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Research Article
Reproductive Biology of Eastern Hoolock Gibbon *Hoolock leuconedys* in Conservation Breeding Centre at Biological Park, Itanagar, Arunachal Pradesh, India

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Abstract

Background and Objective: Eastern Hoolock Gibbon *Hoolock leuconedys* is a threatened species categorized as "Vulnerable" in the IUCN Red List of threatened species. It has narrow distribution range in the foothill forest of Eastern India, China and Myanmar. Besides, few works on its population distribution, feeding behaviour and conservation issues, there has been no research regarding its reproductive behaviour conducted so far. The aim of the study was to explore the various reproductive aspects and other behaviours of *H. leuconedys*. **Materials and Methods:** Six focal groups of *H. leuconedys* residing in free-ranging enclosures were selected to observe their sexual and reproductive behaviours from July, 2011-December, 2016. *Ad libitum* and focal animal techniques were used to record its various reproductive parameters such as sexual solicitation, mating postures, gestation length after gestation length birth interval etc. Statistically data was analyzed by percentage, mean and standard error. **Results:** During the study period, 94 mating attempts were recorded. Based on number of attempts/day *H. leuconedys* was distinguished as "Single mount ejaculator." Mating was throughout the year with maximum attempts in January and minimum in July and October. Mating events occurred between 0800-1200 h. Of the 91 mating events, 39 events of solicitation were recorded in which female or male or both solicited each other before mating. Record of a rare posture "Female superior position," along with dorsoventral and ventroventral postures was also noted. The average duration of each copulation was 28.4±1.2 sec. The gestation length was 189±0.92 days. Two birth seasonality were observed, first from June to December and second in March. Two distinct inter birth intervals were estimated based on infant survival (3.1±0.3 years) and infant mortality (1.5±0.2 years) just after infant birth. The average birth rate of five groups was 0.42±0.06 birth/female/year. **Conclusion:** The present study provides information on the various reproductive aspects of *Hoolock leuconedys* such as mating behaviour, mating period, birth seasonality, gestation length, birth interval, post-copulatory behaviours, etc., that would be useful for conservation of this threatened species. This information will also be useful for preparation of husbandry manual for gibbon to act as a guiding tool for gibbon management in *ex situ* condition.

Key words: Eastern Hoolock gibbon, reproductive biology, mating behaviour, birth seasonality conservation breeding

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

A thorough knowledge of the reproductive biology of primates that are mainly susceptible in their natural habitat is essential. This can help in estimating their population status in improving the conservation and management practices and its implementation[1]. Reproductive biology of an individual within a species or population refers to its productivity and other life history factors such as age at first reproduction, birth interval, reproductive seasonality, gestation length etc.[2]. These features help to understand an individual's reproductive success and reproductive potentiality[3]. For the successful establishment of *ex situ* breeding program, such information are essential as it would help in efficient management of species in *in situ* conditions[4-7] that are almost on the verge of extinction. Collecting data on reproductive parameters of mammals (primates in particular that live on tree canopy) that have a long life history is, however, challenging in the wild condition[8]. As a result, the reproductive biology of most gibbons (*Hylobatidae*) remains to be the least documented date[9].

Globally, Eastern Hoolock Gibbon *Hoolock leuconedys* is a highly threatened Hoolock species. This is because of the existing anthropogenic threats in most of its distributional sites[10-14]. They inhabit only the forested regions in Eastern India, west of the Salween River in China and East of the Chindwin River in Myanmar[10]. Within India, it occupies only specific areas in Arunachal Pradesh and a small forest part in Assam. With an overall population of less than 200 individuals in the wild[15-19], *H. leuconedys* faces greater risk of extinction. Therefore, in the IUCN Red List of threatened species, it has been categorized as "Vulnerable"[20,21]. It is also listed in Appendix I of CITES and Schedule I of Wildlife (Protection) Act, 1972 in India. The species plays a significant role as seed dispersing agent and thus, their contribution towards the preservation and management of the forest ecosystem is enormous. *H. leuconedys* has also been recognized as flagship species due to its uniqueness and loud call for the wildlife tourism[22] thereby signifying the reproductive and behavioural study of the species in particular. Literature reviews reveal work on its behaviour and habitat study[23], diet and time budget[24], distribution, population and conservation issues[10,11,15-19,25-27]. Except for one incidence of masturbation act of a captive female housed at the International Center for Gibbon Studies[28], no study has been carried out on its reproductive behaviour. However, several studies have been carried out on reproduction of other Hylobatid species like Western Hoolock gibbon *Hoolock hoolock*[29-34], White handed gibbon *Hylobates lar*[9,35-42], Kloss gibbon *Hylobates klossii*[43], Hainan gibbon *Nomascus hainanus*[44], Javan gibbon *Hylobates moloch*[45,46], White-cheeked gibbon *Hylobates leucogenys*[47] and Siamang *Hylobates syndactylus*[9,37,48-50]. These studies are based on their sexual behaviour and other reproductive characteristics such as sexual maturity, menarche, copulation pattern, age at first birth, inter birth interval, ovarian cycle, sexual swelling and gestation length etc. both in wild and captive condition. Among gibbon species, the reproductive biology of *Hylobates lar* is the most extensively studied. These information's are, however, not satisfactory to understand the reproductive functioning of the Hylobatid species as a whole[51] and particularly in Eastern Hoolock.

The present study is, thus, an attempt to fill in these gaps by providing significant information on the reproductive biology of Eastern hoolock gibbon and will add to this study knowledge on the gibbons social bond, copulatory systems and reproductive tactics[52]. Being high canopy dwellers, such data are relatively difficult to obtain from the wild. It will be useful towards standardizing the management protocols of conservation breeding program for further release (reintroduction/introduction) of the species into their natural habitat. As a result, by restocking the dwindling population of *H. leuconedys*, they can be prevented from getting extinct in ensuing years. The present study is the first attempt to record the various aspects of reproductive behaviour of Eastern hoolock gibbon (*Hoolock leuconedys*) in free ranging captive condition under conservation breeding centre.

MATERIALS AND METHODS

Study site: The study was conducted in the Conservation Breeding Centre (CBC) located on the Eastern side of Biological Park, Itanagar, Arunachal Pradesh, India. It lies (27°03'N and 93°35'E) within the Itanagar Wildlife Sanctuary covering a total area of 250 ha. The centre was established in 2007 with a founder stock of 10 individuals (male = 5 and female = 5) out of 15 *H. leuconedys* rescued from the fragmented habitat of Delo Area, Lower Dibang Valley District of Arunachal Pradesh, India. An area of 10 ha of land was demarcated for the CBC within the park that was free from human disturbances with evergreen forest and undulating landscape similar to the habitat the species dwelled in the wild. The CBC has been acknowledged as the world's first centre to ever breed successfully *H. leuconedys* since 2007.

Study groups and data acquisition: Six groups of *H. leuconedys* were selected and habituated for 4 months to collect unbiased data on sexual behavioural and reproductive biology of the animals from July, 2011 to December, 2016. Of

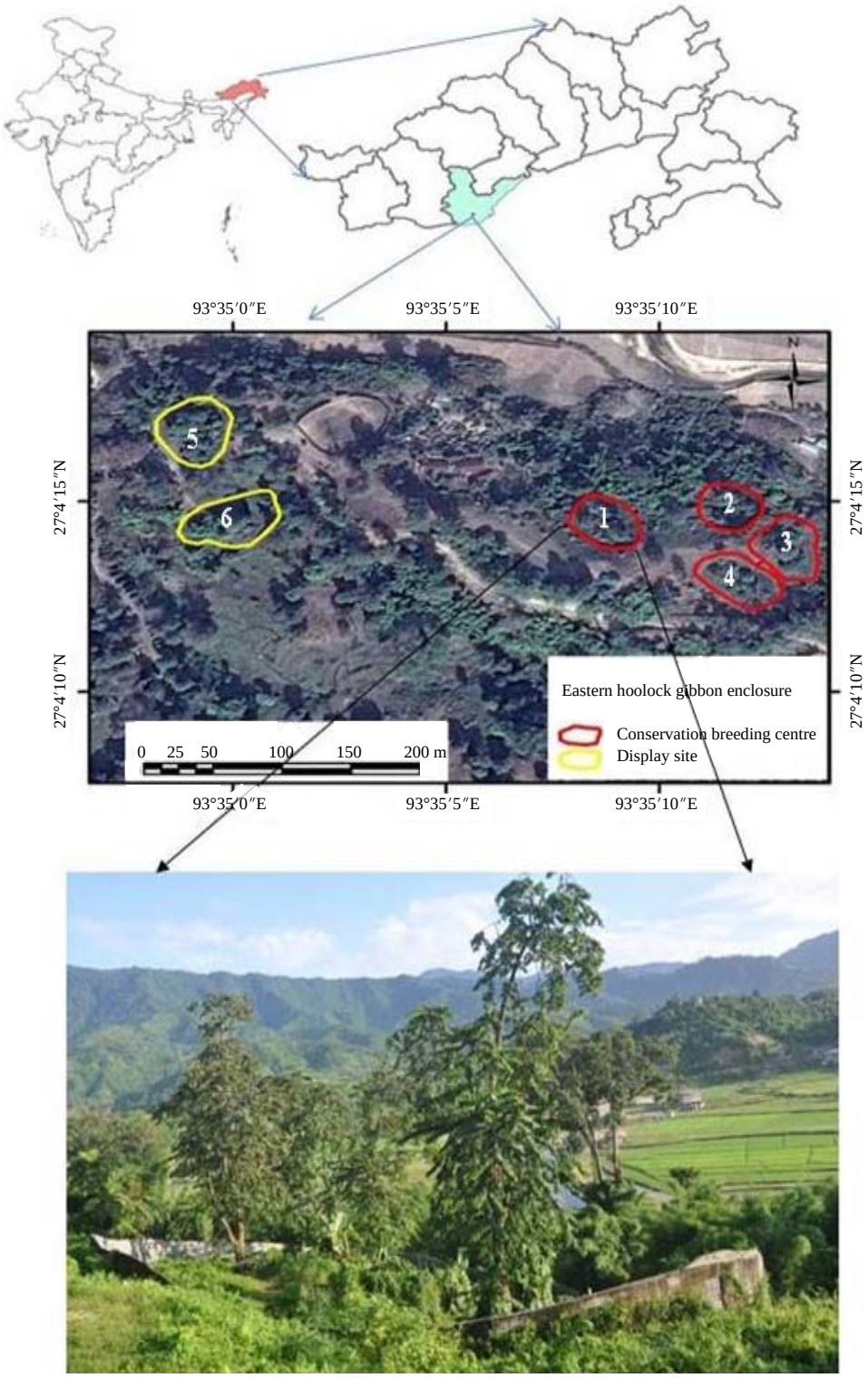

Fig. 1: Map showing the study site at biological park, Itanagar along with the six enclosures (1-4 of CBC and 5-6 of display site)

the 6 groups, 4 groups (Encl. I-IV) were housed in enclosures located within the area of CBC while the other two groups were kept outside the CBC, particularly in the public display site (Encl. V and VI). All gibbon enclosures were designed in such a manner to enable them to live in free ranging condition (Fig. 1). Each enclosure has an area of approx. 2500-3000 m^2

Table 1: Detail of group composition year-wise of *Hoolock leuconedys* (2011-2016) residing in Biological Park, Itanagar, Arunachal Pradesh, India

	Conservation breeding centre				Display site	
Periods	Enclosure I/Group-1	Enclosure II/Group-2	Enclosure III/Group-3	Enclosure IV/Group-4	Enclosure V/Group-5	Enclosure VI/Group-6
2011	1 SA(M)	1 AM, 1 AF, 1 J(M)	1 AM, 1 AF, 1 In(Un)[a]	1 AM[b], 1 AF	1 AM, 1 AF, 1 J(F), 1 In(Un)	1 AM, 1AF[b], 1 J(F)[c], 1 In(M)
2012	1 SA(M), 1 J(M)[b]	1 AM, 1 AF, 1In(Un)[a]	1 AM, 1 AF, 1 In(Un)	1 AM, 1 AF, 1 In(Un)[a,c]	1 AM, 1 AF, 1 J(F), 1 In(Un)	1 AM, 1 AF, 1 J(M)[c]
2013	1 AM, 1 J(M)	1 AM, 1 AF, 1In(Un)	1 AM, 1 AF, 1 J(Un)	1 AM, 1 AF, 1 In(Un)[a,c]	1 AM, 1 AF[c], 1 J(F), 1 J(Un), 1 In(Un)[a,c]	1 AM, 1 AF, 1 In(Un)[a]
2014	1AM[c], 1 SA(M), 1 SA(F)[b]	1 AM, 1 AF, 1J(Un)	1 AM, 1 AF, 1 J(Un)	1 AM, 1 AF, 1 In(Un)[a]	1 AM, 1 J(Un)	1 AM, 1AF[c],1 In(Un)
2015	1 SA(M), 1 SA(F)	1 AM, 1 AF, 1J(Un)	1 AM, 1 AF, 1 J(Un), 1 In(Un)[a]	1 AM, 1 AF, 1 In(Un)	1 AM, 1 J(Un)	1 AM, 1 J(Un)
2016	1 AM, 1 AF	1 AM, 1 AF[c], 1J(Un), 1In(Un)[a,c]	1 AM, 1 AF, 1 J(Un), 1 In(Un)	1 AM, 1 AF, 1 J(Un)	1 AM, 1 J(Un)	1 AM, 1 J(Un)

A: Adult, M: Male, F: Female, SA: Sub-adult, J: Juvenile, In: Infant, Un: Unknown gender, [a]Captive born, [b]Either transferred or introduced from another enclosure, [c]Died

Table 2: Explanation of reproductive parameters recorded under the present study on *H. leuconedys*

Reproductive Parameters	Definition
Sexual solicitation	Behaviours occurring prior to one hour of copulation[56]
Copulatory attempt (CA)	Attempted copulation (AC): Attempts made for copulation that was either not successful or incomplete
Possible copulation (PC)	When observation conditions obscured the behaviour of copulation
Brief copulation (BC)	When mounting is for very short time (<10 sec) or intromission was possibly not accomplished
Complete copulation (CC)	When mounting was achieved and pelvic thrusts occurred ($\geq$10 sec). Modified as by Ahsan[32]
Copulatory event/episode (CE)	It is the number of copulatory events occurring in a day. If the time gap between two copulatory events is <5 min then it will be considered as one copulatory event. If the time gap is $\geq$5 min then it will be considered as another copulatory event
Copulatory postures (CP)	Dorsoventral: The male sitting behind the crouching female and mounting from above and behind Ventroventral: The pair hanging face-to-face with their legs wrapping around each other and the male performing thrusts[30,31]
Temporal distribution of copulation	The period in a day where the majority of copulations were attempted such as early morning, late morning, midday and afternoon
Mating season	The period in a year where the majority of copulations took place
Gestation length	The duration from last mating day to the date of infant birth
Birth season	The period in a year where the majority of the birth does occur[55]
Birth peak	The period of the year with the highest proportion of births[55]
Birth interval	The interval between a female's successive births. In case where the infants died immediately after birth, the interval was reduced[54]
Post-copulatory and spousal behaviour	Behaviour observed within one hour after mating exercise[53]

comprising of dense vegetation and tall trees, which provide natural habitat environment to the species. Opportunistic data was recorded on reproductive biology of *H. leuconedys* from July, 2011 to December, 2016. In addition, a few reproductive data (No. of birth, birth date etc.) obtained from the previous zoo records were also incorporated in the analysis with the aim to get better results. During the study period, innate deaths of three adult females and four infants took place along with one sub-adult female shifted to Enclosure I of CBC to form a new group (Encl. VI) in April 2014. Details of group composition year-wise are given in Table 1.

Observations: Intensive observations were made from dawn to dusk to record their sexual and reproductive activities whenever possible for 3-4 days alternatively each month for 12 h/observation day. A 10×50 power Nikon CN binocular was used to observe the gibbons from a distance of 25-30 m. Quantitative data on various parameters of reproductive biology such as sexual solicitation, attempt to copulation, duration of copulation, frequency of copulation, temporal distribution of copulation, copulatory postures, gestation period, birth season, birth peak and birth interval were recorded based on the methods described[31,32,53-56] using *ad libitum* sampling technique (Table 2). The exact birth dates of all infants born were recorded to estimate the birth rate based on the total number of births given by each female by using the formula ($b = I_{FX}/Y_{FX}$) of Eisenberg *et al.*[57], where, I_{FX} is the number of offspring produced by each female and Y_{FX} is the number of years that each female was observed. Data on the females bred for more than 2 consecutive years were considered. Post-copulatory and spousal behaviours were observed using focal animal sampling[53] at one-minute interval.

Statistical analysis: Statistically data was analyzed by percentage, mean and standard error.

RESULTS

Sexual solicitation: Out of 91 mating events recorded throughout the study period, 39 events were observed for sexual solicitations. In 41% (n = 16) of the occasions, the estrous females solicited the male either by exposing their rump portion in a bent position or shaking a branch of the tree

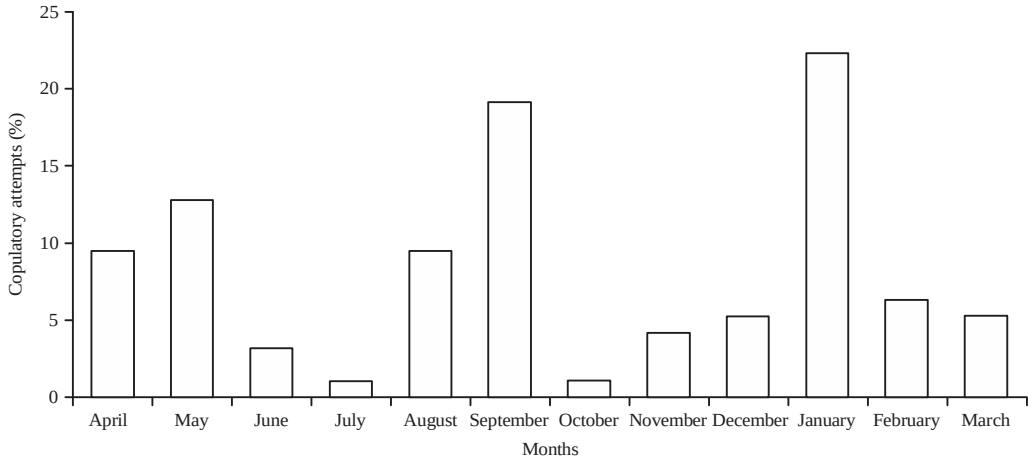

Fig. 2: Monthly distribution of copulatory attempts

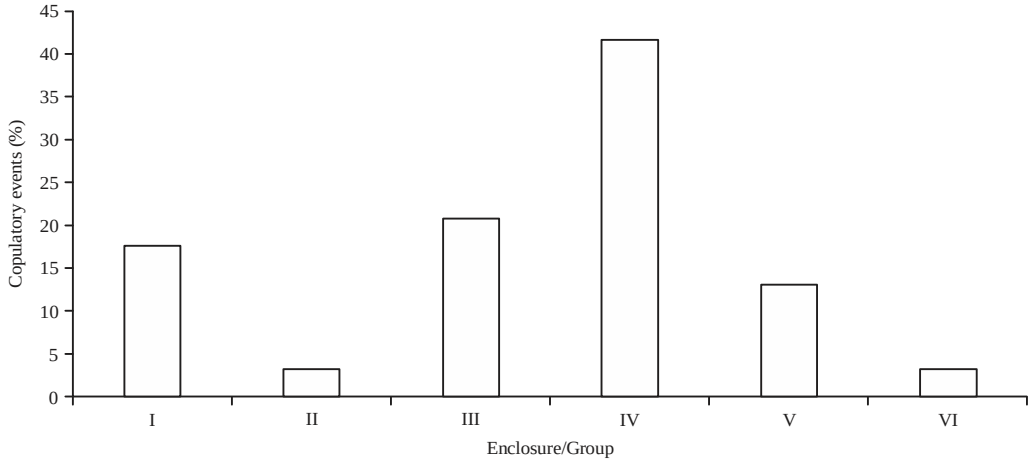

Fig. 3: Percentage of copulatory events recorded in each enclosure/group

and nodding her head to which male responded positively. While in 26% (n = 10) occasions the males solicited by sitting close to female and grooming her. In addition, 33% (n = 13) occasions both male and female together initiated by playing/chasing or grooming one another.

Mating behaviour: Mating was recorded to take place unevenly in all months of the year with maximum occurrence in January (22.3%) and minimum in July and October (1.1%) (Fig. 2). A total of 94 copulatory attempts (CA) were recorded from selected groups, of which nearly 61.7% (n = 58) were single attempts and the rest (n = 36) were multiple attempts which accounted for 38.3% of the total copulations. During the observation period, *H. leuconedys* made a single attempt of copulation in a day. However, multiple attempts of copulation were also recorded in a day (2-4 attempts/day) which took place very rarely.

Of the 94 copulatory attempts, complete copulation was recorded with highest percentage (90.4%, n = 85), followed by brief copulation (6.4%, n = 6), possible copulation (2.1%, n = 2) and attempted copulation (1.1%, n = 1). The highest percentage (41.7%) of copulatory events was recorded in Group 4 housed in the Enclosure-IV and lowest (3.3%) in Group 2 and 6 (Enclosure-II and VI) respectively (Fig. 3). The average duration of copulation was 28.4±1.2 sec/copulatory episode (range: 5-117 sec) with pelvic thrusts (23±1.2) varying from 2-96 in each copulatory episode. The maximum copulatory episodes (33.11±3.92 sec) were recorded from Group-4 and the minimum (24.67±3.12 sec) from Group-5 (Table 3). The highest copulatory episodes (23.1%, n = 21) took place within the range of 26-30 sec of copulation duration. The maximum duration of the copulatory episode was recorded within the range of 116-120 sec which very rarely occurred (1.1%, n = 1) and the minimum was less than 5 sec

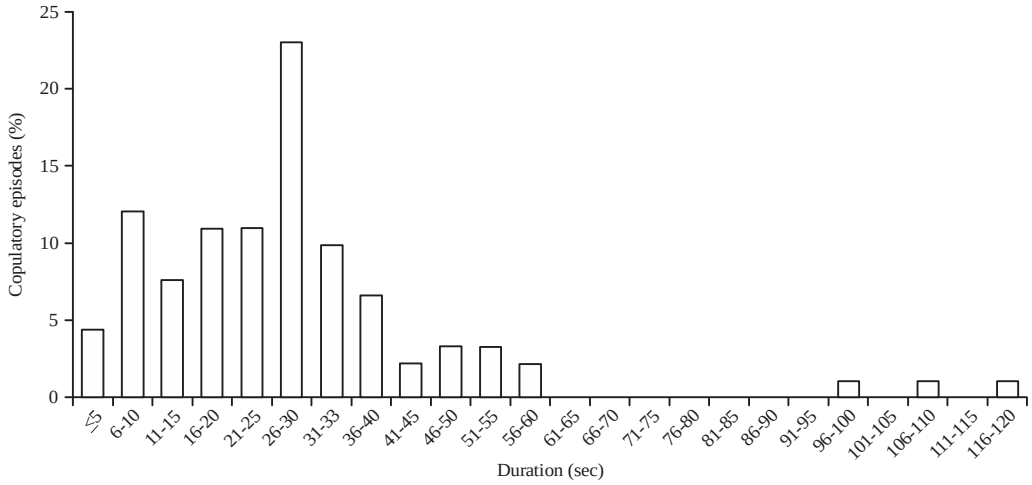

Fig. 4: Duration of copulatory episodes recorded in *H. leuconedys*

Table 3: Number of copulatory episodes and time spent on copulation and pelvic thrust during reproductive behaviour of *H. leuconedys*

Group No.	Number of copulatory episode	Total time spent in copulation (sec)	Average time spent/copulatory episode (sec, Mean±SEM)	Total time spent in pelvic thrust (sec)	Average nos. pelvic thrust/mating episode (Mean±SEM)
Group-1	16	456	28.50±5.34	368	23.00±4.76
Group-2	3	90	30.00±2.89	75	25.00±2.89
Group-3	19	500	26.32±3.27	430	22.63±3.22
Group-4	38	1258	33.11±3.92	1014	26.82±3.04
Group-5	12	296	24.67±3.12	252	21.00±3.02
Group-6	3	83	27.67±1.45	70	18.80±1.70
Total	91	2683	28.40±1.20	2209	23.00±1.20

(4.4%, n = 4) (Fig. 4). About 87.2% (n = 82) of the copulatory attempts occurred in dorsoventral posture in which the male usually approached crouching female from behind and sometimes from below, 11.7% (n = 11) in ventroventral posture in which both male and female hung from rope facing each other with female wrapping her legs around male and 1.1% (n = 1) in 'female superior position' in which female sat on top of the male. At the time of copulation no emission of sound was recorded. Sometimes towards completion of successful copulation, we observed females shaking/quivering after which they immediately left the place. While the males were seen quickening their thrusting pace and they rested for few seconds. Later, they moved away from the mating place. All copulations were recorded to occur at the middle canopy of the tree at >15 m height.

It was observed that *H. leuconedys* display a distinct temporal interval of copulatory attempts. Frequent attempts were seen to occur during the late morning sessions (0800-1100 h) with least in the afternoon session (1400-1700 h). They made fewer attempts during midday (1100-1300 h) and early morning (0500-0800 h) sessions. Maximum copulatory attempts (88.72%) were observed to occur between 0800 and 1200 h (Fig. 5). During the course of post-copulatory behavior, the male and female rested together and groomed one another or sat separately for few seconds and then moved into opposite directions. At times, females were seen moving closer and grooming the males, after which they took a piece of a food item by their mouth from the male's hand to which no reaction was observed. The females were groomed more (1.28%) than the males (0.72%) and rested longer (75.2%) than the males (74%) after post-copulation within an hour.

Birth seasonality and birth rate: Fifteen numbers of births were recorded till 2016 after the establishment of CBC, out of which 9 infants were born during the period (2011-2016).Two distinct birth seasons were recorded based on the infants born, the first season started from June to December which was longer than the second season March (Fig. 6). September, October and March were observed as birth peak time as nine infants (60%) were born in these months The sex ratio was recorded as 2:1 (M: F) among the infants of identified sex. No births were recorded to occur during the months January to February and April to May.

Though the number of infants born in each group varied, successive year-wise births were seen to take place. The mean birth rate from six focal female was estimated to be 0.42±0.06 births/female/year (Table 4). Rukhmini exhibited the highest birth rate (0.67) while Yasum, Mishmi Baideo, Yapa and Mununu the lowest birth rate (0.33).

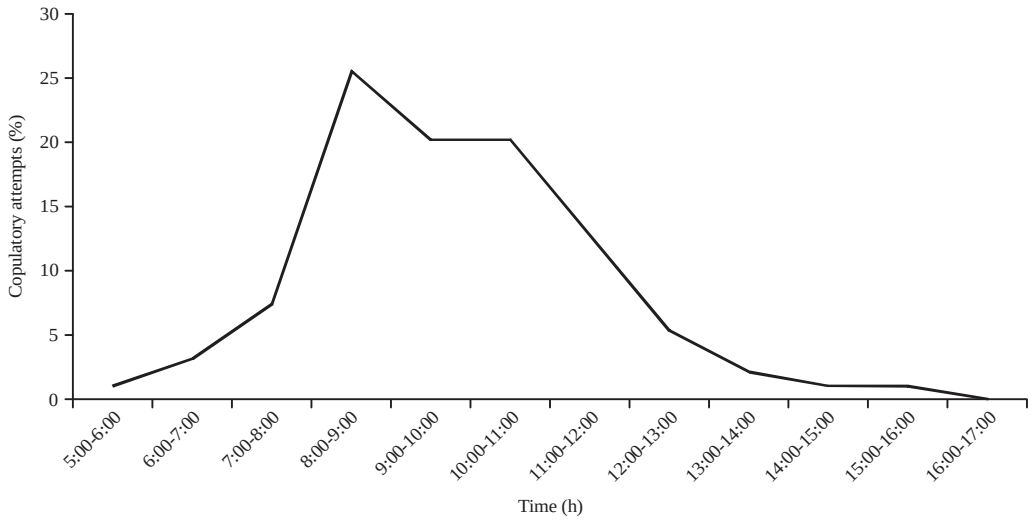

Fig. 5: Temporal interval pattern of copulatory attempts recorded in *H. leuconedys*

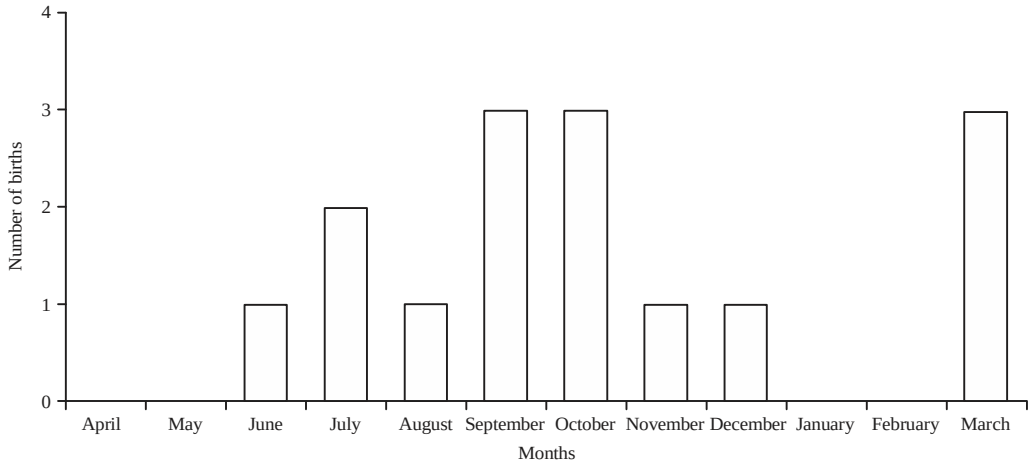

Fig. 6: Monthly distribution of birth pattern of *H. leuconedys*

Table 4: Birth and birth rate recorded for six females kept under observation from 2008-2016

Female ID (Encl. No.)	Date of birth	Number of times female produce infant	Number of years female was observed	Birth rate (Mean)
Yasum/II	22/09/2008	3	9	0.33
	30/06/2012			
	27/03/2016			
Mishmi Baideo/III	26/09/2009	3	9	0.33
	18/09/2011			
	07/10/2015			
Yapa/IV	20/03/2012	3	9	0.33
	26/07/2013			
	30/11/2014			
Dello/V	05/10/2008	3	6	0.50
	25/12/2010			
	19/10/2013			
Rukhmini/VI	05/07/2008	2	3	0.67
	09/08/2010			
Munumunu/VI	26/03/2013	1	3	0.33
Total				2.50
Mean±SEM				0.42±0.06

Gestation length and Inter-birth interval: The average gestation period was estimated 189±0.92 (n = 14) days ranging from 184-193 days. Inter birth interval (IBI) was calculated and averaged of females that had produced two or more than two times infant birth. Female whose infants were alive and surviving had an average IBI of 3.1±0.3 years (ranging from 2.1-4.0 years). While, those whose infants died immediately or shortly after birth had an average IBI of 1.5±0.2 years (range = 1.3-2.0 years).

DISCUSSION

Information on various reproductive features of a species is essential for a successful breeding. Sexual solicitation also referred to as "Pre-copulatory act" is a fundamental aspect of reproductive behaviour. It helps to maximize the chances of conception and thus strengthens the male-female social bonding[58]. In the present study, the receptive females are mostly seen soliciting (41%) while it is occasional by males (26%). In addition, 33% time of solicitation events was spent on soliciting one another simultaneously. Similar findings are also reported for *H. hoolock*[31,34]. In other gibbon species, it is usually witnessed the females initiate the solicitation process to which males responded positively: *Hoolock hoolock*[30,33], *Hylobates moloch*[46], *Nomascus hainanus*[44], *Hylobates agilis albibarbis* and *Hylobates muelleri*[59], *Hylobates leucogenys*[47] and *Hylobates pileatus*[60]. During the entire solicitation act, no aggressive behaviour was seen by either male or female in all studied groups. It is reported that both sexes of *Hylobates moloch* had equal occasions to instigate their alliance behaviour in captive condition[46].

For a successful reproduction to take place, effective copulation is a necessity[61]. Copulations in *H. leuconedys* is seen to occur throughout the year in an uneven pattern (Fig. 2). Similar findings are reported from other gibbon species such as *Nomascus* spp. and *Hylobates syndactylus* at AZA (Association of Zoos and Aquarium)[51] and *Hylobates lar* at Khao Yai National Park[40]. However, some researchers[29,32,34,49,62] have reported copulations in gibbon species to occur during specific seasons of the year. Ellefson[36], reported gibbons as typical "Single mount ejaculator". The present study is in confirmation with this study. The average duration of copulation recorded for *H. leuconedys* is 28.4±1.2 sec (range: 5-117 sec) which varies from records of *Hoolock hoolock* by Lauppe[34] (avg. 35.5s, range: 10-90 sec) and Ahsan[32] (avg. 36.6s, range: 5-120 sec, n = 39). Cheyne and Chivers[59] have also reported higher duration of copulation in *Hylobates agilis* and *Hylobates muelleri* of 34 sec (ranging from 12-53 sec, n = 108) as compare to the present study (28.4 sec). Reichard[63] recorded *Hylobates lar* to copulate for 7-179 sec while *Hylobates syndactylus* for 31 sec[64]. Such variations may be possible due to the difference in position or timing of day of copulatory activity[65]. Another cause in attaining such diverse results may also be the difficulty in observing these high canopy dwellers copulating in the wild[63].

Study of the various positions that apes adopt during copulation is crucial as it brings out the significance of socialization in reproductive behaviors. Display of such variations occurs more in *ex situ* conditions than in the wild[49]. *H. leuconedys* was seen to copulate in both dorsoventral and ventroventral postures very similar to that of *H. hoolock*[30,31,33,34]. Alfred and Sati[29] have reported that all gibbon species copulate mostly in dorsoventral position. Copulation was highest in dorsoventral position (88%) than ventroventral position (11%) in present study, which is similar to *H. hoolock*[33,34]. During the study period, a unique posture known as "Female superior position' as described by Dixson[66], was also recorded rarely. No emission of sounds was heard during the copulatory event like *H. hoolock*[33,34]. Emitting of groaning or soft "Hoo" sounds during copulations is reported in certain gibbon species such as *H. lar*[36], *H. agilis* and *H. muelleri*[59] and *Nomascus hainanus*[44]. All copulatory acts were performed at middle canopy height (>15 m) of the tree. A similar finding has also been reported in wild gibbon species to avoid interference or attack from possible predators during copulation[33]. *Hoolock leuconedys* at CBC are mostly seen to copulate during the first half of the day (Fig. 5) like captive *H. hoolock*[34] and *Nomascus hainanus*[44]. Huang *et al*.[33] reported that *H. Hoolock* to copulate during the noon in the wild which is recorded rarely in our study (2%, n = 2).

In *H. leuconedys*, birth took place mainly between June-December and March with birth peaks in March, September and October (Fig. 6). In wild *H. hoolock*, birth normally occurs during winters between September to March[67-69] with birth peaks ranging from mid-September to January[70]. There are records of births during the summer[32,69] which coincide with the birth months of *H. leuconedys*. Similarly, maximum births of *H. lar* were reported in September and early October[41,71]. The average gestation length of *H. leuconedys* at CBC was estimated to be 189±0.92 days (range: 184-193 days) which is more or less similar to 180-186 days recorded by Panor[72] on the same species. The gestation length of *H. leuconedys* is also similar to *Hylobates lar* (184-195 days)[39] and *Hylobates leucogenys* (184-198 days)[51]. The gestation length of *H. leuconedys* was recorded less than *H. hoolock*: 195-210 days[29] and 180-240 days[32]. The gestation length of one premature infant was recorded173 days less than the gestation length of other

gibbon species[73]. The average IBI of *H. leuconedys* females whose infants survived after birth was 3.1±0.3 years while infants that died immediately after birth had an average BI of 1.5±0.2 years. Reichard *et al.*[42] reported IBI of *Hylobates lar* to be 3.4±0.7 years when the infant was alive and 2.2±0.7 years when the infant died which are found to be higher than the present findings. The IBI's of *H. leuconedys* is found to be higher than that of *Hylobates moloch* (2.3±0.4 years and 1.0±0.3 years) housed at Howletts Wild Animal Park at UK[45].

CONCLUSION

The present study provides a detailed account on the various reproductive aspects of *Hoolock leuconedys* such as mating behaviours, mating period, birth seasonality, gestation length, birth interval, post-copulatory behaviours etc., which are vital for conservation breeding and re-introduction/introduction of species. Successful birth of infants implies reproductive potentiality of the individuals is noteworthy as it signifies the ability of the male-female pairs to reproduce. It also highlights the strong male-female bonding that is necessary to understand the pairing (male and female) process for conservation breeding as well as introducing or reintroducing the population in their natural habitat for restoration of population.

FURTHER IMPLICATION AND SUGGESTION

The present study would be helpful in the formulation of "Husbandry Manual" for *H. leuconedys* that will be a source of information for improving husbandry management of the species.

It will also act as a guiding tool for zoos worldwide in general and India in particular for initiating conservation breeding, introduction and release program for the concerned species in the wild.

The details of precise male-female pairing, mating season and birth seasonality are important reproductive features of species that need a strong consideration before their release, for effective protection and management of the species in wild.

SIGNIFICANCE STATEMENTS

This study is the first to discover the various reproductive aspects of Eastern Hoolock Gibbon *Hoolock leuconedys* that can be beneficial for the formulation of "Husbandry Manual" and release programme of the species in the wild. This study will enable the researchers to develop a guiding tool for successful conservation breeding programs for the species worldwide especially in India that many researchers were not able to explore. Thus, a new theory on these reproductive characteristics have been arrived at.

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