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An eco-ethological study on Golden Langurs (*Trachypithecus geei*) in Western Assam, India -With reference to their Social organization

Debahutee Roy[1] and R. Nagarajan[2]

[1]*All India Network Project On Vertebrate Pest Management, Professor Jayashankar Telangana State Agricultural University, Hyderabad, India*

[2] *PG and Research Department of Zoology and Wildlife Biology, A.V.C. College (Autonomous), Mannampandal, Mayiladuthurai, Tamil Nadu, Southern India*

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ABSTRACT

Eco-ethological aspects of the Golden Langur (*Trachypithecus geei*) were studied between May 2013 to April 2015 in three fragmented habitats of Western Assam. The months were grouped into two broad seasons (Wet – May to October and Dry – November to April). Three troops in each three habitats were taken and each group was followed for an average of 6-10 days per month for determining group-size and composition, age-sex relationship. A total of 33 troops were sighted and troop size (number of individuals in the troop) was recorded during the study period. Troop size varied from 3 to 25 individuals.

Key words: Golden Langur, *Trachypithecus geei*, ecology, social organization, India

INTRODUCTION

The colobine monkeys have provided primatologists with a rich array of ethological and ecological data upon which many models have been generated on the evolution of primate behavior. The colobines are medium-sized primates with long tails and diverse colorations. In this group of monkey most of the research information is available on two species viz., (a) Hanuman Langur and (b) on Red Colobus monkey. The genus *Trachypithecus* is the most diverse langur taxon, having a broad distribution including India, Sri Lanka, Bangladesh, Southwestern China, and Southeast Asia. It is phylogenetically embedded within the family Cercopithecidae and closely related to Semnopithecus. Golden Langur *Trachypithecus geei* (Khajuria 1956) is one of the least studied primate species of Northeast India. The Golden Langur is a rare colobine monkey with a very restricted range being confined to Western Assam in India and Bhutan only. Due to rapid transformation of natural habitats into human settlements, agricultural plots and industrial complexes, Golden Langurs have virtually disappeared from their former range in Western Assam in India. Golden Langur troops are still left in small and isolated pockets of 19 fragmented areas in western Assam which was originally a single habitat. Except for Manas, Ripu, and to some extent Chirang, the remaining populations have no link with the larger and more secure Bhutanese populations (Roy and Nagarajan, 2018). Many of these fragmented populations have little possibility of long-term survival. Thus, primates that specialize in one primary habitat are more likely to go extinct. Here we report various aspects of Golden Langurs including the group size and composition, age-sex relationship, food plants used and techniques used to feed on plants.

MATERIALS AND METHODS

Collection Methods

The group-size and composition, age-sex ratios and relationships have been determined on the basis of fieldwork conducted between May 2013 to April 2015. For each sighting of Golden Langur troop, group size and composition were recorded by taking care to spend time in all habitats in proportion to their size. Individuals in a group were classified into different age sex classes based on the criteria followed as per Stanford (1991). The Langurs were categorised into adult males, adult females, sub adult males, sub adult females, juveniles and infants. During the scan sampling methods (Altmann, 1974), animals were systematically scanned from left to right of the observed group, thus the randomness was maintained on individuals or behaviours. Age- sex class and behavior of each individual were recorded during the scan. Each group in all the three habitats was followed from dawn to dusk for six to ten consecutive days every. All data were gathered through direct observations. A pair of 10×50 mm binoculars was used in this work when needed.

Study Sites

Three fragments of forest reserves were selected for intensive study on the basis of Golden Langur's presence, size and isolation, similarity of vegetation and the surrounding matrix, and logistic feasibility (Figures 1 & 2).

Semi evergreen Forest (SEF)

For this type of habitat, Kakoijana Reserve Forest an isolated habitat situated in Bongaigaon District of Southern Assam, India (26° 24' N-latitude and 90° 36.5'

*Corresponding Author's E-mail: moni.roy8@gmail.com

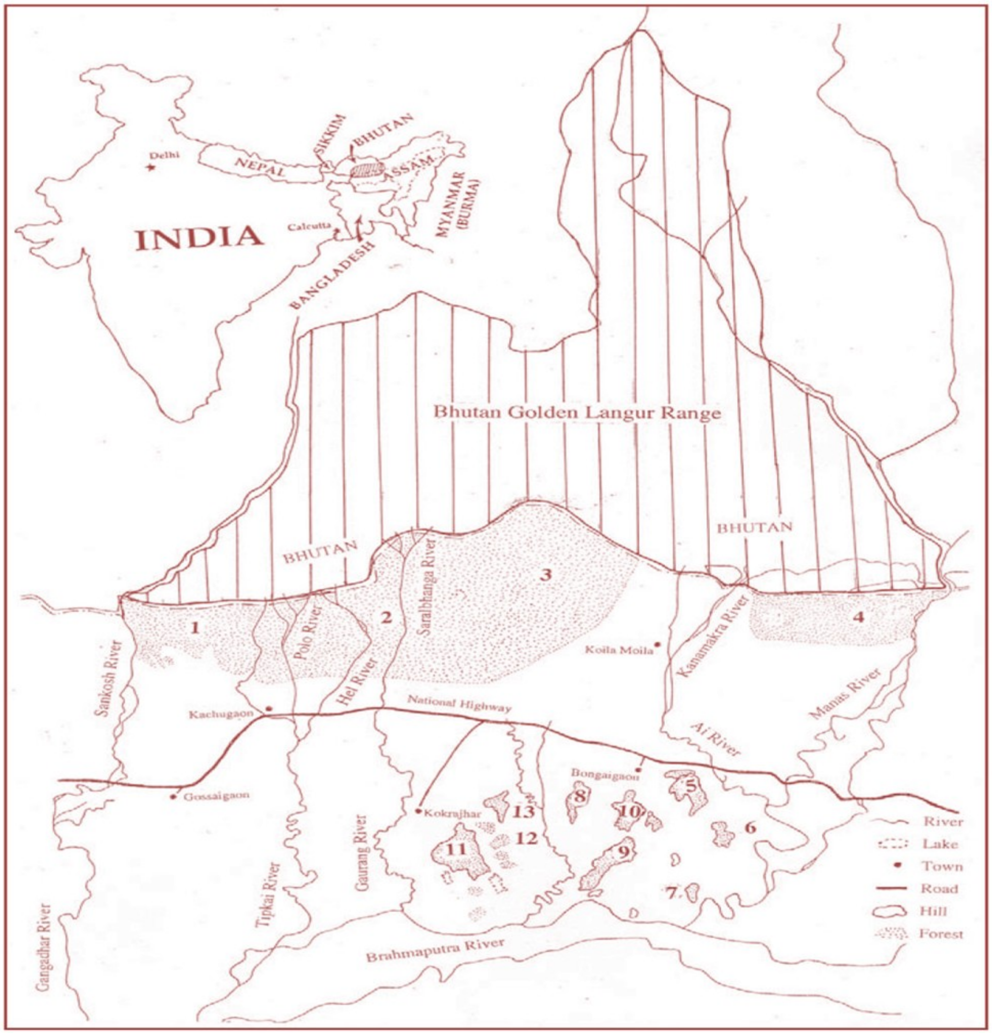

Figure 1. In the map marked with an arrow, 5- Kakoijana Reserve Forest; 6- Bamungaon Reserve Forest and 12- Abhaya Rubber Plantation

E longitude) with a total area of 17.201 square kms was selected. Kakoijana Reserve Forest is bounded on East by the river Aie and on west by river Kujia with its tributaries. Remaining sides of Kakoijana Reserve Forest possess paddy fields. Vegetation type of Kakoijana Reserve Forest is semi evergreens to mix deciduous with a wide range of floral and faunal diversity, hence it was declared as reserve forest for biodiversity conservation (Figure 2a).

Mixed deciduous Forest (MDF)

For this type of habitat, Bamungaon Reserve Forest situated in Bongaigaon district of Southern Assam, with a total area of 10.07square kms was selected which is bounded by paddy fields. Vegetation type of Bamungaon Reserve Forest is semi evergreens to mix deciduous with a wide range of floral and faunal diversity(Figure 2b).

Rubber dominating sal (Shorea robusta) Fragmented Forest (RDF)

To study Golden Langur in this type of habitat, Nyakgaon Proposed Reserve Forest or Abhaya Rubber Plantation, Western Assam, India was selected which is a private land area of 174.03 ha of rubber plantation and patches of natural forest which was once was a continuous habitat. The estate, lies between 26^{0}7’12” N to 26^{0}47’50” N and 89^{0}47’40’’ E to 92^{0}18’30’’ E longitude situated in the Kokrajhar district, 20 kms away from Kokrajhar town has a small isolated population of endangered Golden Langur *Trachypithecus geei*. Golden Langurs were first reported from the area when rubber plantations were started in 1985. It seems that the area was once natural habitat of Golden Langurs and they continued to survive in the altered habitat (Figure 2c).

Data Analysis

Basic statistics viz. mean, standard deviation and standard error were calculated for all the replicative variables and are given as $\bar{X}$±SD or $\bar{X}$±SE. Statistical analyses were performed by using Windows based statistical package *viz.* Microsoft Excel, MINITAB (Ryan *et al*., 1992), Mainly parametric test *viz*. Pearson correlation coefficient, Analysis of Variance and Multiple regression equation were used to test different hypothesis. Appropriate data transformations were made whenever needed. For hypothesis testing $P<0.05$ and $P<0.01$ were considered and these level of significance were indicated at appropriate places.

Figure2 a. Landscape showing the habitat of Golden Langur in Kakoijana Reserve Forest of Assam, a fragmented SEF with adjacent paddy fields. The langur population found in this habitat is isolated.

Figure 2 b. Landscape showing the habitat of Golden Langur in Bamungaon Reserve Forest of Assam, a fragmented MDF with adjacent paddy fields. The langur population found in this habitat is isolated.

Figure 2c. Landscape showing the habitat of Golden Langur in Nayakgaon Rubber garden of Assam, a fragmented RDF. The langur population found in this habitat is also isolated.

RESULTS

Variations in Golden Langur age-sex social system in three different habitats across seasons

The variation ($\bar{X}$±SD) in the number of Golden Langur individuals (n=144) in different social system among the habitats in two different seasons is given in Table 1

The overall (irrespective of habitats and age-sex classes) number of Golden Langur individuals in five different social systems varied. The average number of Golden Langur individuals in dry season was 13.2±4.96/10sq.kms. (irrespective of social systems) and the average number of Golden Langur individuals in wet season was 13.1±4.27/10sq.kms. (irrespective of social systems). Among the five social system, in the dry season, Golden Langur individual was highest in multi male -multi female social system (18.5±6.24/10sq.kms.) and lowest in all male and lone male social system each being

Table 1. Number of individuals in different social systems of Golden Langur (*Trachypithecus geei*) of various age-sex classes in various habitats across the seasons in fragmented habitats of Western Assam from May 2013-April 2015.

Habitat [b]	Season	N	Social system	Age sex class [a]									
				AM	AF	SAM	SAF	JM	JF	INF	A?	SA?	Overall
SEF	Dry	18	Uni male-multi female	1.00±0.00	4.66±0.90	0.72±0.66	0.88±0.75	1.38±0.84	0.77±0.73	0.83±0.61	0.22±0.42	0.05±0.23	10.5±1.46
		19	Bi male multi female	2.00±0.00	5.47±1.17	0.52±0.61	1.00±1.00	1.78±0.71	1.00±0.94	1.68±0.47	0.52±0.69	0.15±0.50	14.1±2.21
		3	Multi male multi female	4.66±1.53	5.33±4.50	0.66±0.57	1.00±1.00	2.33±1.15	1.66±2.08	2.33±0.57	0.66±1.15	0	18.6±7.63
		0	Lone male	--	--	--	--	--	--	--	--	--	--
		0	All male	--	--	--	--	--	--	--	--	--	--
		40	Overall	1.75±1.03	5.10±1.48	0.62±0.62	0.95±0.87	1.65±0.83	0.95±0.95	1.35±0.73	0.40±0.63	0.10±0.37	12.8±3.47
	Wet	54	Uni male-multi female	1.07±0.38	4.61±0.76	0.55±0.60	0.72±0.81	1.44±0.83	0.83±0.69	0.90±0.68	0.27±0.45	0.33±0.82	10.7±1.45
		53	Bi male multi female	2.02±0.14	5.54±1.24	0.61±0.69	1.22±1.03	1.71±0.79	1.01±0.97	1.56±0.57	0.45±0.69	0.16±0.50	14.3±2.17
		9	Multi male multi female	4.22±1.48	5.33±3.90	0.66±0.50	1.22±0.97	2.55±0.72	1.00±0.86	2.55±1.58	0.66±1.00	0	18.2±7.15
		0	Lone male	--	--	--	--	--	--	--	--	--	--
		0	All male	--	--	--	--	--	--	--	--	--	--
		116	Overall	1.75±0.97	5.09±1.49	0.59±0.63	0.99±0.95	1.65±0.85	0.93±0.84	1.33±0.87	0.38±0.62	0.23±0.66	12.9±3.45

Table 1 continued…

Habitat [b]	Season	N	Social system	AM	AF	SAM	SAF	JM	JF	INF	A?	SA?	Overall
MDF	Dry	8	Uni male-multi female	1.00±0.00	3.75±0.88	0.50±0.53	1.75±0.46	0.75±0.46	0	0	0	0	7.75±0.88
		2	Bi male multi female	2.00±0.00	4.00±0.00	1.00±0.00	2.00±0.00	2.00±0.00	0	0	0	0	11.0±0.00
		0	Multi male multi female	--	--	--	--	--	--	--	--	--	--
		0	Lone male	--	--	--	--	--	--	--	--	--	--
		0	All male	--	--	--	--	--	--	--	--	--	--
		10	Overall	1.20±0.42	3.80±0.78	0.60±0.51	1.80±0.42	1.00±0.66	0	0	0	0	8.40±1.57
	Wet	8	Uni male-multi female	1.00±0.00	3.75±0.88	0.50±0.53	1.75±0.46	0.75±0.46	0	0.12±0.35	0	0	7.87±1.12
		2	Bi male multi female	2.00±0.00	4.00±0.00	1.00±0.00	2.00±0.00	2.00±0.00	0	0	0	0	11.0±0.00
		0	Multi male multi female	--	--	--	--	--	--	--	--	--	--
		0	Lone male	--	--	--	--	--	--	--	--	--	--
		0	All male	--	--	--	--	--	--	--	--	--	--
		10	Overall	1.20±0.42	3.80±0.78	0.60±0.51	1.80±0.42	1.00±0.66	0	0.10±0.31	0	0	8.50±1.65

Table 1 continued…

Habitat b	Season	N	Social system	AM	AF	SAM	SAF	JM	JF	INF	A?	SA?	Overall
RDF	Dry	8	Uni male-multi female	1.00±0.00	5.87±0.99	1.12±1.24	2.12±0.35	1.00±0.75	2.12±1.24	1.37±1.40	0	0	14.6±2.50
		7	Bi male multi female	2.00±0.00	8.14±0.69	2.42±0.97	2.85±0.89	1.42±0.53	1.85±0.89	2.42±0.78	0.57±0.97	0.57±0.97	22.2±3.09
		1	Multi male-multi female	3.00±0.00	6.00±0.00	0	3.00±0.00	2.00±0.00	0	4.00±0.00	0	0	18.0±0.00
		1	Lone male	1.00±0.00	0	2.00±0.00	0	0	0	0	0	0	3.00±0.00
		1	All male	3.00±0.00	0	0	0	0	0	0	0	0	3.00±0.00
		18	Overall	1.61±0.69	6.11±2.58	1.55±1.29	2.22±1.06	1.11±0.75	1.66±1.23	1.77±1.39	0.22±0.64	0.22±0.64	16.5±6.55
	Wet	8	Uni male-multi female	1.00±0.00	5.87±0.99	1.25±1.16	2.12±0.35	1.12±0.64	2	1.62±1.30	0	0	15.0±2.20
		7	Bi male multi female	2.00±0.00	8.28±0.95	2.42±0.97	2.85±0.89	1.42±0.53	1.85±0.89	2.57±0.53	0.57±0.97	0.57±0.97	22.5±2.76
		1	Multi male multi female	2.00±0.00	6.00±0.00	2.00±0.00	3.00±0.00	2.00±0.00	1.00±0.00	1.00±0.00	0	0	17.0±0.00
		1	Lone male	1.00±0.00	0	0	0	0	0	0	0	0	1.00±0.00
		1	All male	3.00±0.00	0	0	0	0	0	0	0	0	3.00±0.00
		18	Overall	1.55±0.61	6.16±2.66	1.61±1.24	2.22±1.06	1.16±0.70	1.66±1.13	1.77±1.21	0.22±0.64	0.22±0.64	16.6±6.76

Table 1 continued…

Habitat b	Season	N	Social system	AM	AF	SAM	SAF	JM	JF	INF	A?	SA?	Over-all
Overall	Dry	34	Uni male-multi female	1.00±0.00	4.73±1.16	0.76±0.81	1.38±0.81	1.14±0.78	0.91±1.08	0.76±0.92	0.11±0.32	0.02±0.17	10.8±2.90
		28	Bi male multi fe-male	2.00±0.00	6.03±1.64	1.03±1.07	1.53±1.23	1.71±0.65	1.14±1.00	1.75±0.79	0.50±0.74	0.25±0.64	15.9±4.46
		4	Multi male multi female	4.25±1.50	5.50±3.69	0.50±0.57	1.50±1.29	2.25±0.95	1.25±1.89	2.75±0.95	0.50±1.00	0	18.5±6.24
		1	Lone male	1.00±0.00	0	2.00±0.00	0	0	0	0	0	0	3.00±0.00
		1	All male	3.00±0.00	0	0	0	0	0	0	0	0	3.00±0.00
		68	Overall	1.63±0.89	5.17±1.89	0.86±0.92	1.41±1.04	1.41±0.83	1.00±1.09	1.26±1.05	0.29±0.59	0.11±0.44	13.1±4.96
	Wet	70	Uni male-multi female	1.05±0.33	4.65±0.94	0.62±0.70	1.00±0.90	1.32±0.81	0.87±0.86	0.90±0.81	0.21±0.41	0.25±0.73	10.9±2.29
		62	Bi male multi fe-male	2.01±0.12	5.80±1.51	0.83±0.91	1.43±1.12	1.69±0.75	1.08±0.99	1.62±0.70	0.45±0.71	0.20±0.57	15.1±3.50
		10	Multi male multi female	4.00±1.56	5.40±3.68	0.80±0.63	1.40±1.07	2.50±0.70	1.00±0.81	2.40±1.57	0.60±0.96	0	18.1±6.75
		1	Lone male	1.00±0.00	0	0	0	0	0	0	0	0	1.00±0.00
		1	All male	3.00±0.00	0	0	0	0	0	0	0	0	3.00±0.00
		144	Overall	1.68±0.91	5.13±1.71	0.72±0.79	1.20±1.03	1.54±0.85	0.95±0.92	1.30±0.96	0.34±0.61	0.21±0.63	13.1±4.27
ANOVA			Habitat	**F=78.0; P<0.05**	**F=33.15; P<0.05**	**F=29.66; P<0.05**	**F=48.5; P<0.05**	**F=5.07; P<0.05**	**F=28.97; P<0.05**	**F=30.96; P<0.05**	**F=2.45; P<0.05**	**F=1.22 P<0.05**	**F=79.08;P<0.05**
			Group	**F=74.0; P<0.05**	**F=31.47; P<0.05**	**F=3.96; P<0.05**	**F=11.4; P<0.05**	**F=10.2; P<0.05**	**F=4.39; P<0.05**	**F=24.37; P<0.05**	**F=2.69; P<0.05**	**F=0.64; P=0.63**	**F=74.01; P<0.05**
			Season	F=0.12; P>0.05	F=0.01; P>0.05	F=0.01; P>0.05	F=0.07; P>0.05	F=0.02; P>0.05	F=0.01; P>0.05	F=0.01; P>0.05	F=0.00; P>0.05	F=1.05; P>0.05	F=0.12; P>0.05

[a] AM=Adult Male; AF= Adult Female; SAM= Sub Adult Male; SAF=Sub Adult Female; JM=Juvenile Male; JF-Juvenile Female; INF=Infant; A?= Sex Unidentified Adult; SA?=Sex Unidentified Sub adult. [b] SEF= Semi Evergreen Forest; MDF=Mixed Deciduous Forest; RDF= Rubber dominating sal (*Shorea robusta*) Forest.

3.0/10sq.kms whereas, in the wet season, it was highest in multi male-multi female social system (18.1±6.75 /10sq.kms.) and lowest in lone male social system with 1.0 individual followed by all male social system with 3.0/10sq.kms. (Table 1).

The mean percentage of Golden Langur individuals of various age-sex classes varied significantly among habitats except unidentified adult male ($F=2.45$; $P>0.05$) and unidentified adult female ($F=1.22$; $P>0.05$) (Table 1). The mean percentage of Golden Langur individuals of all age sex classes showed a significant variation among the social system categories except unidentified sub adult ($F=0.64$; $P>0.05$) (Table 1) whereas, there was no significant variation of Golden Langur age-sex classes across the seasons ($F=0.01$; $P>0.05$) (Table 1).

Troop size and Age and sex composition

Golden Langur is a gregarious animal lives in troops. A total of 33 troops were sighted and troop size (number of individuals in the troop) was recorded during the study period. Troop size varied from 3 to 25 individuals. Other than single or solitary individual (males) which were recorded most frequently in RDF, and the frequent group size was four. The median group size was four recorded in MDF. The maximum group size of individuals 25 was recorded in SEF. The solitary individual sightings constituted 16% of overall sightings and they were all adult males alone (16%) (Figure 3).

The percent compositions of different age-sex class of Golden Langur in different habitats across various seasons are given in Table. 2.

Overall age-sex composition

Bulk of the population composed of adult females with a percentage of 6.17% followed by sub adult females (2.22%) in dry season. Juvenile male and unidentified adult composed of 1.55% and 0.34% in wet season. The percentage of infant and juvenile female was higher with 1.78% and 1.67% respectively in dry season. Unidentified sub adult percentage remained similar in both seasons with 0.22% for wet and dry seasons respectively (Table 2).

Habitat and seasonal variation

SEF- Dry season: In SEF, bulk of the population composed of adult female (5.10%) followed by adult male (1.75%) juvenile male (1.65%) and infant (1.35%). The sub-adult male and sub adult female constituted 0.63% and 0.95. The unidentified adult and unidentified sub adult were less than 0.50% respectively (Table 2).

SEF- Wet season In SEF, bulk of the population composed of adult female (5.18%) followed by adult male (1.63%). Sub adult female and juvenile male each constituted 1.41% respectively followed by infant with 1.26%. Others are less than 1.0% (Table 2).

MDF- Dry season: In MDF, mass of the population composed of adult female (3.80%) followed by sub adult female (1.80%), adult male (1.20%), juvenile male (1.00%) and sub adult male (0.60%). Juvenile female, infant, unidentified adult and unidentified sub adult were not recorded in MDF during dry season (Table 2).

MDF-Wet season: In MDF, mass of the population composed of adult female (5.09%) followed by adult male (1.75%), juvenile male (1.66%), and infant (1.34%). Others less than 1.0% in MDF during wet season (Table 2).

RDF - Dry season: In MF, bulk of the population composed of adult female (6.11%) followed by sub adult female (2.22%), infant (1.78), Juvenile female (1.67%), adult male (1.61%), sub adult male (1.56%) and juvenile male (1.11%). Unidentified adult and unidentified sub adult were recorded very less with 0.22% each respectively in dry season (Table 2).

RDF- Wet season: In MF, bulk of the population composed of adult female (3.80%) followed by sub adult female (1.80%), adult (1.20%), Juvenile male (1.00%).Others are less than 1.0% in dry season (Table 2).

The percent of all age sex classes in the population varied among habitats (ANOVA) but not across the seasons (Table 2).

Age- Sex ratio

Adult male x Adult female, Sub adult male x sub adult female, Adult female x juvenile male, Adult female x juvenile female and Adult female x infant ratio of Golden Langur (*Trachypithecus geei*) are given in (Table 3). Overall Golden Langur population was skewed towards females (male to female ratio is 1:3.1). Among three different habitats, Rubber dominating sal (*Shorea robusta*) forest had highly slanted ratio (1:4.00). Among the different habitats, percent of males was higher in the Rubber dominating sal (*Shorea robusta*) forest habitat followed by MDF. There was no variation in the percentage of adult males and sub adult males across the seasons in SEF and MDF but the percentage of adult females and sub adult females varied seasonally in the Rubber dominating sal (*Shorea robusta*) forest habitat with a increase in the percentage of adult females in wet season in Rubber dominating sal (*Shorea robusta*) forest and a decrease in the percentage of sub adult females in the wet season in Rubber dominating sal (*Shorea robusta*) forest. Juvenile male was recorded in the population throughout the year but juvenile female was not seen in any of the season in MDF. Infants were observed in the population throughout the year except in the dry season of MDF. Adult female and infant ratio was 1:0.25. Among the two seasons, there was an increase in the percentage of infant in the population during the wet seasons in SEF and MDF but the percentage was similar in Rubber dominating sal (*Shorea robusta*) forest habitat across the seasons (Table 3).

Relationship among the age-sex classes of Golden Langur:

The correlation between different age-sex classes of Golden Langur was assessed using Pearson correlation co-efficient (r) analysis. The correlation indicated that seven of the age-sex classes had significant relationship among themselves (Table 4). The results indicated that there was a significant correlation between the number of adult males to the number of females ($r=0.27$; $P<0.05$) and number of adult females to number of sub adult males ($r=0.25$; $P<0.05$). There was a strong correlation between the number of adult females to number of infants ($r=0.54$; $P<0.05$) (Table 4).

Table 2. Age sex composition of Golden Langur *(Trachypithecus geei)* in different habitats across seasons in different fragmented habitats of Western Assam during the study period May 2013-April 2015.

Age-sex class	**Habitat [a]**						**Overall**		**ANOVA**			
	SEF		**MDF**		**RDF**				**Habitat**		**Season**	
	Dry	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry (N=68)**	**Wet (N=144)**	**F**	**P**	**F**	**P**
Adult male	1.75	1.63	1.20	1.75	1.61	1.20	1.56	1.69	78.0	**P<0.05**	0.12	P>0.05
Adult female	5.10	5.18	3.80	5.09	6.11	3.80	6.17	5.14	33.2	**P<0.05**	0.01	P>0.05
Sub adult male	0.63	0.87	0.60	0.59	1.56	0.60	1.61	0.72	29.7	**P<0.05**	0.01	P>0.05
Sub adult female	0.95	1.41	1.80	0.99	2.22	1.80	2.22	1.20	48.5	**P<0.05**	0.07	P>0.05
Juvenile male	1.65	1.41	1.00	1.66	1.11	1.00	1.17	1.55	5.07	**P<0.05**	0.02	P>0.05
Juvenile female	0.95	1.00	0.00	0.93	1.67	0.00	1.67	0.96	29.0	**P<0.05**	0.01	P>0.05
Infant	1.35	1.26	0.00	1.34	1.78	0.10	1.78	1.31	31.0	**P<0.05**	0.01	P>0.05
Unknown adult	0.40	0.29	0.00	0.39	0.22	0.00	0.22	0.34	2.45	**P<0.05**	0.00	P>0.05
Unknown sub adult	0.10	0.12	0.00	0.23	0.22	0.00	0.22	0.22	1.22	**P<0.05**	1.05	P>0.05

Relationship among the age-sex classes of Golden Langur in uni male- multi female social system.

The correlation between different age-sex classes of Golden Langur in uni male-multi female social system was assessed using Pearson correlation co-efficient (r) analysis. The correlation of the seven age-sex classes had a significant relationship among themselves (Table 5). The results indicated that there is strong correlation between the number of adult females to number of sub adult males (r=0.23; P<0.05) and number of sub adult males to number of sub adult females (r=0.48; P<0.05). There was a significant correlation between the number of adult females to number of infants (r=0.26; P<0.05), number of adult females to number of juvenile male and number of juvenile females (r=0.21; P<0.05) and (r=0.27; P<0.05) respectively (Table 5).

The correlation between age-sex classes in bi male-multi female social system of Golden Langur was assessed using Pearson correlation co-efficient (r) analysis. The correlation of the seven age-sex classes varied significantly among themselves (Table 6). The results indicated that there is strong correlation between the number of adult females to number of sub adult males (r=0.46; P<0.05), number of sub adult males to number of sub adult females and number of juvenile male (r=0.66; P<0.05) and (r=0.42; P<0.05) respectively. There was a strong relationship between the number of adult females to number of juvenile female and number of infants (r=0.59; P<0.05) and (r=0.58; P<0.05) respectively followed by correlation between number of sub adult males to number of infants (r=0.28; P<0.05 (Table 6).

Relationship among the age-sex classes of Golden Langur in multi male- multi female social system

The correlation between age-sex classes in multi male-multi female social system of Golden Langur was assessed using Pearson correlation co-efficient (r) analysis. The correlation of the seven age-sex classes had a significant relationship among themselves (Table 7). The results indicated that there was marginal correlation between the number of adult males to number of adult females (r=0.53; P=0.05), number of adult females to number of sub adult males and number of sub adult female (r=0.64; P<0.05) and (r=0.52; P=0.05) respectively. There was a strong correlation between the number of adult females to number of juvenile male, number of juvenile female and number of infants (r=0.73; P<0.05), (r=0.54; P<0.05) and (r=0.68; P<0.05) respectively followed by correlation between number of sub adult males to number of infants (r=0.62; P<0.05 (Table 7).

DISCUSSION

The most basic characteristics of Primate societies has traditionally been based on social organization alone.The present study showed that the Golden Langur live in a social group. The grouping pattern found to be more or less similar in all the three habitats except lone male and all male band which was encountered only in the rubber domination sal (*Shorea robusta*) habitat. The grouping pattern that has been recorded in this study is similar to the grouping pattern in many other colobines like *Semnopithecus entellus* (Jay 1965), *Colobus guereza (*Dunbar 1987), *Trachypithecus johnii (*Joseph and Ramachandran

Juvenile b) Adult female with infant c) Adult male

d) Sub adult female e) Sub adult male

Figure 3. Age-sex classes of Golden Langurr *(Trachypithecus geei*)

Table 3. Adult male x Adult female, Sub adult male x sub adult female, Adult female x juvenile male, Adult female x juvenile female and Adult female x infant ratio (1:1) of Golden Langur (*Trachypithecus geei*) in different habitats and seasons in fragmented forests of Western Assam from May 2013- April 2015.

Ratio	**SEF**		**MDF**		**RDF**	
	Dry	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**
Adult male x Adult female	2.90	2.90	3.16	3.16	3.79	4.00
Sub adult male x Sub adult female	1.00	1.00	1.80	1.80	1.43	1.37
Adult female x Juvenile male	0.32	0.32	0.47	0.47	0.18	0.18
Adult female x Juvenile female	0.18	0.18	0.00	0.00	0.27	0.27
Adult female x Infant	3.77	3.80	0.00	0.02	0.28	0.28

2003), *Trachypithecus jhonii* (Roy 2012), The uni-male multi female social system followed by bi male-multi female social system is the dominant social structure in our study areas. Among the three habitats, rubber domination sal (*Shorea robusta*) forest was only recorded to have all five social systems and mixed deciduous forest with only two social systems. There are variations in the social system formation among the habitats which may be due to some biological factors such as feeding competition, lack of fertile females in the group and predator risk. The striking diversity of primate social systems has been described and analyzed in reviews by Clutton-Brock (1977). Aspects of this diversity include spacing, grouping and mating patterns, as well as variability in patterns and quality of social relationships.

The most basic dichotomy is that between single- and multi-male groups. During the early years of primate socio-ecology, researchers sought ecological explanations for this dichotomy, such as habitat type or predation risk (Kappeler 2000).

Arboreal folivores demonstrated that the presence of monkey-eating eagles tends to increase the number of males in howlers and colobus on average from one to two, whereas ecologically similar langurs (and some colobus), which are not exposed to such predators, tend to live in single-male groups (van Schaik and Horsterman 1994). In each bisexual group, the number of adult males is related to the predatory pressure (van Schaik and Horstermann 1994). In this study, in rubber domination sal (*Shorea robusta*) forest, Golden Langurs were found to

Table 4. Overall correlation between various age-sex classes of Golden Langur *(Trachypithecus geei)* (irrespective of habitats and seasons) in fragmented habitats of Assam during the study period of May 2013-April

_		AM	AF	SAM	SAF	JM	JF	INF	A?
AF (r)		**0.27**	*	*	*	*	*	*	*
	P	**0.00**	*	*	*	*	*	*	*
SAM (r)		-0.00	**0.25**	*	*	*	*	*	*
	P	0.91	**0.00**	*	*	*	*	*	*
SAF (r)		-0.00	0.10	**0.59**	*	*	*	*	*
	P	0.93	0.13	**0.00**	*	*	*	*	*
JM (r)		**0.32**	**0.34**	**-0.21**	**-0.25**	*	*	*	*
	P	**0.00**	**0.00**	**0.00**	**0.00**	*	*	*	*
JF (r)		**0.15**	**0.46**	0.07	0.06	-0.10	*	*	*
	P	**0.02**	**0.00**	0.26	0.32	0.13	*	*	*
INF (r)		**0.48**	**0.54**	**0.21**	0.12	**0.27**	**0.23**	*	*
	P	**0.00**	**0.00**	**0.00**	0.06	**0.00**	**0.00**	*	*
A? (r)		**0.30**	**0.31**	-0.12	**-0.34**	**0.24**	0.04	**0.25**	*
	P	**0.00**	**0.00**	0.07	**0.00**	**0.00**	0.49	**0.00**	*
SA? (r)		-0.05	**0.13**	-0.05	**-0.26**	0.09	**-0.16**	-0.02	**0.27**
	P	0.42	**0.04**	0.40	**0.00**	0.15	**0.01**	0.77	**0.00**

AF= Adult Female; AM=Adult Male; SAF=Sub Adult Female; SAM=Sub Adult Male; JM=Juvenile Male; JF=Juvenile Female, INF=Infant; A? = Sex Unidentified Adult and SA? = Sex Unidentified Sub Adult.

Table 5. Correlation between various age-sex classes of Golden Langur *(Trachypithecus geei)* (irrespective of habitat and season) in uni male- multi female social system in fragmented habitats of Assam during the study period of

		AM	AF	SAM	SAF	JM	JF	INF	A?
AF (r)		0.04							
	P	0.65							
SAM (r)		0.06	**0.23**						
	P	0.53	**0.01**						
SAF (r)		-0.02	0.05	**0.48**					
	P	0.84	0.57	**0.00**					
JM (r)		-0.04	**0.21**	**-0.42**	**-0.40**				
	P	0.63	**0.03**	**0.00**	**0.00**				
JF (r)		0.01	**0.27**	0.18	0.04	**-0.30**			
	P	0.86	**0.00**	0.06	0.78	**0.00**			
INF (r)		0.02	**0.26**	**0.26**	0.13	-0.02	**0.22**		
	P	0.81	**0.00**	**0.00**	0.15	0.77	**0.02**		
A? (r)		-0.06	**0.22**	**-0.22**	**-0.34**	0.05	-0.12	-0.06	
	P	0.50	**0.02**	**0.02**	**0.00**	0.55	0.19	0.50	
SA? (r)		-0.04	0.09	-0.27	**-0.37**	0.09	-0.11	**-0.29**	**0.22**
	P	0.67	0.34	0.00	**0.00**	0.33	0.25	**0.00**	**0.02**

AF= Adult Female; AM=Adult Male; SAF=Sub Adult Female; SAM=Sub Adult Male; JM=Juvenile Male; JF=Juvenile Female, INF=Infant; A? = Sex Unidentified Adult and SA? = Sex Unidentified Sub Adult.

Table 6. Correlation between various age-sex classes of Golden Langur *(Trachypithecus geei*) (irrespective of habitat and season) in bi male- multi female social system in fragmented habitats of Assam during the study period of May 2013-April 2015.

	AM	AF	SAM	SAF	JM	JF	INF	A?
AF(r)	0.00	×	×	×	×	×	×	×
P	0.47	×	×		×	×	×	×
SAM(r)	0.01	**0.46**	×	×	×	×	×	×
P	0.91	**0.00**	×	×	×	×	×	×
SAF(r)	0.04	0.09	**0.66**	×	×	×	×	×
P	0.64	0.37	**0.00**	×	×	×	×	×
JM(r)	0.19	0.07	**-0.42**	×	×	×	×	×
P	0.07	0.47	**0.00**	×	×	×	×	×
JF(r)	-0.01	**0.59**	0.02	0.14	×	×	×	×
P	0.92	**0.00**	0.84	0.17	×	×	×	×
INF(r)	0.04	**0.58**	**0.28**	0.01	0.06	**0.24**	×	×
P	0.65	**0.00**	**0.00**	0.90	0.55	**0.01**	×	×
A? (r)	-0.06	0.03	-0.06	**-0.39**	0.18	-0.08	0.21	×
P	0.51	0.76	0.56	**0.00**	0.08	0.44	0.04	×
SA? (r)	-0.04	**0.22**	0.11	**-0.21**	0.15	**-0.26**	**0.37**	**0.38**
	0.71	**0.03**	0.26	**0.03**	0.14	**0.01**	**0.00**	**0.00**

AF= Adult Female; AM=Adult Male; SAF=Sub Adult Female; SAM=Sub Adult Male; JM=Juvenile Male; JF=Juvenile Female, INF=Infant; A? = Sex Unidentified Adult and SA? = Sex Unidentified Sub Adult.

Table 7. Correlation between various age-sex classes of Golden Langur *(Trachypithecus geei*) (irrespective of habitat and season) in multi male- multi female social system in fragmented habitats of Assam during the study period of May 2013-April 2015

		AM	AF	SAM	SAF	JM	JF	INF	A?
AF(r)	AF	**0.53**	×	×	×	×	×	×	×
P		**0.05**	×	×	×	×	×	×	×
SAM(r)	SAM	**-0.73**	**-0.64**	×	×	×	×	×	×
P		**0.00**	**0.01**	×	×	×	×	×	×
SAF(r)	SAF	**-0.96**	**-0.52**	**0.66**	×	×	×	×	×
P		**0.00**	**0.05**	**0.01**	×	×	×	×	×
JM(r)	JM	0.10	**0.73**	0.00	-0.24	×	×	×	×
P		0.71	**0.00**	0.18	0.40	×	×	×	×
JF(r)	JF	**0.76**	**0.54**	**-0.52**	**-0.76**	0.14	×	×	×
P		**0.00**	**0.04**	**0.05**	**0.00**	0.63	×	×	×
INF(r)	INF	0.42	**0.68**	**-0.62**	-0.35	0.50	-0.02	×	×
P		0.13	**0.00**	**0.01**	0.21	0.06	0.93	×	×
A? (r)	A?	**0.84**	**0.84**	**-0.76**	**-8.86**	0.49	**0.82**	0.46	
P		**0.00**	**0.00**	**0.00**	**0.00**	0.07	**0.00**	0.09	
SA? (r)	SA?	*	*	*	*	*	*	*	*
		*	*	*	*	*	*	*	*

AF= Adult Female; AM=Adult Male; SAF=Sub Adult Female; SAM=Sub Adult Male; JM=Juvenile Male; JF=Juvenile Female, INF=Infant; A? = Sex Unidentified Adult and SA? = Sex Unidentified Sub Adult.

be driven away by the presence of latex collectors or sometimes chased and killed by dogs (Personal observation). Therefore, we can conclude that wherever there is any other threats or predation risk, Golden Langurs choose to form bi male- multi female social system or multi male-multi female social system to avoid threats and predation risk which may be considered as a principle of social system formation.

Seasonal variation:

In this study, it was found that the occurrence of bi male -multi female group in Golden Langur was more during the wet season when the females were seen to be receptive i.e. in post monsoon season (June to September) (Roy and Nagarajan 2018). Nunn (1999) demonstrated that temporal overlap of female receptive periods predicts the number of males after controlling for the number of females. Furthermore, Mitani *et al*. (1996) found that the qualitative difference between single- and multi male groups is positively associated with the number of females. The socioecological model suggested by Kappeler and Schaik (2002) enthuasized that environmental risks and resources determine the spatial and temporal distribution of fertile females; this ``spatiotemporal'' distribution of females then structures male options for monopolizing fertile matings (Emlen and Oring 1977, Clutton-Brock 1989). Multi male-multi female social systems of Golden Langur have been only reported from rubber domination sal (*Shorea robusta*) habitat during the study period and in the dry season in semi evergreen forest. In many cases, female synchrony probably allows females to break the monopoly of a single male; hence, synchrony may encourage the formation of multi male social groups. Having multiple males in the group also comes with costs. One cost will be increased feeding competition. Moreover, synchronous females may experience more female-female competition for mates, and thus less mate choice (Knowlton, 1979). However, increasing the number of males may also have some positive effects on female choice, in that synchrony would at least increase female proximity to multiple potential mates. The reproduction strategy of males depends on the number of estrous females that can be monopolized by males, which is correlated with both the number of adult females and their reproduction synchronicity (Emlen and Oring 1977, Wrangham 1980).

Bisexual groups of many *Trachypithecus* species are one male multi female groups, though multi male-multi female groups are occasionally observed (Newton and Dunbar 1994). Bisexual groups in Golden Langur in the fragmented habitats usually included one adult male, 2-3 adult females and up to five immature offspring, which is quite similar with that of *T. phayrei* (Koenig *et al.* 2004) and *T. johnii* (Roy *et al*., 2012)

From our study it showed that in bi male-multi female troop, there was no strong correlation between the number of adult males with other age-sex classes but there was a strong correlation between the number of adult females to number of sub adult males ($r=0.46$; $p<0.05$), number of adult females to number of juvenile females ($r=0.59$; $p<0.05$), and number of adult females to number of infants ($r=0.58$; $p<0.05$) whereas, in multi male-multi female troop, there is a strong correlation between the number of adult males with other age-sex classes. The number of males were affected by the number of females, which are restrained by food resources and population size (Dunbar 1988). Therefore, the formation of bi male-multi female troop as well as multi male-multi female troop in Golden Langur correlated with predator pressure, human disturbances and the reproductive phage of adult females.

Group size of Golden Langur

Group size is a primary component of sociality, and has important cost for an individual's fitness as well as the collective and cooperative behaviours of the group as a whole. In our study we recorded high percentage of occurrence of small group. And the group size categories varied among the habitats but not across the seasons. When predator pressure is low and food patches are small and/or abundant, group sizes are usually small; when food patches are large and food is high in variety but low in abundance, group sizes are usually large. The most widely accepted potential cost of grouping is thought to be a decrease in foraging competence. Being with other individuals with the same dietary requirements means that animals either fight over food (contest competition), or one animal in a group beats another to the food, thus when the second animal comes to an area there is simply no food left (scramble competition, Janson and van Schaik 1988). In both of these situations it is thought that competition over food leads the animals to travel farther. The logic behind this argument is relatively simple. Animals must forage over an area that can meet their energetic and dietary supplies. Thus individuals must travel further and expend more energy if they are in a large group, than if they forage in a smaller group. With an increase in the time spent traveling, a point is approached where the energy spent in travel is too costly and smaller groups become gainful. In this way ecological factors can influence movement patterns and foraging efficiency, thereby constraining the size of groups in Golden Langur that can efficiently exploit available food resources. These ideas have been dignified in what has become known as the Ecological Constraints Model (Chapman and Chapman 2000).

In the socioecological model, the forces affecting female and male behaviour differ (Wrangham 1980): for females predation risk, infanticide risk and food competition are most important, whereas for males mate competition and infanticide are the primary forces (Wrangham 1980, Treves 1998). The first feature explained by the model is group living. Groups will be formed when the benefits are larger than the costs. Several benefits of group living have been identified. Living in a group is thought to reduce predation risk (Alexander 1974, Van Schaik 1983). Groups are also formed to reduce the rate of infanticide (Treves 1998). Another advantage of group living may be increased access to important resources. This can result from between-group contest competition (Wrangham 1980) or increased foraging efficiency (Rodman 1988). Group living also has costs, because individuals have to share limited resources. Those living in larger groups may have less resource per capita than those living in smaller groups. In addition, group members may obtain an uneven share of the available resources when these resources are monopolizable. These factors are more vital for females than for males and will consequently explain the organization of groups for females.

In this study, females may have preferred to live in smaller groups in SEF and MDF because the risk of infanticide strongly increases with group size. The advantage of smaller group over larger group size is that competition for quality food decreases. Mean percentage of adult male, sub adult males and sub adult females were higher in large group in SEF and MDF which may be related to predation risk and defense of food resources. Increase in group size will increase the area to find adequate food supplies (Cody 1971, Wrangham 1980). It has been suggested that folivore group size is limited by social factors such as male harassment or infanticide or that females can disperse more easily and thus maintain group size near optimum levels (Treves and Chapman 1996).

Socioecological theory assumes that ecological factors are largely responsible for this variation: better predation avoidance as group size increases favours living in larger groups, whereas increased travel costs and reduced net food intake due to within-group competition for resources set the upper limit to viable group size (Dunbar 1988).

The conclusion for Golden Langur is that the presence of more number of adult males, sub adult male and sub adult females in large group in SEF and MDF can be related to finding of quality food supplies, decreased predation risk and infanticide. In RDF, it was recorded with more percentage of adult females, sub adult females along with infants and juveniles in large group. Langurs are killed by dogs, specially the juveniles and infants mainly in the fringe areas of the rubber dominating sal (*Shorea robusta*) forest. During this study, nine incidences were recorded during two year (2013–2015). Golden Langurs being chased and sometimes killed by dogs of these, three of the wounded langurs were adult females and six were juveniles. Similar threat or predation by dogs were also reported (Chetry and Chetrty 2009) at Chakrashila Wildlife Sanctuary, Kokrajhar in Western Assam.

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