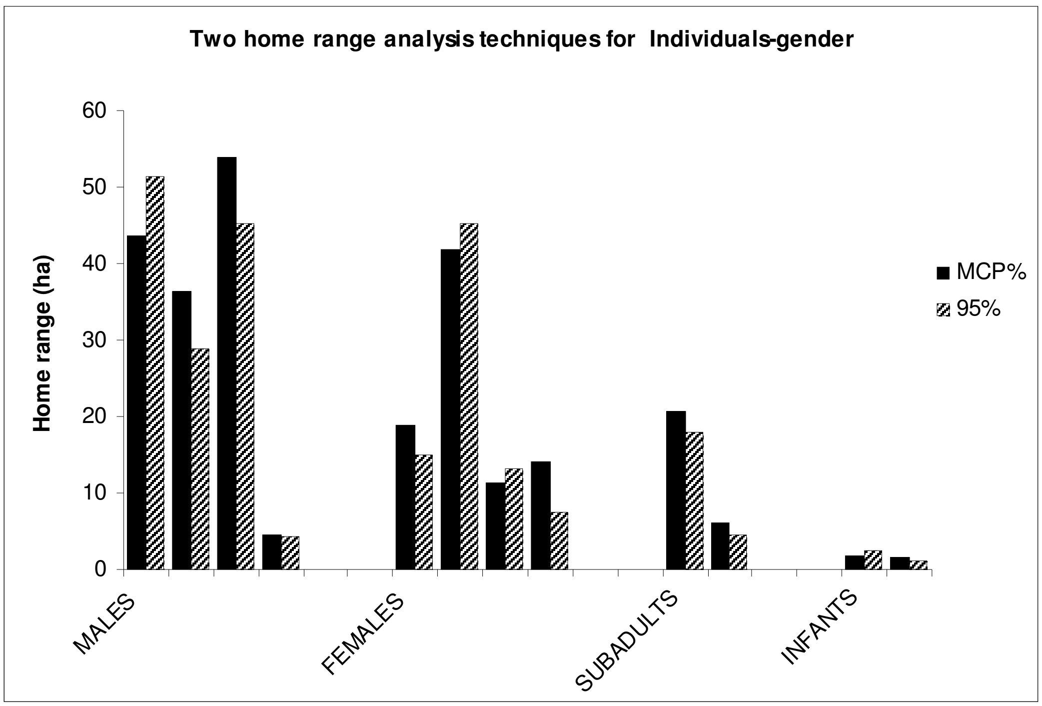


Figure 5.15 Showing Home Range Analysis results obtained in (ha) by using two analysis techniques, MCP % and Kernel Density Estimation (KDE h_{ref}).

Kernel 95 % and MCP % (of valid locations) produced comparable estimates for male KRO, infant LITTLE. For the remaining, there were no significant differences in the home scores between MCP and KDE (T-test: t= .0, p = 0.80) (Table 5.9). When computing home range with the estimator KDE h_{ref} the probability contours were set from 50 % to 95 % (Table 5.9) using the default smoothing factor, resulted in different bandwidth and described in this study with different colors (Figure 5.17), giving better visualization for analysis.

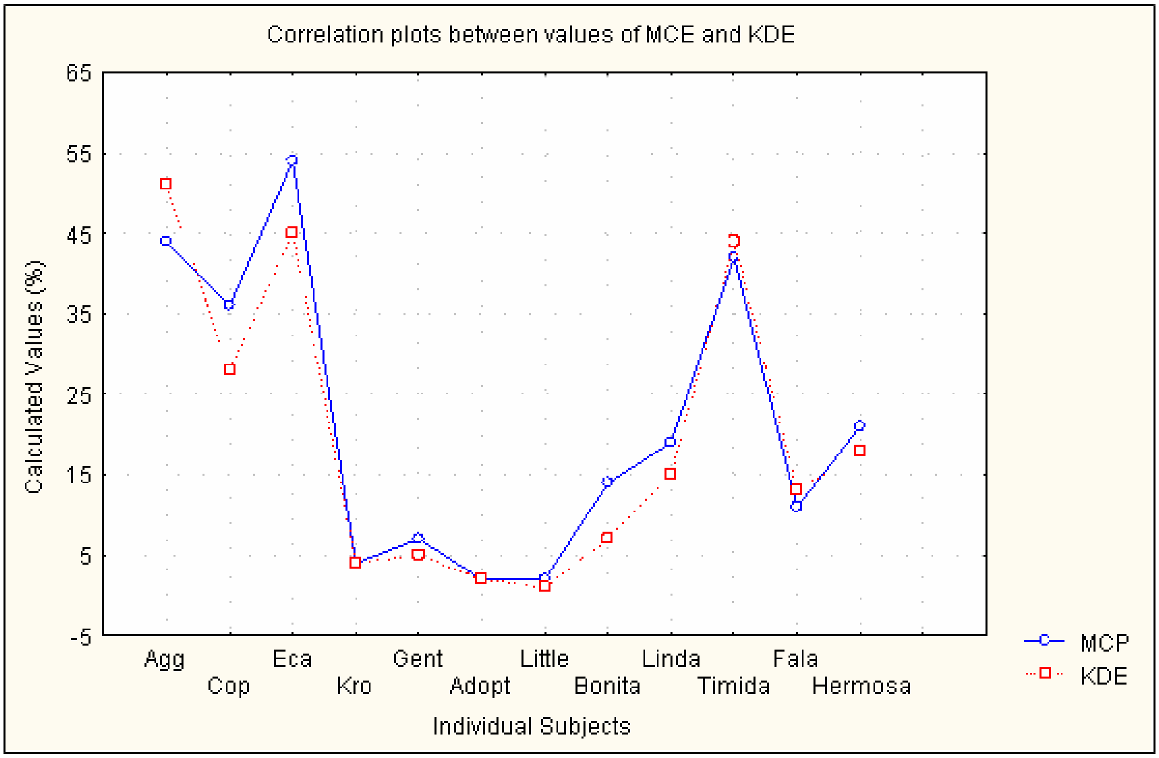
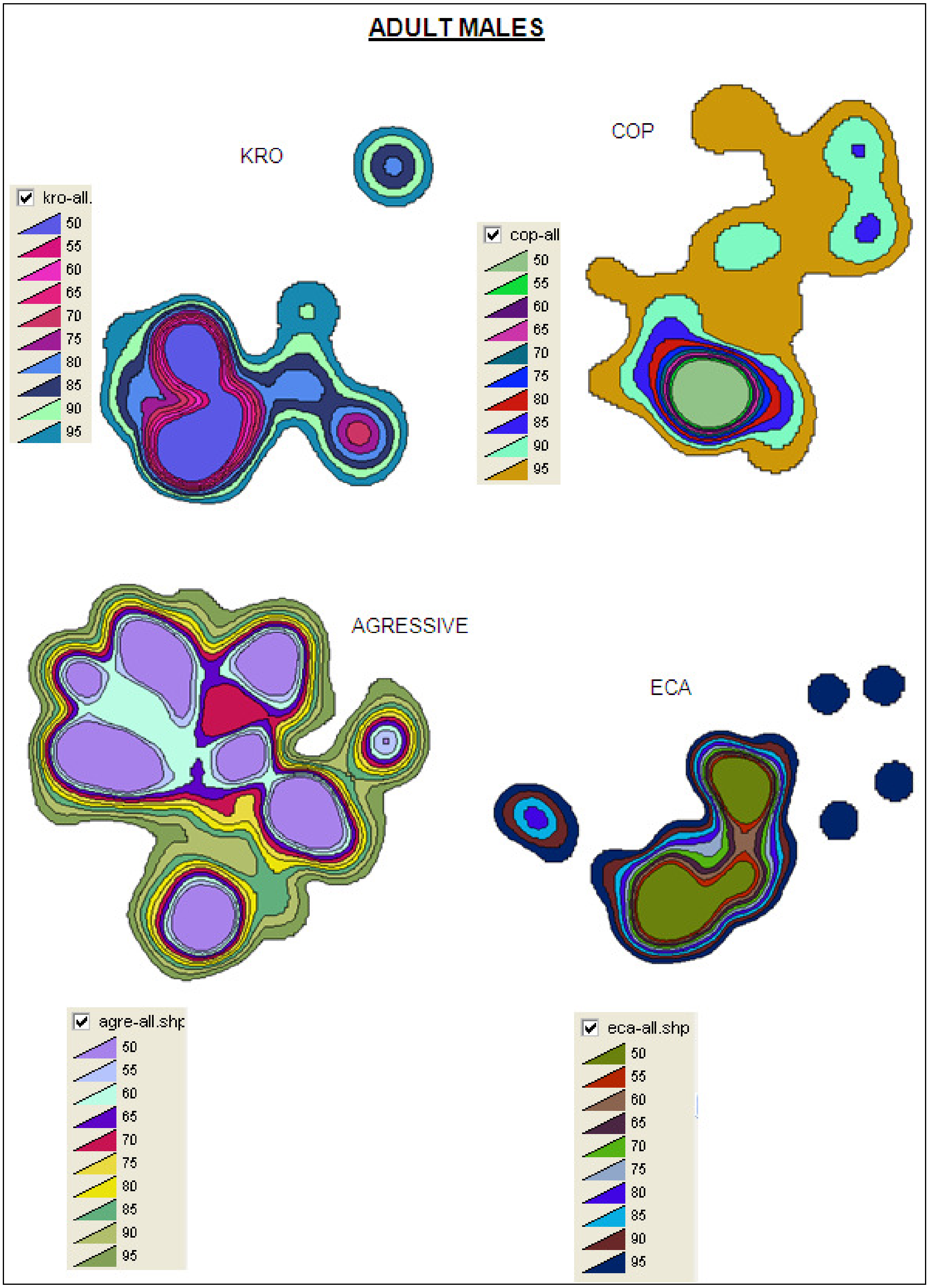


Figure 5.16 Correlation Plots between Analysis Techniques MCP % and Kernel Density Estimation (KDE h_{ref}).

The average home-range sizes between sexes ranged from 34.61 ha for adult males, 21.48 ha for adult females, 13.46 ha for sub-adults and 1.68 ha for infants using MCP %. Adult males had significantly larger home ranges compared to the adult females (T-test: $t=15.05$, $d.f=22$, $p<0.05$) for MCP %.


ADULT MALES
KRO
kro-all.
50
55
60
65
70
75
80
85
90
95
COP
cop-all
50
55
60
65
70
75
80
85
90
95
AGRESSIVE
ECA
agre-all.shp
50
55
60
65
70
75
80
85
90
95
eca-all.shp
50
55
60
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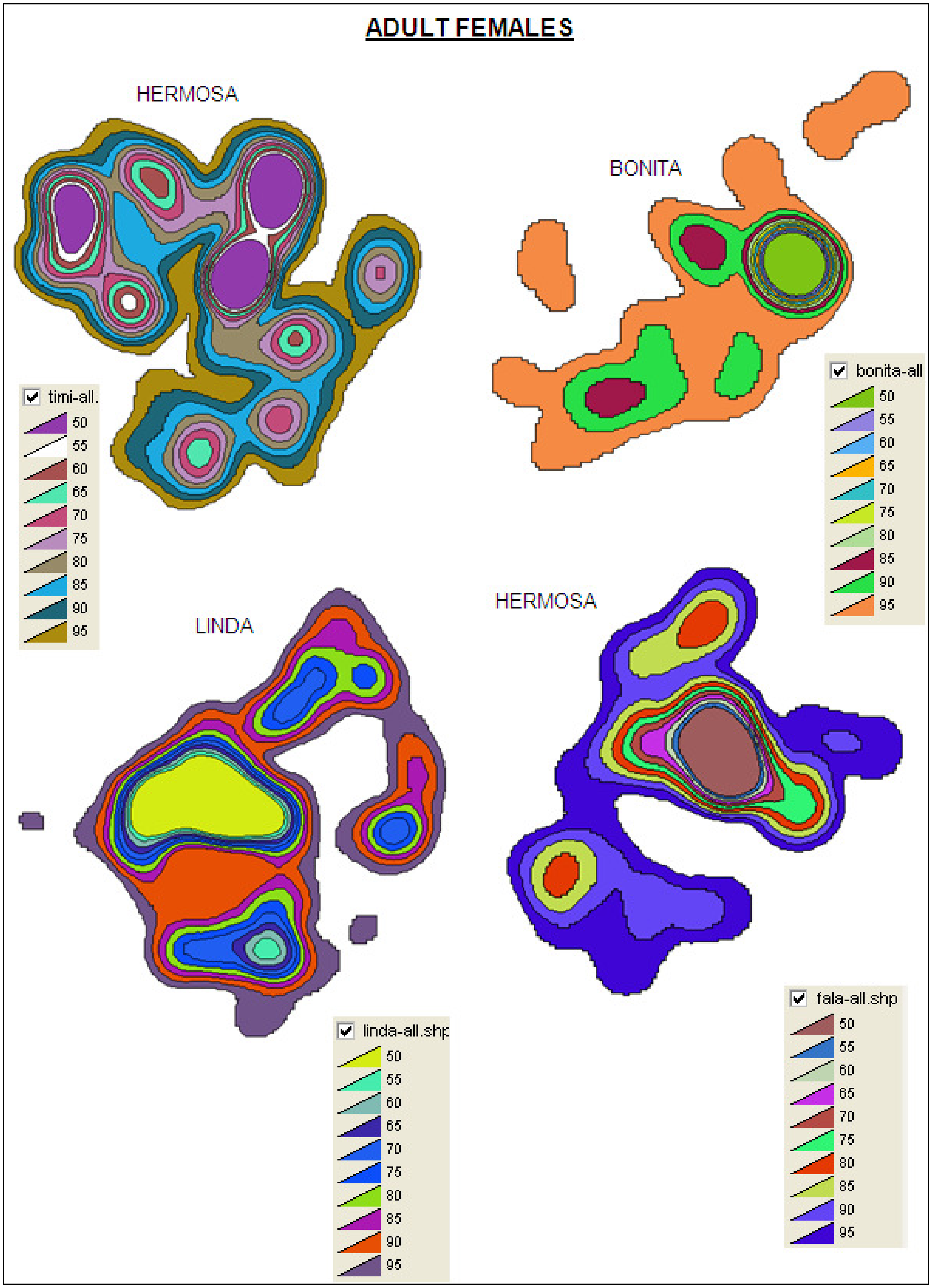
70
75
80
85
90
95


ADULT FEMALES
HERMOSA
timi-all.
50
55
60
65
70
75
80
85
90
95
BONITA
bonita-all
50
55
60
65
70
75
80
85
90
95
LINDA
linda-all.shp
50
55
60
65
70
75
80
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90
95
HERMOSA
fala-all.shp
50
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75
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95

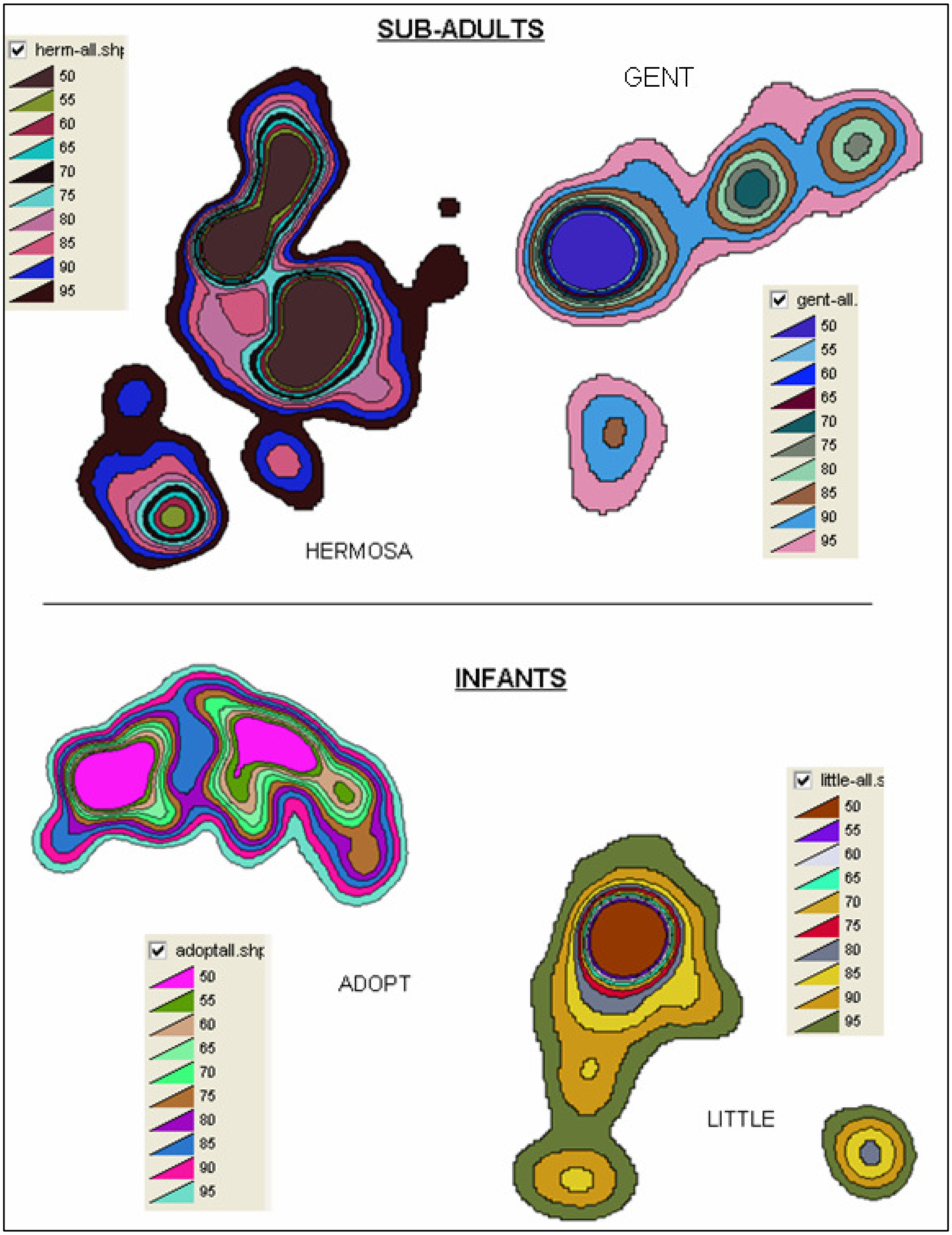


Figure 5.17 Home Range color illustrations for ADULT M/F, SUB-ADULTS, and INFANTS tracked using Kernel Density Estimation (KDE h_{ref}) Home range with smoothing factor HDE $_{(href)}$. Concentric contours indicate intensity of use, ranging from 95% (most external contours) to 50 % (most internal contour line). Complementary information in Table 5.9.

The observed average values were 32.43 ha for males, 20.23 ha for females, 11.29 ha for sub-adults and 1.77 ha for infants using KDE ($_{ref}$) 95 %.The adult males had larger home range values in contrast to adult females (T-test: $t=12.67$, $p<0.05$) for KDE ($_{ref}$) 95 %. The average home-range area using both MCP and Kernel 95% was 33.52 ha for adult males, 20.86 ha for adult females, 12.38 ha for sub-adults and 1.73 ha for infants (Figure 5.18).

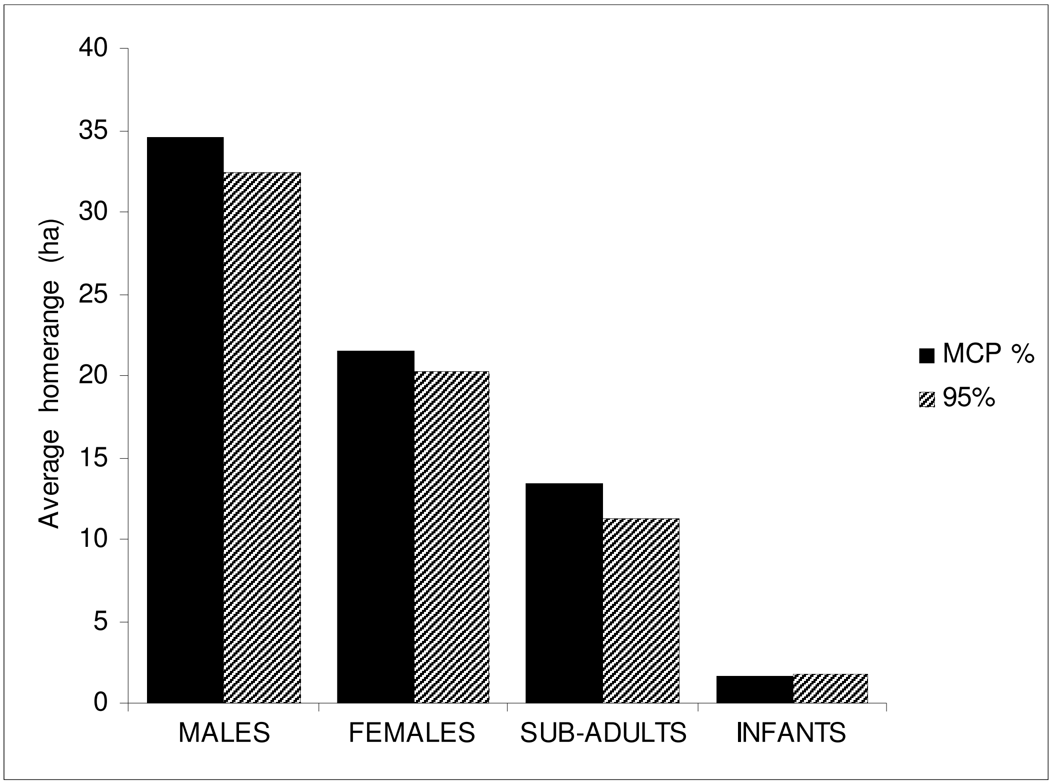


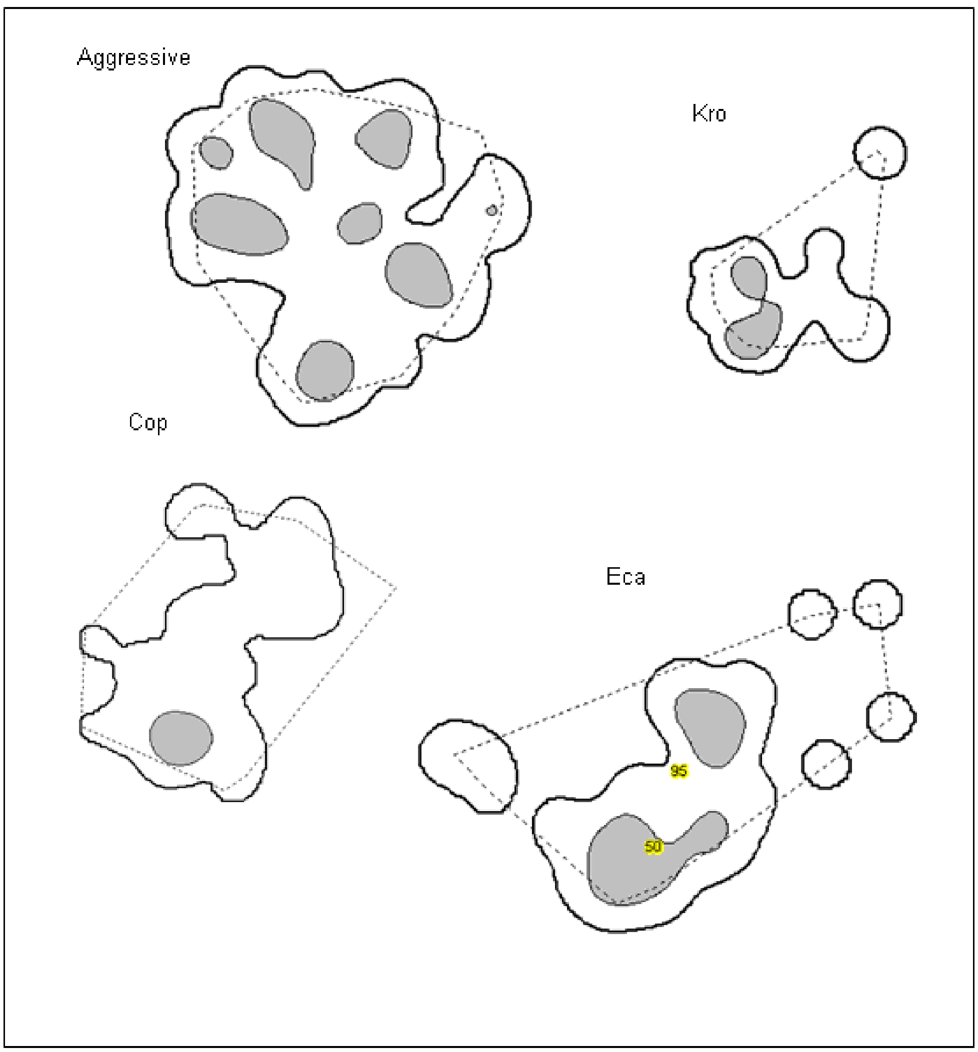
Figure 5.18 Graph representing the average home range in adults combining by groups Males, Females, Sub-adults and infants with the method of MCP % and KDE 95 %.

Kernel (95% and 50%) allowed visualization of the intensity with which each animal used its home range (Figure 5.19). It was also noticed that home ranges of males had in general more than one intensively used area (Figure. 5.19A), while home range of females were more concentrated around a single area (Figure. 5.19B).

5.2.2 Home Range by Type, Shape and Distribution

Considering 95% of fixes in Kernel contours (KDE h_{ref}), this shows that home ranges of individuals had distinct characteristics. One male (Aggressive) presented a concave undivided range with seven centre activities, follow by one female (Timida) presenting a concave undivided range with 3 activities centers. Two other individuals showed concave undivided ranges, with adult male "Cop" and infant "Adopt" with one and two activity centers respectively. The rest of the study animals all had disjointed home ranges, and with one and two activity centers (Figure 5.19).

A) MALES



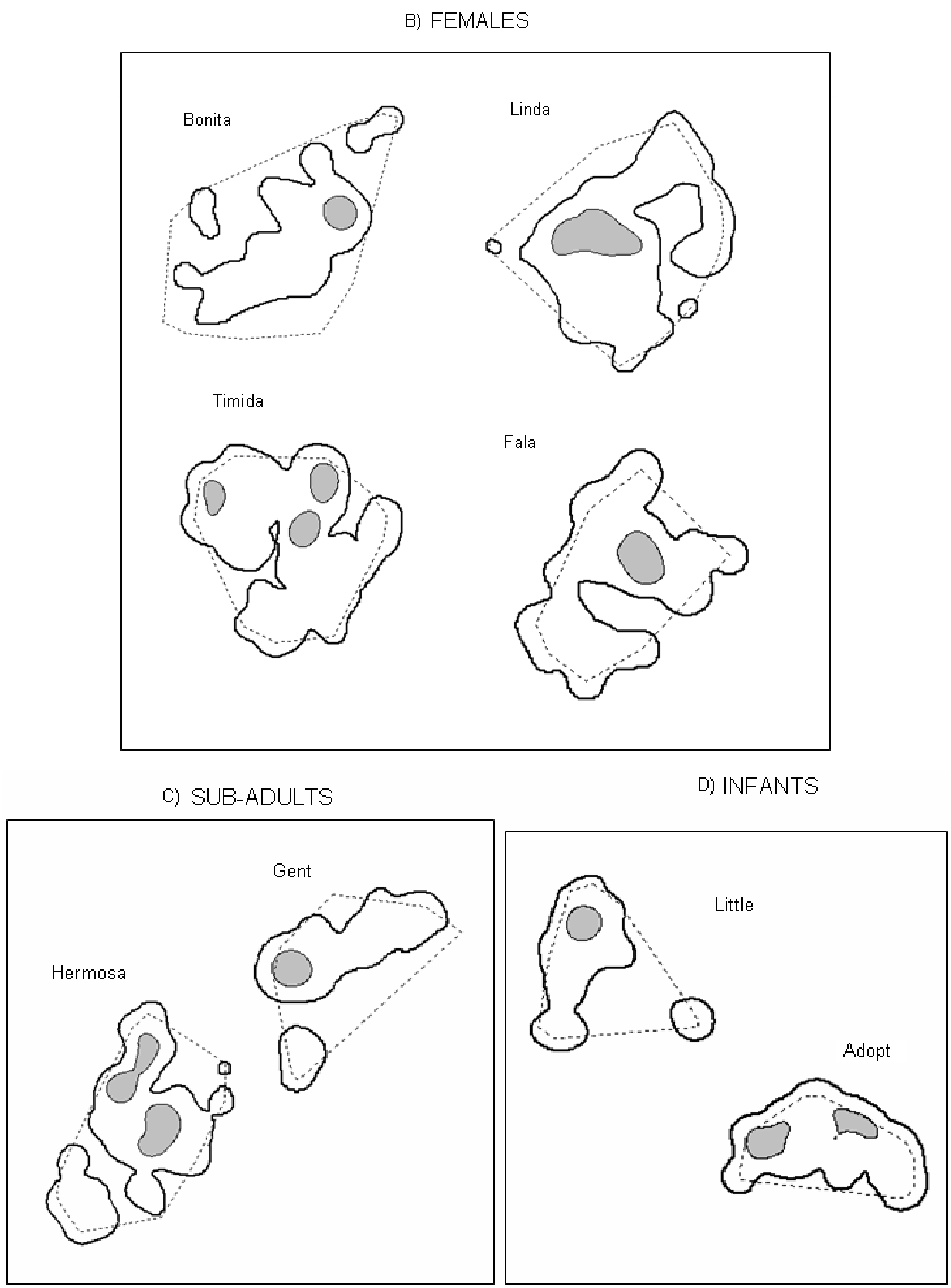


Figure 5.19 Home Ranges of (A) MALES and (B) FEMALE (C) SUB-ADULTS and (D) INFANTS. The continuous black line denotes home range estimation calculated using fixed Kernel method 95% and 50 % (grey color). Areas bordered by dot lines represent Minimum Convex Polygon method 100%.

5.2.3 Home Range Estimators: KDE h_{ref} 50 % Core Areas Contours

The core areas of activity (KDE h_{ref} 50%) varied from 0.319 ha for the infants “Adopt” to 0.093 ha for the individual “Little”, and sub-adults ranged from 0.38 to 2.79 ha. Adult male’s core area differed in size across males from 0.74 to 11.78 ha, and showed larger areas than females which ranged from 0.379 to 3.95 ha (Table 5.10) (Figure 5.20). The numbers of core areas were different among individuals (Table 5.10) too. The 50 % “core areas were geographically distinct, with some core areas only partially overlapping, the use of continuous forest or patch of forest/biotopes as core areas varied among the 12 individuals *Nycticebus c. coucang.*

Table 5.10 Number of Core Areas visited by *Nycticebus c. coucang* and Biotopes located within these.

Individual	Number of core areas	CORE AREA in (ha)	Biotopes
Aggressive	8	11.78	Orchards, High Forest, Rubber Plantation
Kro	2	0.74	Belukar/ Rubber Plantation
Cop	1	1.84	Orchards
ECA	2	9.69	Belukar and Rubber Plantation
Bonita	1	0.37	Belukar
Linda	1	1.65	Belukar
Timida	3	3.95	Orchards/ Belukar(s)
Fala	1	0.93	Orchards
Hermosa	2	2.79	Orchards / Belukar (s)
Gent	1	0.38	Orchards / Belukar (s)
Little	1	0.093	Orchards
Adopt	1	0.319	Belukar

For instance, Adult male “Aggressive” had eight core areas and it is evident that this individual actively used several biotopes such, Belukar, Orchards, High Forest, Rubber and Plantation. On the other hand, male adult Cop had one core area located in the Orchards (Table 5.10) and (Figure 5.20). Core areas were visually stable during the sampling period, although they were used more heavily in some sessions than others.

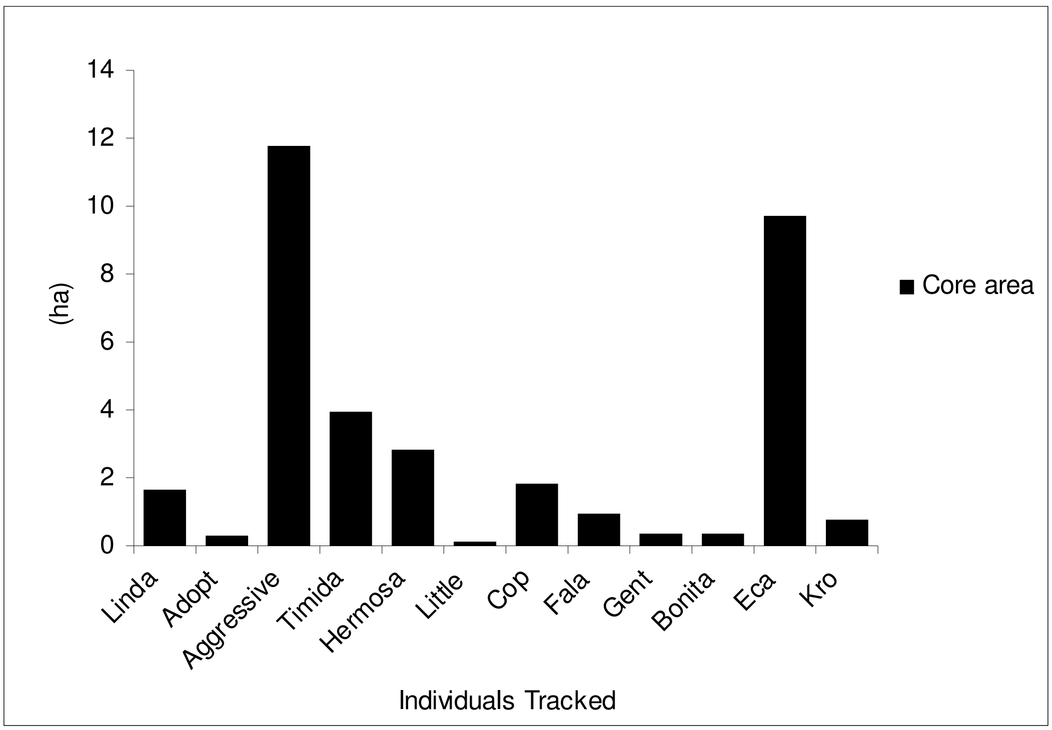


Figure 5.20 The Core Areas (ha) of the Individuals Tracked.

For further analysis of each individual home range illustration refer to Appendix 2A and 2B.

5.3 Analysis of Overlapping Home Ranges

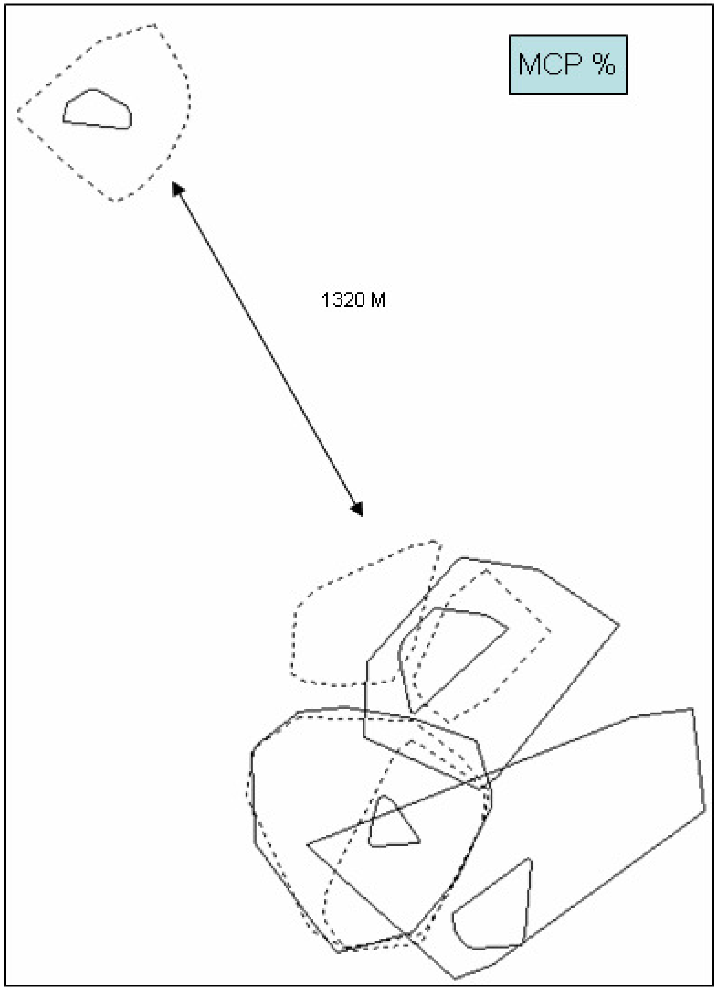
5.3.1 Spatial Overlap of Individual Home Ranges

Percentage home range overlapping for intra-groups and inter-groups differed in size and shape (Figure 5.21) between estimators (Minimum Convex Polygon (MCP %) [See Table 5.11A & Figure 5.22 A & B] and Kernel Density Estimation with reference smoothing factor KDE (h_{ref}) 95 %. [See Table 5.11 B & Figure 5.23 A & B]. Table 11 A and B should be read as the following sample for MCP % method: "79.10 % of the female Timida home range was overlapped by the adult male (AG) Aggressive." For MCP and KDE mean percentage overlap tended towards asymptote at between 40 to 50 data points.

The mean percentage overlapping between individuals for intra-group and inter-group were higher for MCP % estimator (58.77 % and 15.21 %) respectively; whereas KDE 95 % estimator was lower with 53.63 % for intra-group and 10.60 % for inter group. For those individuals (GIA, ROU, IAB, and Newborn) that were seen but not tagged a possible home range were drawn using locations and data field obtained throughout the study period.

5.3.1.2 Intra-Group Overlap Estimated Using MCP % and KDE 95 %

The adult males overlapped the home range of adult females in high percentage, sub-adults and infants in group B and C. Nevertheless in the group E, 100 % of the adult male "KRO "was overlapped by an adult male "ECA" (see Figure 5.22A and 5.23A of the both estimators). Females overlapped their infants or sub-adult offspring's home ranges by 100 %. However there was a case in the group C showing a different pattern, the adult female FALA overlapped the home range of a sub-adult male "Gent" over 65 % and 65.59 % values obtained by MCP % and KDE 95 % respectively.



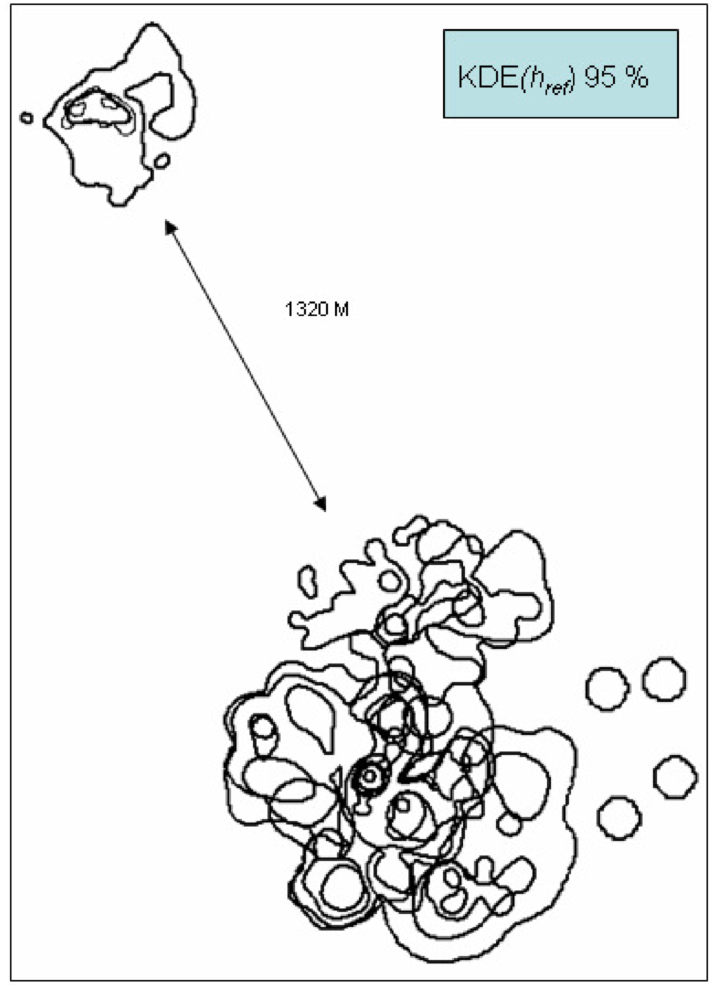


Figure 5.21 Represents the Spatial home ranges overlap of 12 individuals tracked using two estimators MCP % and KDE($_{href}$) 95 %

Table 5.11 A Showing Home Range Overlapping Using	**MCP % :**	**Intra Group Overlap**				**Inter Group Overlap**				**Inter Group Overlap**			
		Percent (%) overlapped by:											
Group A (Bukit Boloh)		**Male**	**Female**	**Subadult**	**Infant**	**Male**	**Female**	**Subadult**	**Infant**	**Male**	**Female**	**Subadult**	**Infant**
Male Adult (GIA)	seen- not caught	□	□	□	□	□	□	□	□	□	□	□	□
Female Adult (LI)		□	□	□	5.3294	□	□	□	□	□	□	□	□
Male Infant (Adopted-ADA)		□	100.0	□	□	□	□	□	□	□	□	□	□
Group B (Cempaka)													
Male Adults (AG)		□	75.70	36.70	2.290	27.53	□	□	□	9.176	□	□	□
Female Adult (TIM)		79.104	□	40.75	2.397	28.77	□	□	□	2.39	□	□	□
Female Subadult (HE)		100.0	100.0	□	4.81	52.94	□	□	□	4.81	□	□	□
Male Infant (Little)		100.0	100.0	100.0	□	63.77	□	□	□	□	□	□	□
Group C (Cempaka)													
Male Adult (CO)		□	24.68	13.71	□	10.97	8.22	2.74	□	1.6	5.48	□	□
Female Adult (FA)		100.0	□	35.27	□	□	□	□	□	□	□	□	□
Male Subadult (GE)		100.0	65	□	□	□	3.25	□	□	□	□	□	□
Group D (Cempaka)													
Male Adult (ROU)	seen- not caught	□	□	□	□	□	□	□	□	□	□	□	□
Bonita Adult (BO)		□	□	□	□	14.16	□	1.41	□	□	□	□	□
Infant Born (B.B) (Delivered by Bonita)	caught , not radio collared	□	100.0	□	□	□	□	□	□	□	□	□	□
Group E (Cempaka)													
Male Adult (ECA)		7.41	□	□	□	22.23	22.26	20.38	1.85	0.31	□	□	□
Male Adult (KRO)		100.0	□	□	□	□	□	□	□	□	□	□	□
Male Subadult (IAB)	caught, not radio collared	□	□	□	□	□	□	□	□	□	□	□	□

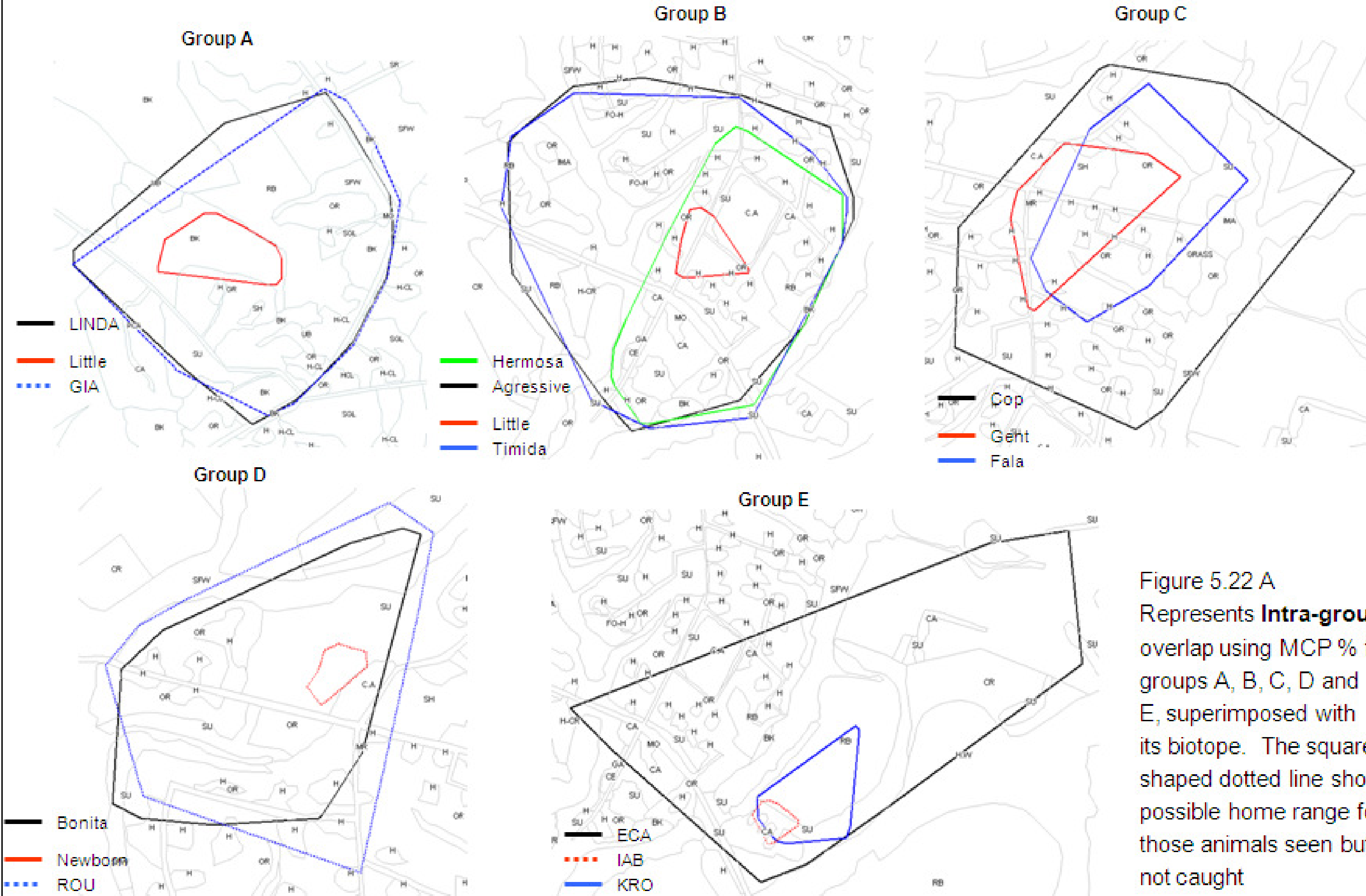
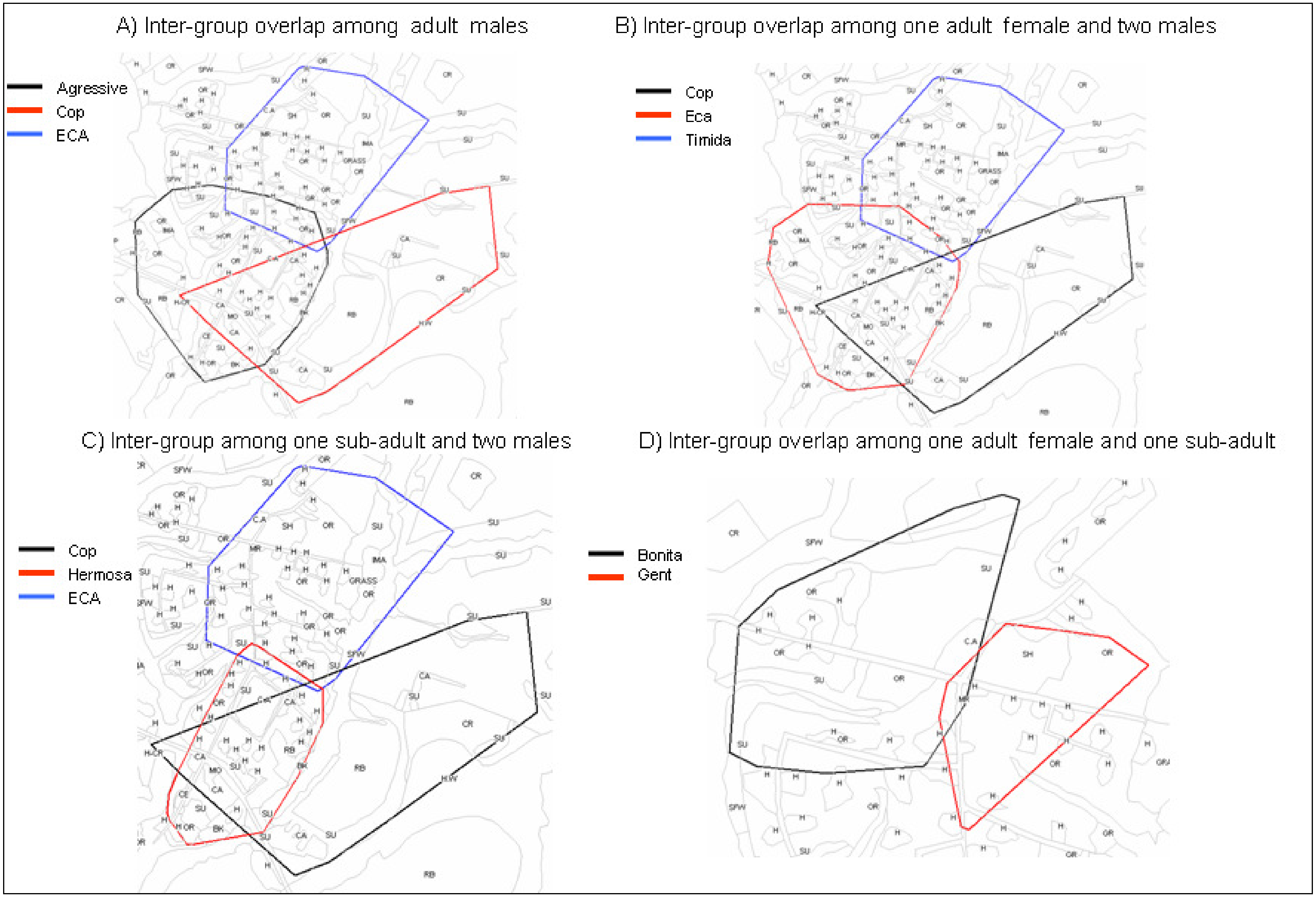
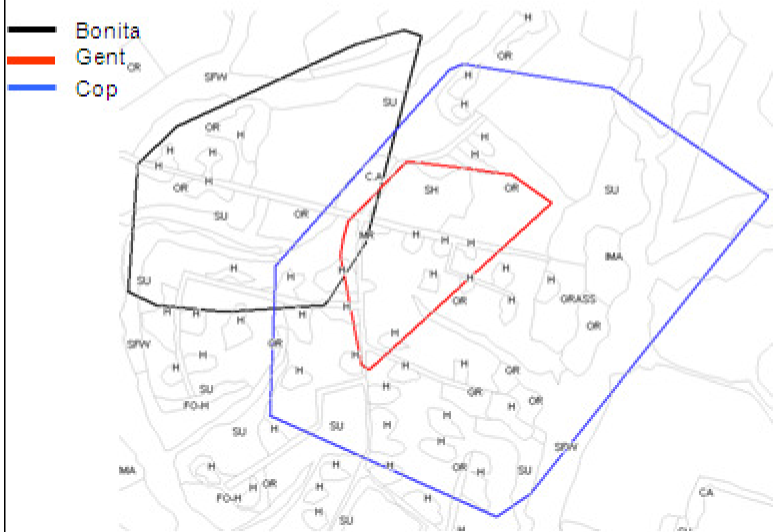


Figure 5.22 A Represents **Intra-group** overlap using MCP % for groups A, B, C, D and E, superimposed with its biotope. The square shaped dotted line shows possible home range for those animals seen but not caught


A) Inter-group overlap among adult males
Agressive
Cop
ECA
B) Inter-group overlap among one adult female and two males
Cop
Eca
Timida
C) Inter-group among one sub-adult and two males
Cop
Hermosa
ECA
D) Inter-group overlap among one adult female and one sub-adult
Bonita
Gent

E) Inter-group among one sub-adult, one female adult and one adult male



F) Inter-group among one sub-adult and two males

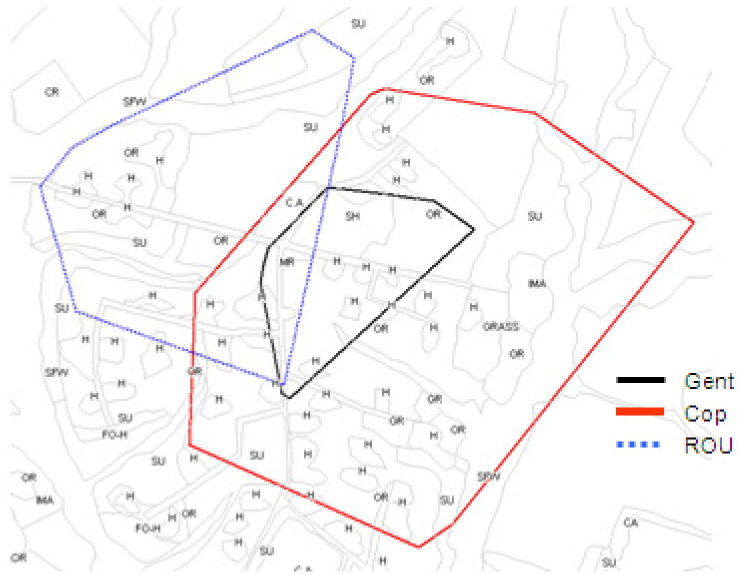


Figure 5.22 B Showing 6 types (A,B,C, D, E, F) of **Inter-group** overlap using MCP % superimposed with its biotope. The square shaped dotted line shows possible home range for those animals seen but not caught.

The percentage home range of individual within group overlapped extensively in form and size in B group, for estimator MCP % (male 79.14; female 75.70 %) and KDE 95% (male 79.7, female, 70.13), individuals within the same group used their common home range almost exclusively. Males shared core areas, with the same extent as females. MCP % intra-group range from 100 % to 2.29 whereas KDE 95 % (100% to 2.214, showing decreasing in values when KDE estimator.

5.3.1.3 Inter-Group Overlap Estimated Using MCP %

Inter-specific overlap of home ranges was lower than that observed among those Individuals from the same group. There was no significant overlap between core areas of inter-groups individuals which was not reflected in significant overlap in resource use.

The number of overlapping types obtained among individuals from estimators MCP and KDE 95 % varied from 6 to 4 respectively (Figure 5.22 B) and (Figure 5.23 B). There were no home ranges overlapping among those neighboring females. Male-Male (AG, COP, ECA) mean home range overlapped was different for estimator MCP (11.96 %) and KDE 95 % (11.7%). Female (Timida) and two males (Cop and ECA) the mean overlapping was 36.7 and 35.42 for the estimators MCP and KDE 95 % respectively.

One sub-adult female (Hermosa) and two males (ECA AND COP) overlapped 28.87 % for MCP % and 13.86% for the estimator KDE 95%. One adult female (Bonita) and one sub-adult (Gent) overlapped 0.09 % and 3.25% for the estimator MCP % and KDE 95%. Two types of overlapping (see E and F of Figure 5.22B B) were found in with the estimator MCP % which was not observed at the moment of running analysis with the estimator KDE 95 %.

Table 5.11 B Showing Home Range Overlapping Using KDE (href) 95 % :		**Intra Group Overlap**				**Inter Group Overlap**				**Inter Group Overlap**			
		Percent (%) overlapped by:											
Group A (Bukit Boloh)		**Male**	**Female**	**Subadult**	**Infant**	**Male**	**Female**	**Subadult**	**Infant**	**Male**	**Female**	**Subadult**	**Infant**
Male Adult (GIA)	seen- not caught	□	□	□	□	□	□	□	□	□	□	□	□
Female Adult (LI)		□	□	□	13.34	□	□	□	□	□	□	□	□
Male Infant (Adopted-ADA)		□	100.0	□	□	□	□	□	□	□	□	□	□
Group B (Cempaka)													
Male Adults (AG)		□	70.13	29.22	1.948	17.53	□	□	□	9.74	□	□	□
Female Adult (TIM)		79.7	□	30.998	2.214	17.71	□	□	□	8.85	□	□	□
Female Subadult (HE)		100.0	100.0	□	5.54	16.64	□	□	□	11.09	□	□	□
Male Infant (Little)		100.0	100.0	100.0	□	0.0	□	□	□	□	□	□	□
Group C (Cempaka)													
Male Adult (CO)		□	31.26	6.947	□	17.360	13.89	6.9	□	3.47	□	□	□
Female Adult (FA)		67.92	□	22.64	□	□	□	□	□	□	□	□	□
Male Subadult (GE)		43.72	65.59	□	□	□	0.09	□	□	□	□	□	□
Group D (Cempaka)													
Male Adult (ROU)	seen- not caught	□	□	□	□	□	□	□	□	□	□	□	□
Bonita Adult (BO)		□	□	□	□	0.0	□	0.06	□	□	□	□	□
Infant Born (B.B) (Delivered by Bonita)	caught , not radio collared	□	100.0	□	□	□	□	□	□	□	□	□	□
Group E (Cempaka)													
Male Adult (ECA)		8.84	□	□	□	19.89	17.68	6.63	0.0	2.21	□	□	□
Male Adult (KRO)		100.0	□	□	□	□	□	□	□	□	□	□	□
Male Subadult (IAB)	caught, not radio collared	□	□	□	□	□	□	□	□	□	□	□	□

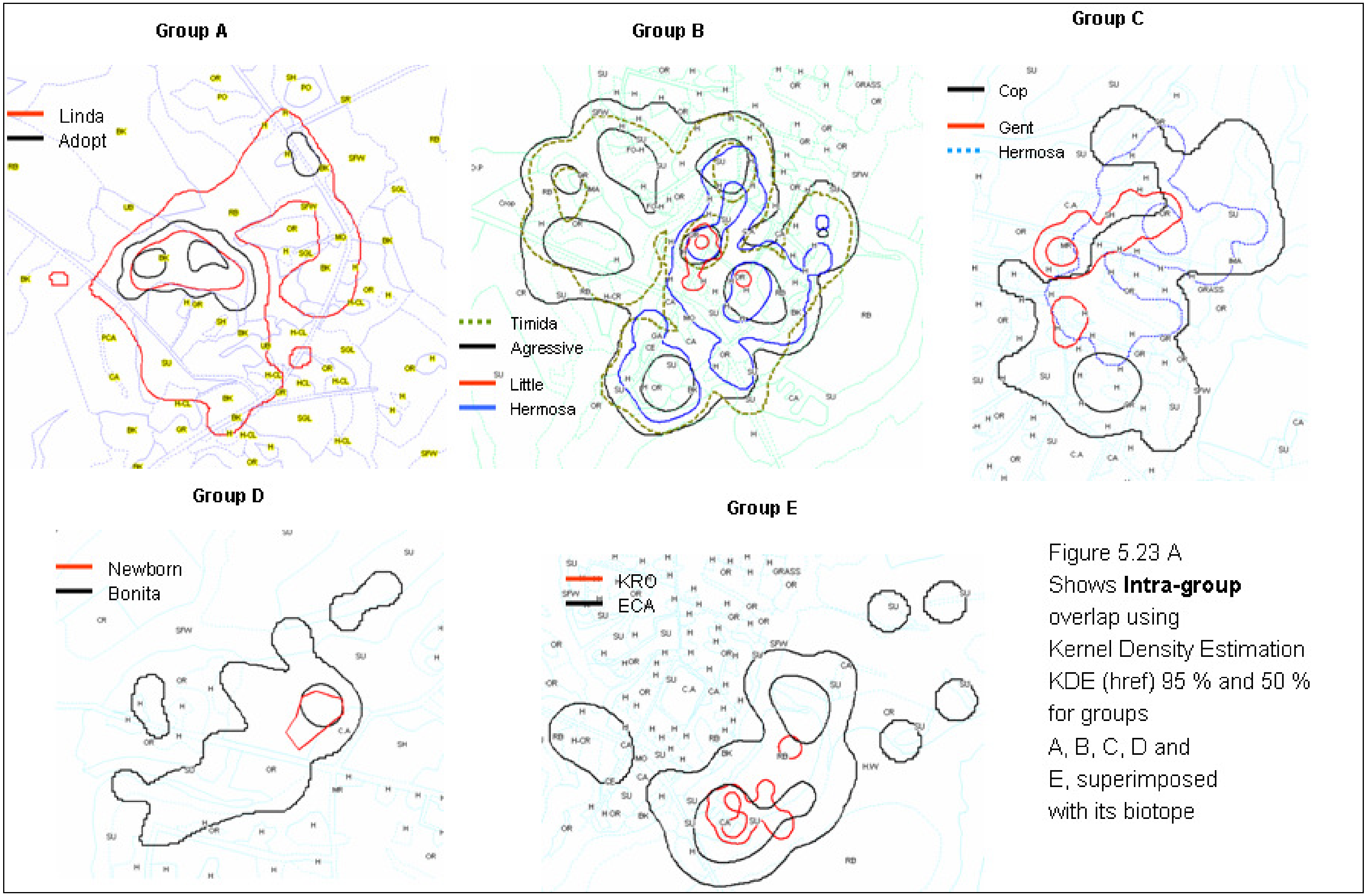


Figure 5.23 A
Shows **Intra-group** overlap using Kernel Density Estimation KDE (href) 95 % and 50 % for groups A, B, C, D and E, superimposed with its biotope

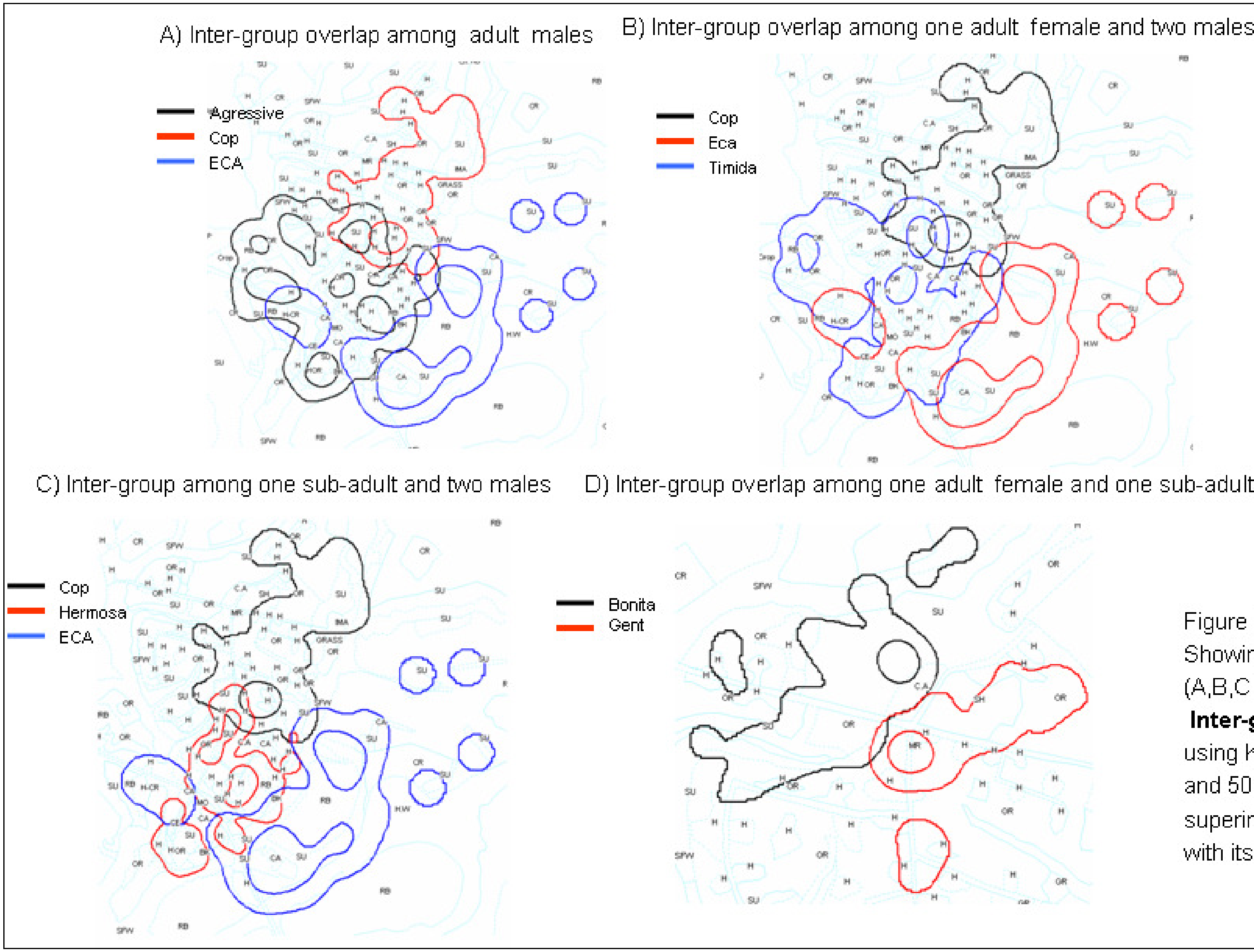


Figure 5.23 B Showing 4 types (A,B,C, D) of **Inter-group** overlap using KDE (href) 95 % and 50 % superimposed with its biotope.

5.4 Analysis of Three Home Range Estimators Employed to Estimate *Nycticebus c. coucang* Home Ranges (MCP %, KDE (h_{ref}) and KDE h_{lcsv})

For kernel home range estimators, the average value of the smoothing factor (h_{ref}) ranged from 12.6 meters to 67. 6 meters, when using LCSV the smoothing factor decreased ranging from 12.2 meters to 65.3 meters (Table 5.12).

There was low agreement between MCP and KDF (h_{ref}). MCP areas tended to be larger for 8 individuals, happening especially in situations like the individual ECA where there were areas within his territory that was never visited during the timing of data collection. Nevertheless in four such cases individuals “Aggressive”, “Timida”, “Fala” and “Adopt”, the physical space bounded by the method KDE (h_{ref}) produced larger home ranges than MCP (Figure 5.24); and decreased again in value when employing the estimator KDE LCSV.

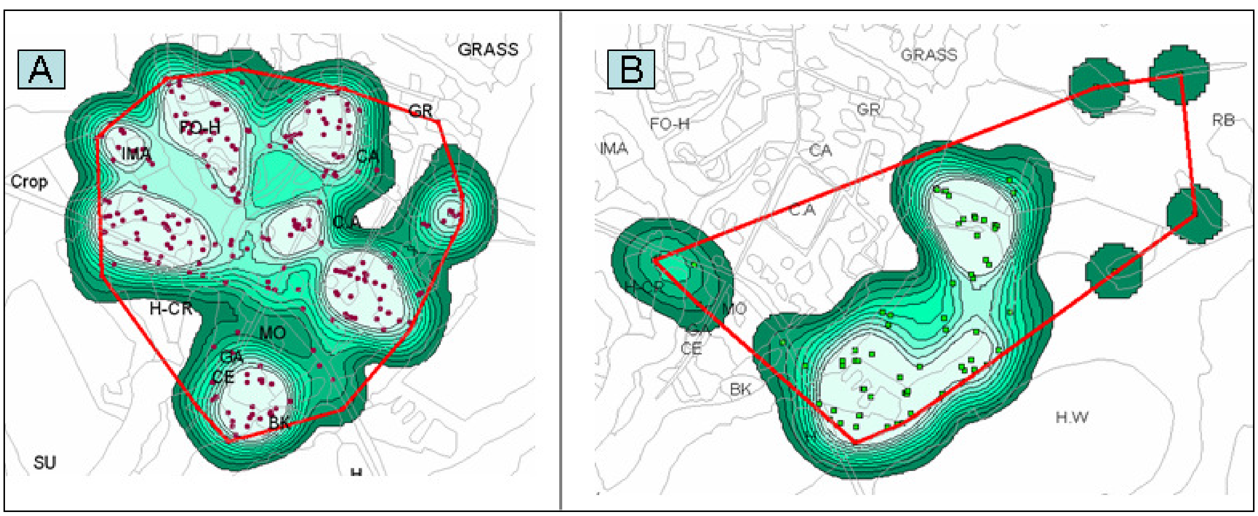


Figure 5.24 Territory boundaries for two individual males generated by the KDE 95 % (h_{ref}) and the MCP red outline. A. Areas enclosed by the MCP % do not overlap with the kernel boundaries but the area obtained by the estimator KDE 95 % produced biologically unrealistic range contours in this case. B. Areas enclosed by the minimum convex polygon that do not overlap with the kernel boundaries for this individual adult male ECA were in Orchards, and Fresh Water, and certainly the individual was never recorded there.

Table 5.12 Kernel Density Estimation (KDE) 95 % and 50 % with smoothing factor KDE (h_{ref}), Least Squares Cross-Validation KDE(h_{lscv}) and Minimum Convex Polygon (MCP %) for the *Nycticebus c. coucang* individuals tracked.

No. Ind	Ind	Sex	No.fixes	MCP 100 % (ha)	95 % fixed KDE contours (href)	50% fixed KDE core area Contours (href)	Reference smoothing factor (href) m
1	BO	F	213	14.116	7.547	0.379	27.3
2	ADA	M	126	1.797	2.393	0.3191	13.7
3	AG	M	257	43.587	51.326	11.7865	49.9
4	CO	M	71	36.461	28.787	1.8475	57.5
5	ECA	M	73	53.966	45.233	9.696	67.6
6	FA	F	40	11.339	13.249	0.9308	36.3
7	GE	M	72	6.153	4.573	0.3811	25.5
8	HE	F	250	20.778	18.022	2.7976	33.9
9	KRO	M	39	4.441	4.409	0.7478	24.1
10	LI	F	316	18.763	14.995	1.6525	27.4
11	TIM	F	215	41.717	45.164	3.957	50
12	Little	M	76	1.567	1.163	0.09398	12.6

No. Ind	Ind	Sex	No.fixes	MCP 100 % (ha)	95 % fixed KDE contours (hlscv)	50% fixed KDE core area Contours (hlscv)	Least squares Cross-validation (hlscv) m
1	BO	F	213	14.116	7.19243	0.35648	26.4
2	ADA	M	126	1.797	2.3502	0.2999	13.2
3	AG	M	257	43.587	50.4471	11.2696	48.2
4	CO	M	71	36.461	27.6824	1.7155	55.6
5	ECA	M	73	53.966	44.8105	9.6719	65.3
6	FA	F	40	11.339	12.9200	0.8918	35.1
7	GE	M	72	6.153	4.42987	0.3597	24.7
8	HE	F	250	20.778	17.6781	2.7172	32.8
9	KRO	M	39	4.441	4.2742	0.7014	23.2
10	LI	F	316	18.763	14.777	1.6187	26.5
11	TIM	F	215	41.717	44.3801	3.5549	48.3
12	LIAG	M	76	1.567	1.12687	0.0872	12.2

The coefficient of variation of estimator KDE (h_{ref}) and estimator (h_{lcsv}) were not reduced with increasing number of fixes. Sample size was correlated among the estimators MCP, KDE (h_{ref}) and KDE (h_{lcsv}) of home range and core area size (Figure 5.25 A) Core areas relationship between number of fixes and core area size did not differ for estimators KDE h_{ref} and KDE h_{lcsv} (Figure 25B).

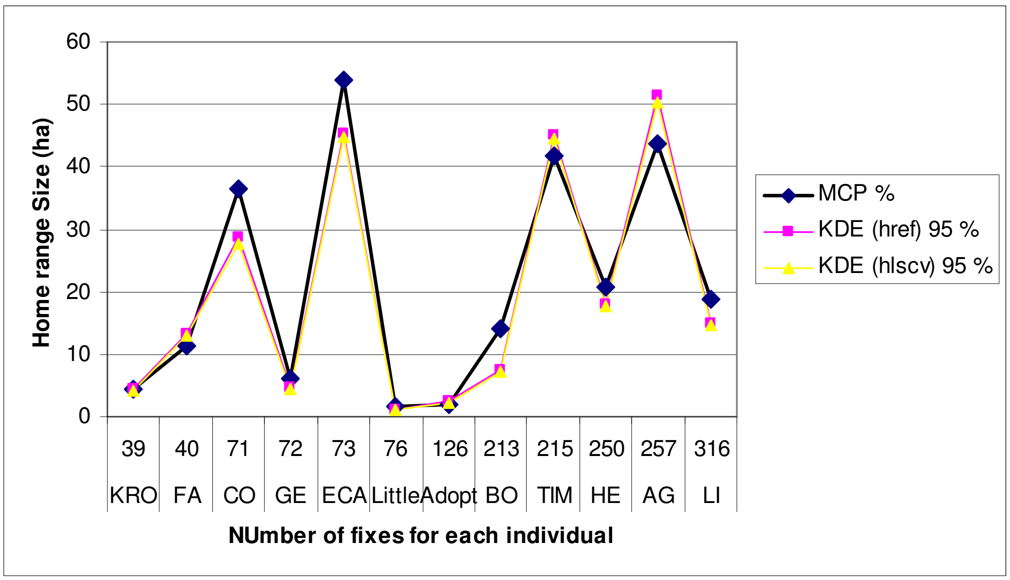


Figure 25 A. Individuals Number of Fixes vs. Home Range Estimator Comparison (ha)

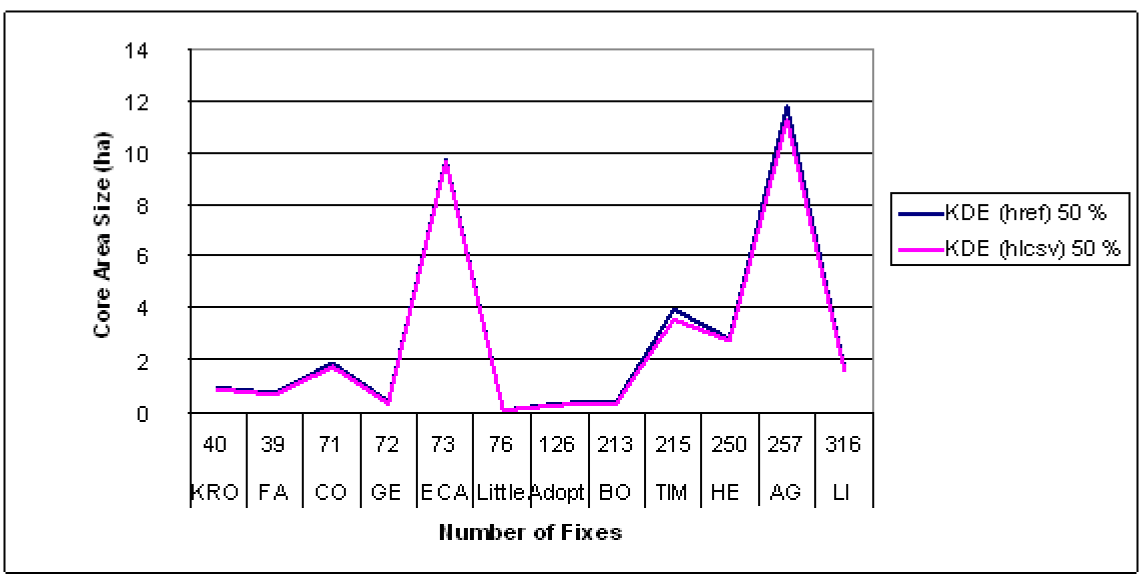


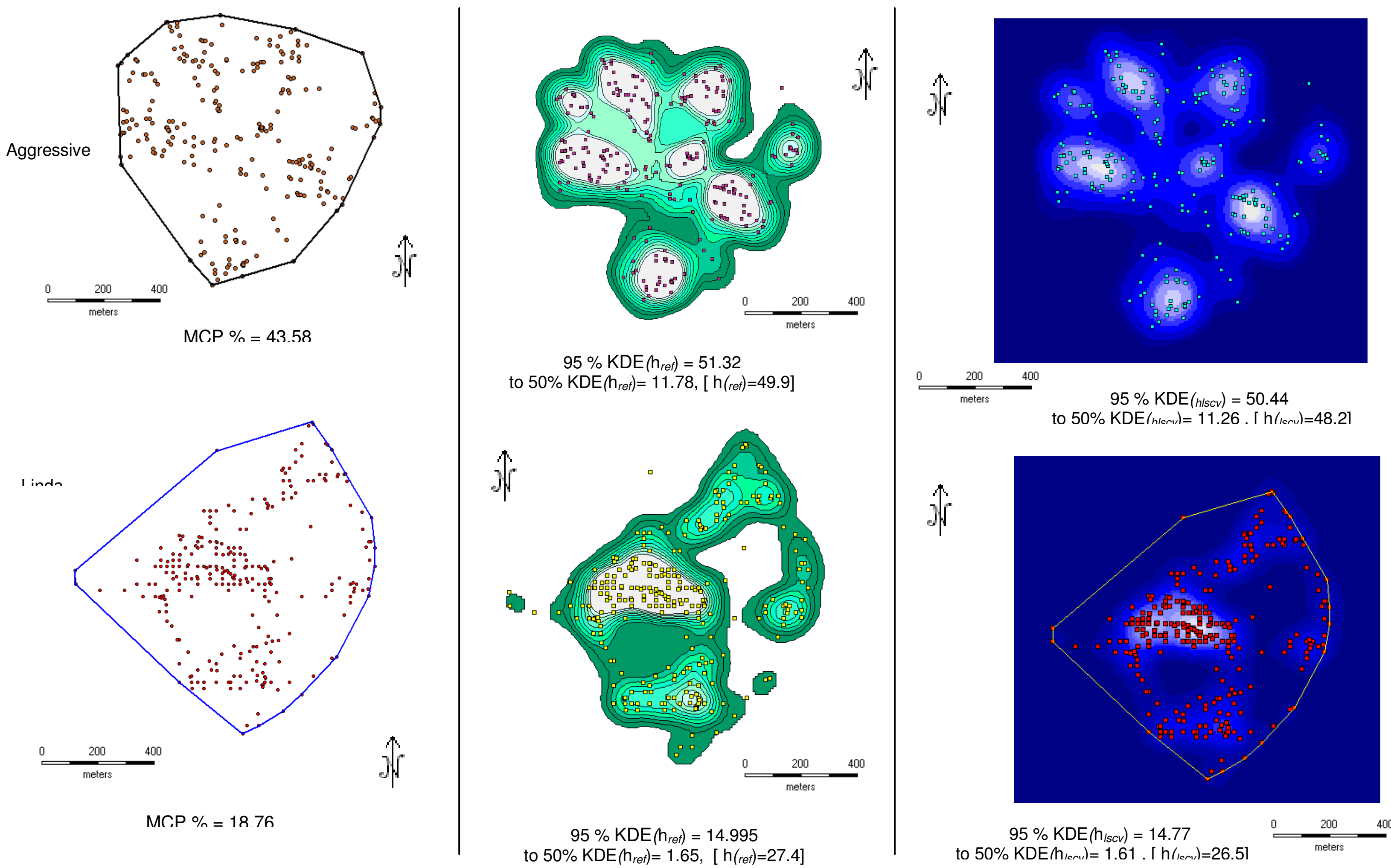
Figure 25 B. Number of Fixes for Individuals vs. Core area (ha) using Different Estimators

The appropriate value (h) was obtained at the time of running the software for the data sets. However, the smoothing factor KDE (h_{ref}) and KDE (h_{lcsv}) were different in all estimations, presenting high values for KDE (h_{ref}) compared with KDE h_{lcsv} (Table 5.12). The relationship between h and sample size was inspected in all the samples for both KDE (h_{ref}) and KDE (h_{lcsv}) and the values and variation did not tend to decline with increasing sample size.

Nevertheless, the value of h employed influenced the size of home range as estimated by KDE using the date sets obtained in the field. The influence of $h$home range size and shape is observed at the time of running the data sate for the adult male "Aggressive" (AG) and the adult female Linda (LI). The raw data of (n-277 fixes) from AG with a MCP; (B-C) 50 to 95 Kernel density isopleths using (h_{ref}) = 49.9 and 48.2 (h_{lcsv}). D, The raw data (n= 316 fixes) from Linda with a MCP. (E-F) 50% to 95 % Kernel density isopleths (h_{ref}) = 27.4 and 26.5 ($h_{lcsv)}$ (Figure 5.26).

Despite the four cases of high home range value contours obtained with KDE 95 % (h_{ref}) this estimator performed well as compared with MCP which produced almost 80% of the biologically unrealistic range cases. The best performance was achieved by KDE LCSV with contours shape and home range values closely comparable to the biological reality observed in the field (Figure 5.26).

Figure 5.26 Examples of comparisons of two Individuals (Aggressive & Linda) home range values in (ha) using three Home-range estimators (MPC % ; KDE (h_{ref}) ; KDE (h_{lcsv}), and different smoothing factors.



5.5 Analysis of Biotope/Habitat Association

Habitat types covered by the individual *Nycticebus c. coucang* within the study areas of Bukit Boloh and Cempaka were analyzed using MCP % estimator (see Figure. 5.27 A & B). The biotopes included Belukar, Forest-High Orchards, Rubber Plantation, Scrub Grass Land, Grass, Main/Small Roads, Cemetery, Mosque and Shrubs and Clear Area. Individuals tracked within the study period and namely group A, B, C, D, E used all or some of the biotopes within their own group home range which reflected overlapping resources utilized.

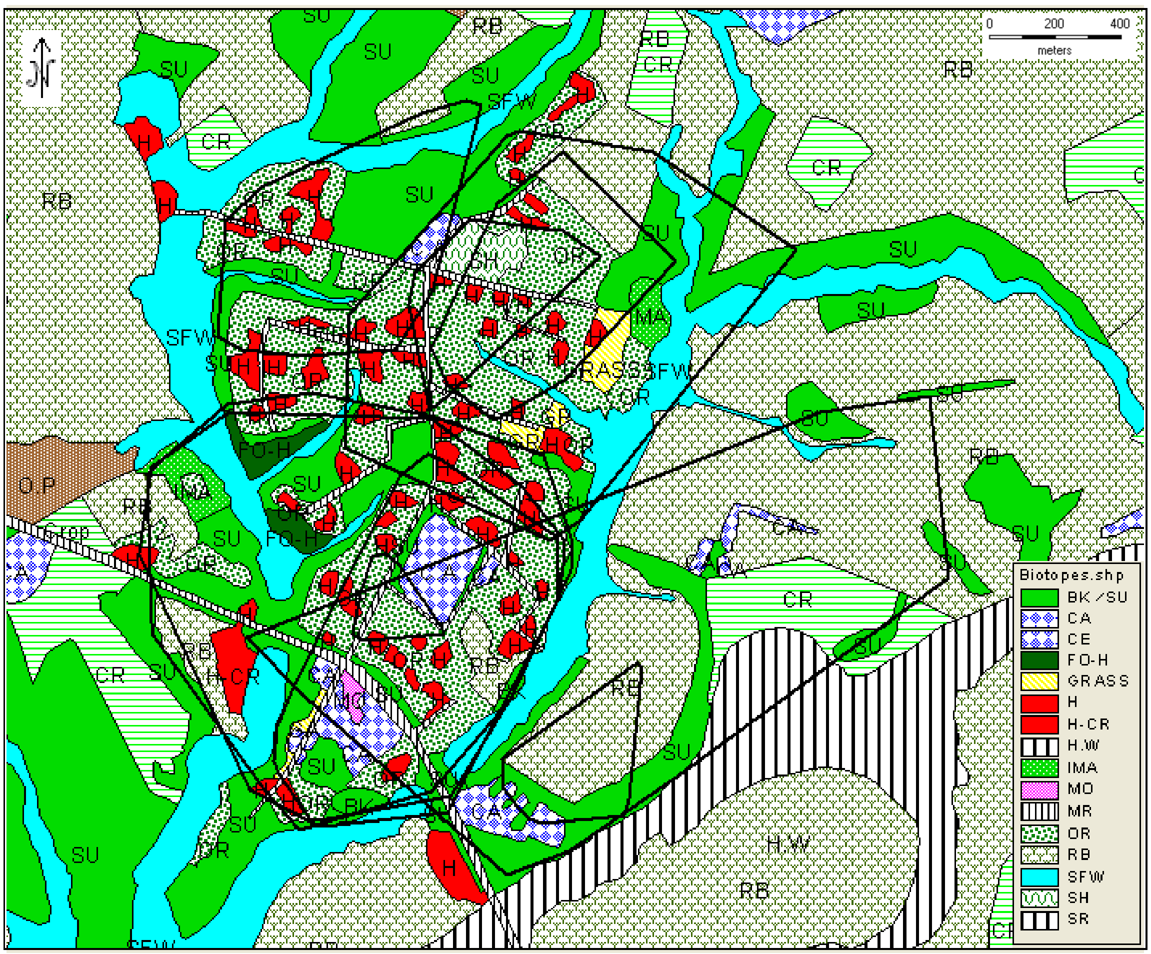


Figure 5.27A Biotopes visited by the 12 individuals in the Cempaka Area, superimposed with the Home Range estimator Minimum Convex Polygon (MCP %). The thick black color line legend represents individuals tracked.

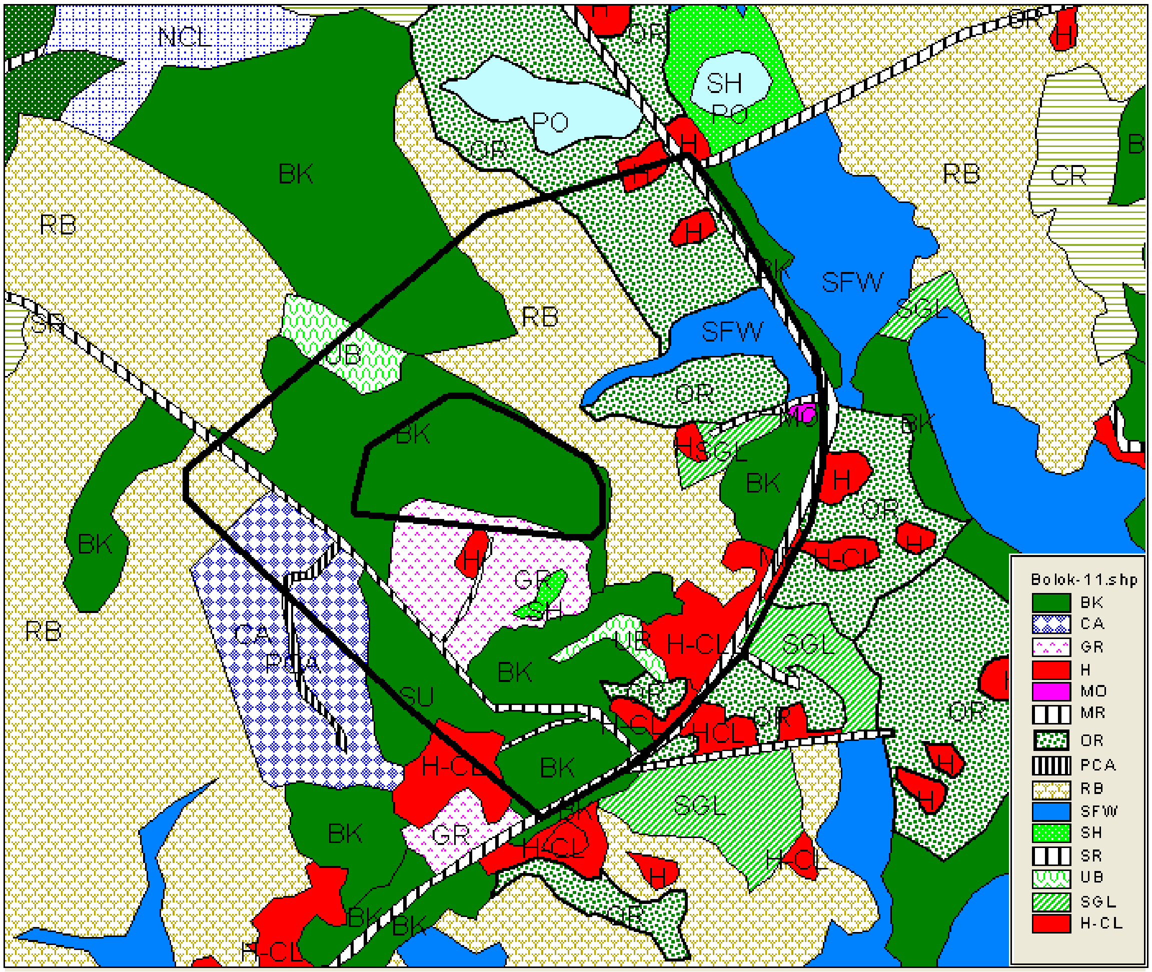


Figure 5.27B Biotopes visited by the two individuals *Nycticebus c. coucang* in the Bukit Boloh area, superimposed with Home Range estimator Minimum Convex Polygon MCP %. The thick black color line legend represents individual tracked.

The Belukar forest was the most common biotope type, having an average observed use of 47 % by all study individuals, followed by all values of biotopes used as reflected in the Figure. 5.28. The order for the biotopes choices were Belukar forest followed by (in order of preference) Orchards, Main & Small Roads which was mainly used when traversing from one forest patch to another biotope by using the long system of thick electrical wires. Biotopes such as Rubber Plantation, Residential Houses and Mosque were used, crossing through thin houses electrical wires from there reaching the house roof as well as by grabbing one of the tree branches while stepping onto the roof. In this way individuals were able to have access to the orchard trees around the houses; small patches of Forest-High around SFW, Clear Area and Cemetery biotopes were visited in several occasions due to fewer scatter trees foraged in.

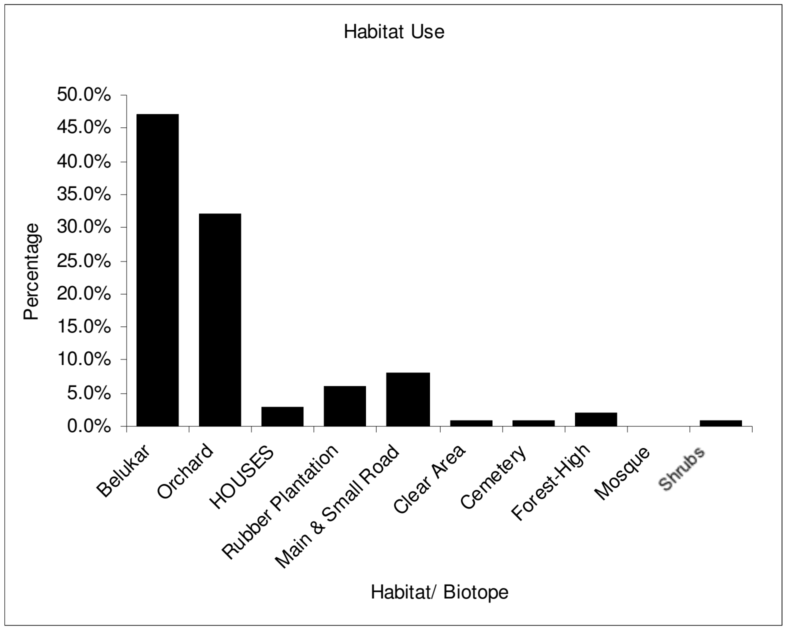


Figure 5.28 Percentage GPS readings/ observed locations and use of habitat types by *Nycticebus c. coucang* in Bukit Boloh and Cempaka area.

There were some habitat types within the study area that *Nycticebus c. coucang* never used such as: Grass, Swamp Fresh Water and Scrub Grass Land.

Taking into account both study areas the number of locations that individuals used within biotope Belukar forest was 842 locations out of 1748 and 546 Orchards (Figure 5.27). Rubber Plantation (108), small patches High Forest (31) and Shrubs accounted for (17) given a total of 156 locations. Housing, Main and Small Roads, Cemetery, Mosque, together accounted for total of 204 locations (Figure. 5.29).

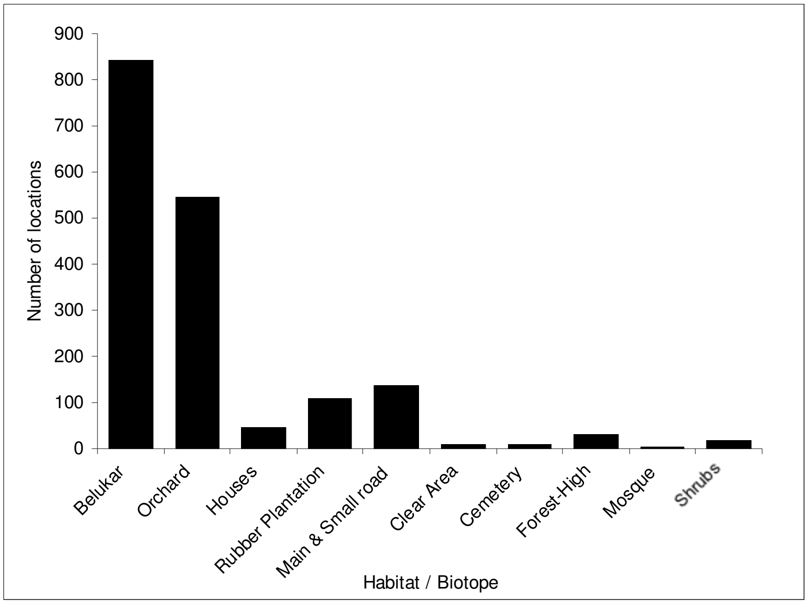


Figure 5.29 Represents Habitat Usage compared with Individual Locations.

5.5.1 Habitat Selection Indicating Sex and Age

5.5.1.1 Biotopes Used by Adult Males

There was a clear selection between biotopes by the males where the individual (Aggressive) visited the highest number of biotopes (7) during the study period such as, Forest-High, Belukar, Orchards, Housing Area, Rubber Plantation, Main and Small Road, Cemetery preferring Belukar (about 40 %). Male ECA visited 4 biotopes (Belukar, Rubber Plantation, Main and Small Road and Clear areas with highest visits recorded in the Belukar biotope (65 %). The male Cop used 5 biotopes in Belukar: Orchards, Rubber Plantation and Small Road, spending about 65 % of the time within the Orchards and about 30 % in Belukar forest, the lowest value among adult males. The adult male KRO presented the lowest used of biotopes (3) and among the all males he used about 50 % in the Belukar forest after ECA (Figure 5.30 A and B). This adult male did not use Main and Small Roads on any occasion while being tracked.

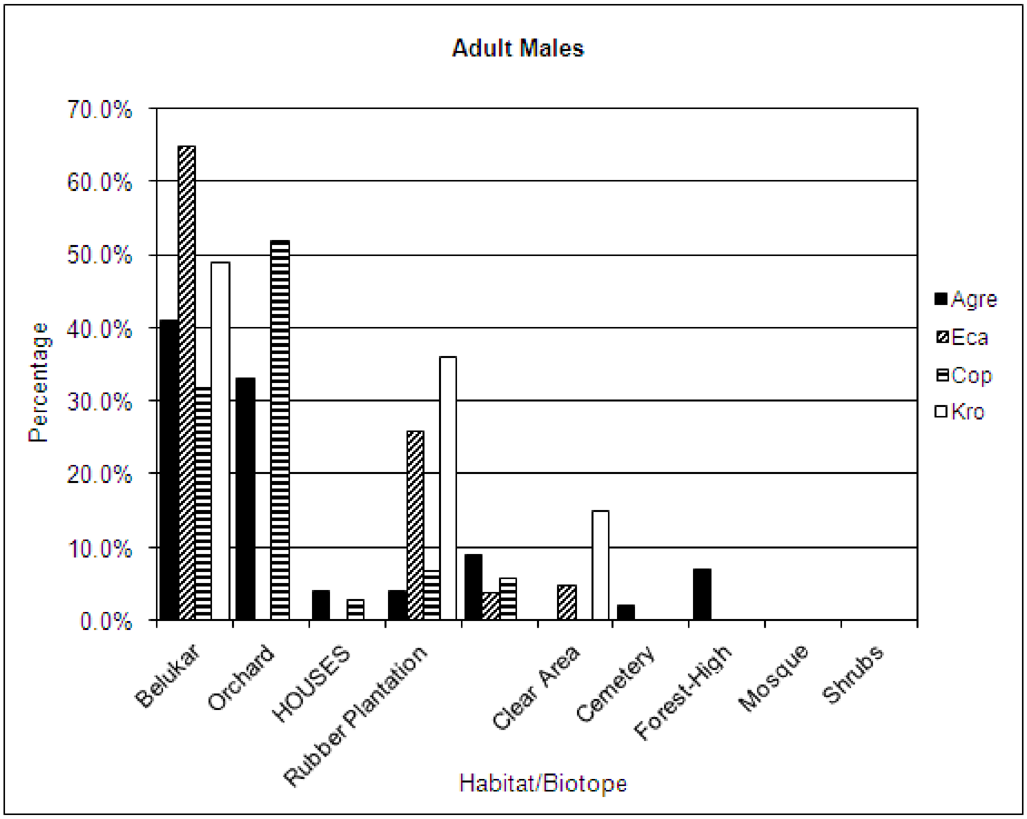


Figure 5.30 A. Percentage of Biotope/Habitat used by each adult male *Nycticebus c. coucang* tracked in Cempaka area.

5.5.1.2 Biotopes Used by Adult Females

The adult female Linda (from Bukit Boloh) visited 7 biotopes, and those used in great proportion were Belukar forest 65 %, and 15 % orchards. Female Timida visited the same proportion of biotopes as the male (AG) (see male above), the most visited biotope by this female was Belukar (65 %) and Orchards (12 %). Bonita, the one which delivered in captivity, used 4 biotopes; the most commonly visited was Belukar with 65 %. Finally, the adult “Fala” used the Orchards most commonly amount the females adults with about 70 %, and with 20 % for Belukar (Figure 5.31 A and B).

Biotope Selection by Adult Males

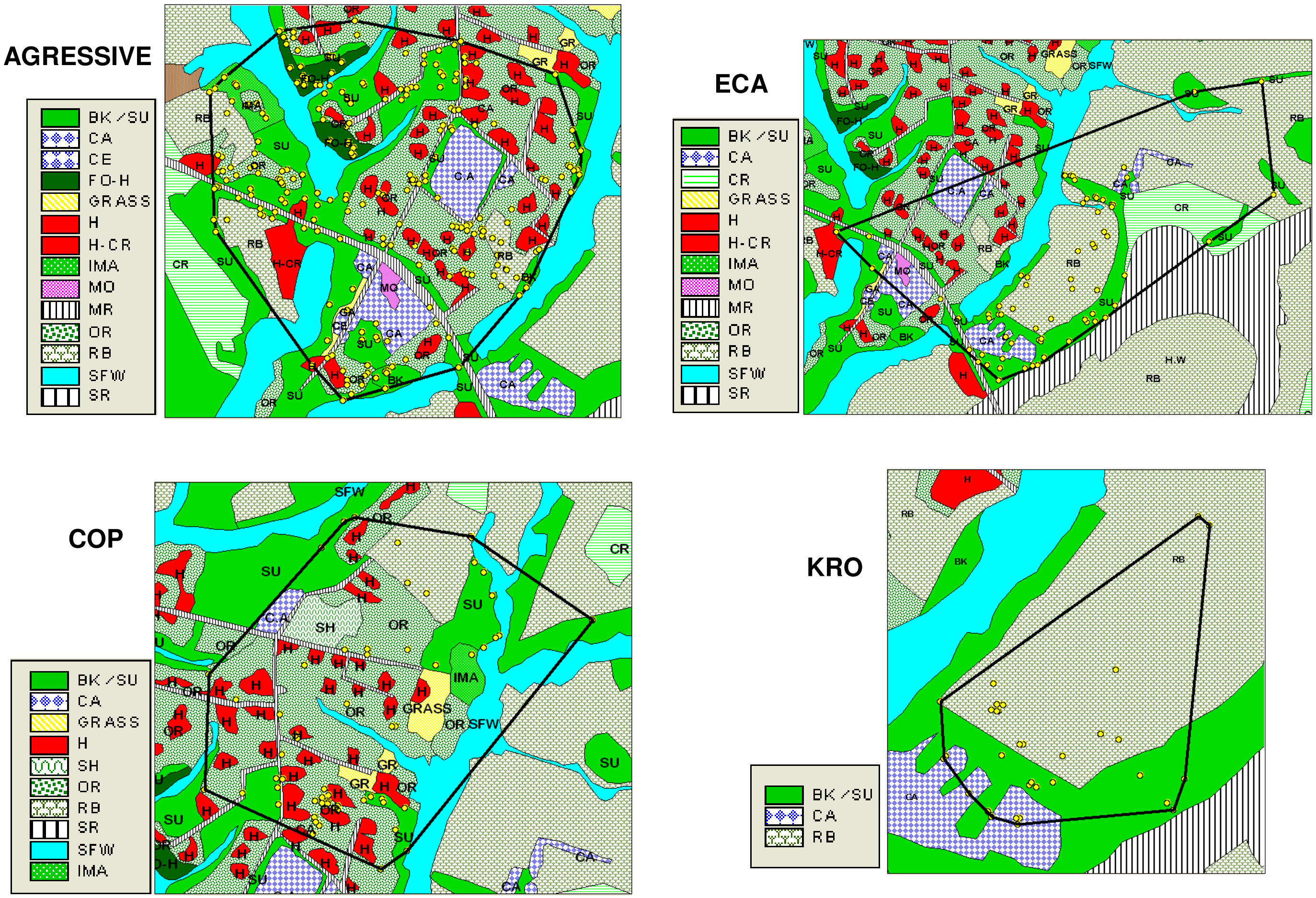


Figure 5.30 B. Biotopes visited by adult males in Cempaka Area, superimposed with Home range estimator Minimum Convex Polygon (MCP %) The thick black color line legend represent individual tracked.

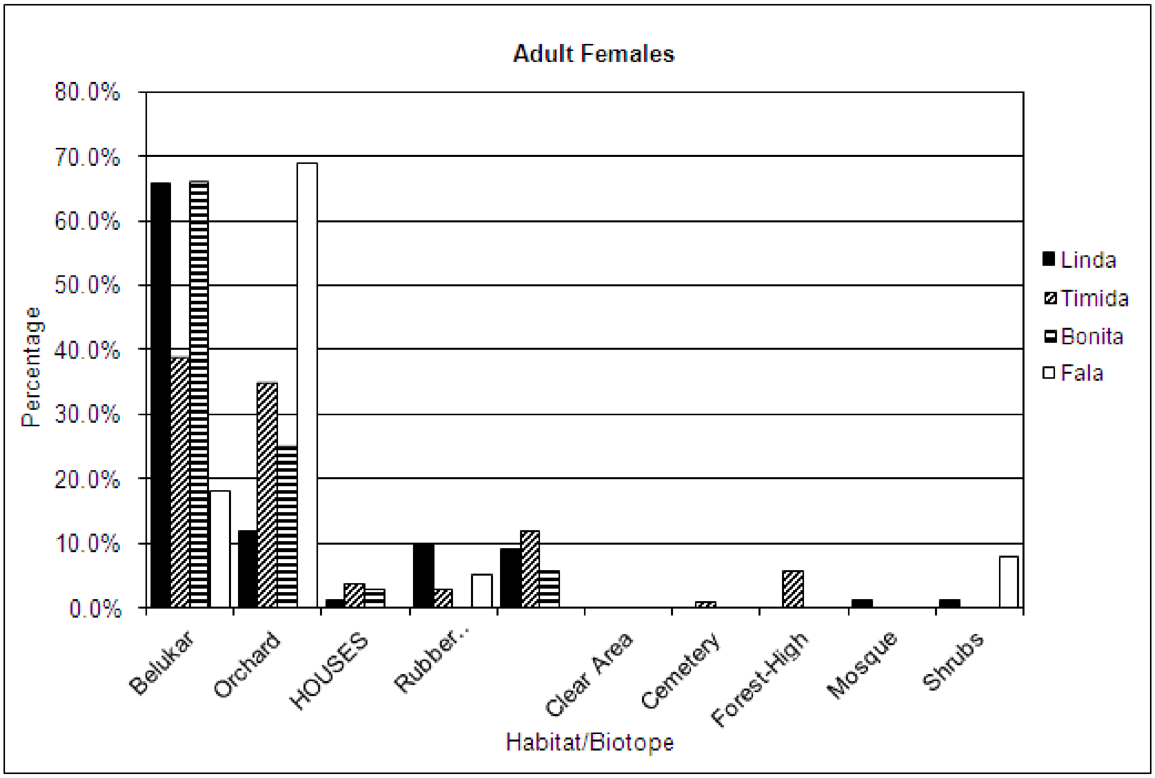


Figure 5.31 A. Percentage of Biotope/Habitat used by each adult female *Nycticebus c. coucang* tracked in the Bukit Boloh and Cempaka areas.

In general the adult females more or less used the Main and Small Roads with equal intensity; nevertheless Fala presented the lowest percentage use (0.5 %).

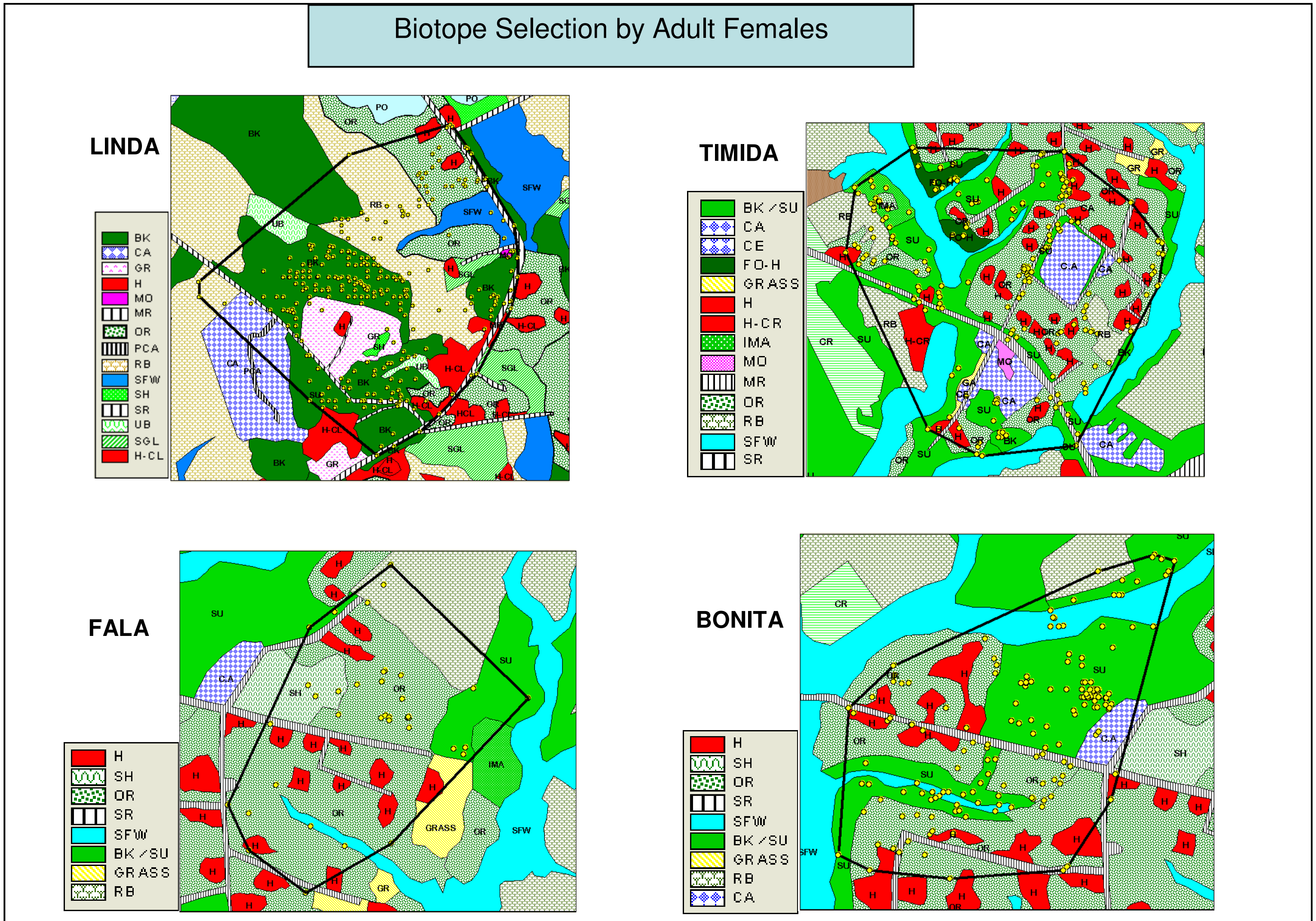


Figure 5.31 B. Biotopes visited by adult females in Bukit Boloh and Cempaka Areas, superimposed with home range estimator Minimum Convex Polygon (MCP %) The thick black color line legend represent individual tracked

5.5.1.3 Biotopes Used by Sub-adults

The sub-adult female “Hermosa” visited twice the number of Biotopes (6) than the sub-adult male Gent (3). Hermosa visited almost the same number biotopes as Timida and Aggressive, but spent a much smaller proportion of time in these.

The two most frequently visited biotopes of this sub-adult female were Orchards 50 % and Belukar 25 %. The sub-adult male did not visit Belukar forest, but recorded the highest percentage value for Orchards used (50 %) among all individuals tracked in Cempaka (Figure 5.32 A and B).

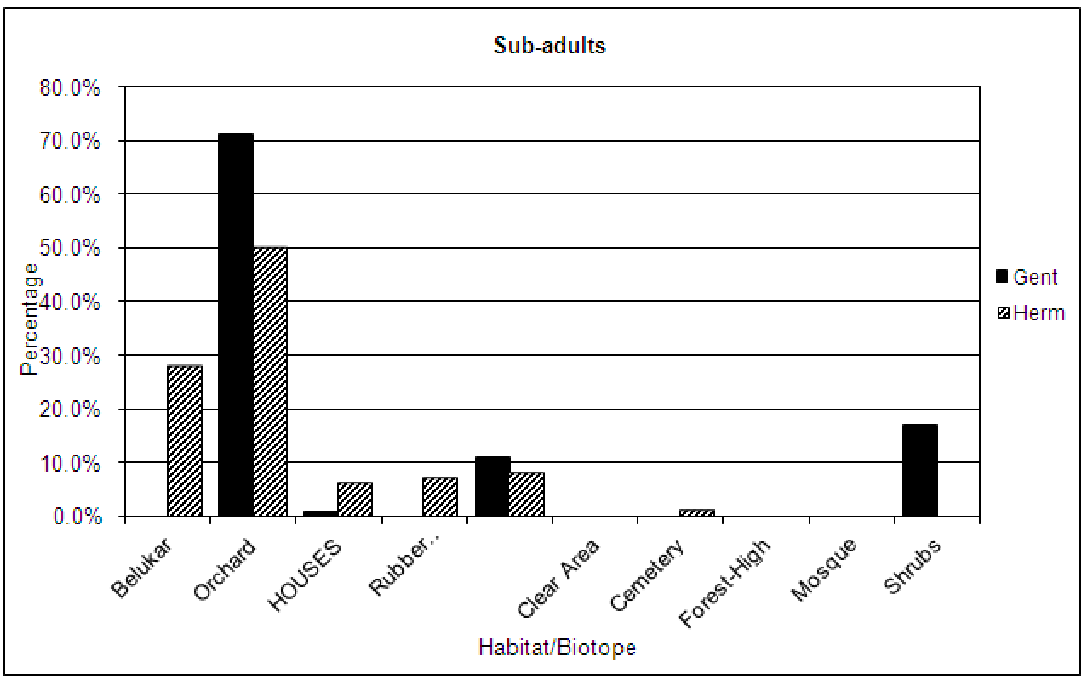


Figure 5.32 A. Percentage of Biotope/Habitat used by each sub-adult tracked in Cempaka area, six biotopes were used by sub-adult female “Hermosa” and four biotopes by sub-adult male “Gent”.

Biotope Selection by Sub-adults

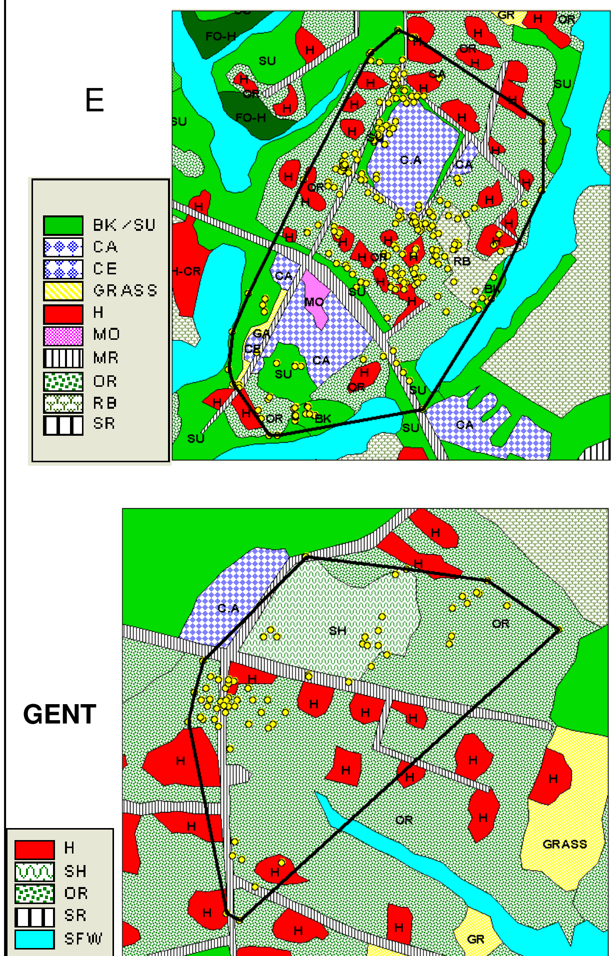


Figure 5 32 B. Biotopes visited by Sub-adult female and Sub-adult male Cempaka Area,

Biotope Selection by Infants

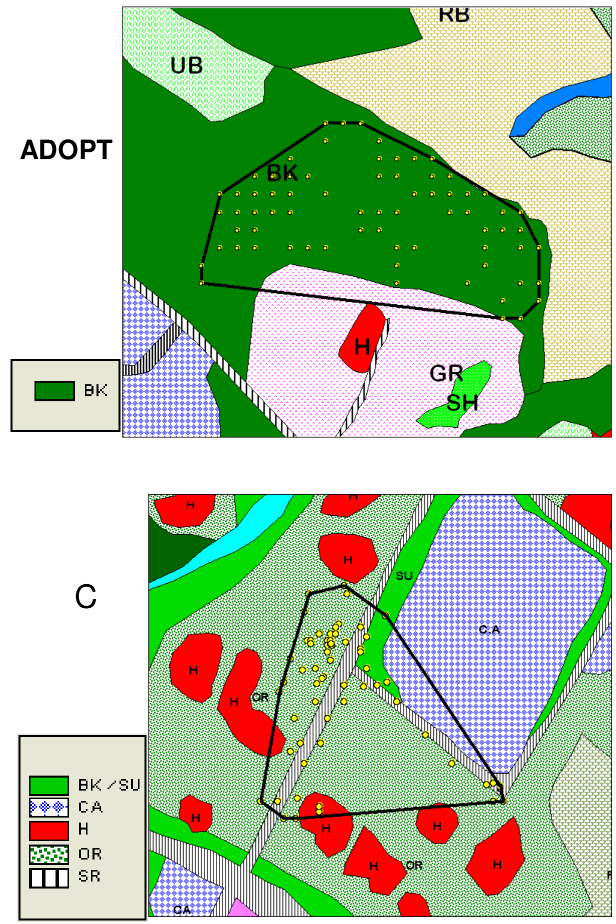


Figure 5 33 A. Biotopes visited by Infant Adopt in Bukit Boloh and Infant Little in Cempaka Area,

5.5.1.4 Biotopes Used by Infants

The offspring "Little" of the adult parent (Timida and Aggressive) utilized a relatively high numbers of biotopes (4) in contrast to the adopted offspring "Adopt" which only visited one (1) biotope. The "Little" infant used the same orchards previously associated with Aggressive, Timida and Hermosa with a percentage of 67 % and with low used of Belukar 0.8 % (Figure 33 A and B).

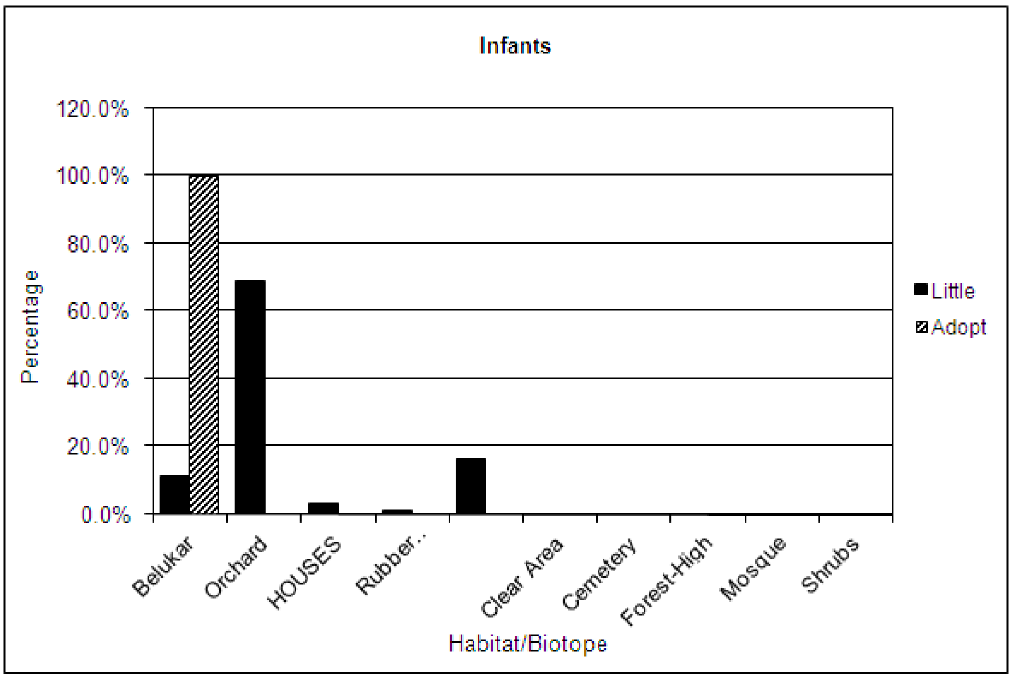


Figure 5.33 B. Percentage of biotope/habitats used by each infant tracked in Bukit Boloh and Cempaka area.

5.6 Analysis of Each Individual

Further analyses were carried out for sleeping sites corridors, home ranges, estimators, movement and biotopes, individually for each individual tracked. Illustration is presented per each analysis for all individuals in Appendix 2B and Appendix 2C.