



Social integration and associational behaviour of male Asian elephants in northwest India: a new social learning

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Resumen

Se ha reconocido ampliamente que los elefantes machos adolescentes africanos (*Loxodonta africana*) se asocian con otros elefantes machos después de abandonar sus unidades familiares, lo que facilita el aprendizaje de comportamientos sociales y la supervivencia en condiciones ambientales adversas. Sin embargo, este aspecto ha sido menos estudiado en elefantes asiáticos (*Elephas maximus*) y los estudios sobre interacciones macho-macho son escasos. La integración social de los machos adolescentes con otros elefantes asiáticos machos, que viven en solitario o en pequeños grupos compuestos por machos, es un proceso dinámico que se produce durante un período de varios años. Este estudio revela el comportamiento de un elefante asiático macho subadulto y su integración en un grupo exclusivamente masculino. Además, este estudio también revela una asociación a largo plazo entre los elefantes asiáticos machos, que no se había informado anteriormente en la región. El estudio tuvo como objetivo observar el comportamiento de los elefantes asiáticos machos durante la etapa de la adolescencia, así como observar interacciones macho-macho y asociaciones a largo plazo. Realizamos el estudio en la cordillera forestal de Chilla del Parque Nacional Rajaji y en los bosques adyacentes, las divisiones forestales de Haridwar y Lansdowne, respectivamente. Las observaciones abarcaron un período de más de una década, de 2006 a 2017, y se centraron en el comportamiento de los adolescentes entre 2007 y 2011 y en las asociaciones entre hombres de 2006 a 2017. Proponemos que este estudio sea el primer informe en el contexto de la evolución del comportamiento en elefantes asiáticos machos en el noroeste de la India.

Palabras clave: *Elephas maximus*, etapa de adolescencia, asociación de elefantes macho, comportamiento social, noroeste de India.

Abstract

It has been widely acknowledged that adolescent male African elephants (*Loxodonta africana*) associate with other male elephants after leaving their natal family units, which facilitates in learning social behaviour and surviving in adverse environmental conditions. This aspect has been less studied in Asian elephants (*Elephas maximus*) and studies on male-male interactions are scarce. Social integration of adolescent males with other male Asian elephants, living either solitary or in small all-male elephant groups is a dynamic process that occurs over a period of several years. This study elucidates the behaviour of an adolescent male Asian elephant and its integration into an all-male group. Further, this study also explains a long-term association of male Asian elephants, which has not been reported previously from the region. The study aims to observe the behaviour of male Asian elephants during the adolescence stage, as well as to observe male-male interactions and long-term associations. We conducted the study in Chilla forest range of the Rajaji National Park and adjacent forests, namely, Haridwar and Lansdowne forest divisions, respectively. Observations spanned over a period exceeding more than a decade from 2006 to 2017, focusing on adolescent behaviour between 2007 and 2011 and male-male associations from 2006 to 2017. We propose that this study is a first ever report in context of behavioural learning in male Asian elephants in northwest India.

Key words: *Elephas maximus*, adolescence stage, male elephant's association, social behaviour, northwest India.

1. INTRODUCTION

Elephants are the largest terrestrial mammals belonging to the family Elephantidae and order Proboscidea. Two distinct genera of elephant have been identified, the African elephant (*Loxodonta* spp.) and the Asian elephant (*Elephas* spp.). African elephant belongs to the genus *Loxodonta* comprising two species, the African bush or Savannah elephant (*Loxodonta africana*) and the African forest elephant (*Loxodonta cyclotis*). The African bush elephant is distributed widely, having the largest population across south and east African countries, inhabiting savannah, grassland and desert ecosystems of sub-Saharan Africa; however, the forest elephants mainly found in the dense rainforests of west and central Africa. In contrast, Asian elephant (*Elephas maximus*) is the only living species of the genus *Elephas*, which are distributed across Asia from the Indian subcontinent to Southeast Asia.

Though, elephants play an important functional role in maintaining the forest ecosystem and biodiversity, they are identified as endangered species. Unfortunately, following population declines over several decades due to poaching for ivory and loss of habitat, the African forest elephant has been listed as Critically Endangered and the African Savanna elephant as Endangered in the IUCN Red List of Threatened Species (Gobush *et al.* 2021; Gobush *et al.* 2022). Similarly, the Asian elephant is also listed as Endangered in the IUCN Red List of Threatened Species, mainly because of habitat loss and fragmentation and human-elephant conflict (Williams *et al.* 2020).

1.1 ADOLESCENT BEHAVIOUR

Elephants live in a matriarchal society, where the oldest female usually leads the group. In contrast, male elephants begin a solitary life after attaining adolescent stage, dispersing from the natal matriarchal family unit at the age of about 10-15 years. Nevertheless, their movements are confined near the natal groups in search of oestrous females during the mating period, when male elephants also casually join and leave the matriarchal groups. Male elephants leave their natal family units when they are on the threshold of sexual maturity and wander on their own or seek the company of other male elephants. The evolutionary reason for the male's departure from their family may be to avoid inbreeding and genetic research has shown that males do avoid breeding with close maternal and even paternal female relatives (Elephant Voices 2022). Sukumar (1989) revealed that as male elephants cannot recognize their children; males do not show interest in taking care of the infants.

Adolescence in male elephants is one of their most important life stages when they acquire skills and develop relationships that benefit their survival and reproductive success (Evans & Harris 2008). Though the transition is a dynamic process that occurs gradually over the years, adolescent male elephants steadily start spending more time moving alone for a short while (for several hours, even sometimes for one or two days) in the fringes of their natal family units. During adolescence, they learn about solitary life, their immediate physical and social environment, and strategies to address new challenges. They also follow and move with other sub-adult and adult male elephants, which enables them to learn lessons about their natural ranges. Based on the elephant's shoulder heights, the age class of the Asian elephant calf has been classified as less than 1 year, whereas the juvenile is one to five years. The age class of the sub-adult elephant has been classified as 5 to 15 years and the adult elephant as 15 years and above (Varma *et al.* 2012). The adolescence stage in African elephants has been recorded as 8 to 20 years (Evans 2006; Evans & Harris 2008; Lee *et al.* 2011; Elephant Voices 2022). Moreover, there are no sufficient studies on the adolescent behavior of wild Asian elephants to establish the facts on the adolescent stage in male elephants. However, three of the studies have estimated the dispersal stage in male Asian elephants as 7-20 years, which indicates about adolescence in male elephants (Eisenberg *et al.* 1971; McKay 1973; Srinivasaiah *et al.* 2019).

Considering the available records, particularly on the Asian elephants, it appears that sub-adult male Asian elephants are experiencing the adolescence stage, which involves segregation from their natal families. Although any specific study on the adolescent behavior of male Asian elephants has not been carried out so far in Asian elephant ranges, neither is any literature available; quite a few studies carried out in African elephant ranges have given insight into their social interactions (Slotow *et al.* 2000; Evans & Harris 2008; Poole & Moss 2008; Evans *et al.* 2013; Allen *et al.* 2020).

1.2 MALE-MALE ASSOCIATIONAL BEHAVIOUR

Asian male elephants move across a wide range of habitats, travelling longer distances as compared to the female elephants in groups (Sukumar 2008). Such large movements and dispersal ability allow the elephants to meet their nutritional requirements through the access to food resources that are otherwise scarce in space and time and maintain gene flow among populations (Graham *et al.* 2009; Joshi & Puri 2021; Puri & Joshi 2023). Movement across large ranges also facilitates their interaction with other individuals and allows them

to experience new life opportunities and challenges, and to address them. Males were long thought to be largely solitary animals after gaining independence and leaving their family group; though, there is growing evidence that males as well as females live rich social lives. It was long thought that at the threshold of sexual maturity and after segregating from the natal groups, largely male elephants' live life solitarily and facilitating genetic flow across different populations. In the recent past, there has been growing evidence that male elephants also have social lives in the form of all-male groups. Though studies carried out in the African elephant ranges have already revealed that male elephants also form long-term groupings, this aspect is yet to be widely explored and studied in the Asian elephant ranges. It has also been widely acknowledged that older male elephants play an important role in leading all-male groups consisting of sub-adult and adult male elephants.

Such associations of all-male elephants are small, unstable, and normally extended to gain some benefits (Joshi 2015). An older and stronger male elephant usually leads the group, which reflects on a dynamic hierarchical behavior to some extent and developments in evolutionary strategy. In the recent past, studies carried out on the African male elephant's behavior have highlighted that male elephants also form groups and show a degree of sociality, which enables them to explore novel environments, learn and improve cognitive skills, and integrate learning in behavioral development (Lee & Moss 1999; Evans & Harris 2008; Greco *et al.* 2012). Growing evidence shows that male elephants exhibit extensive and flexible social behavior that rivals the complexity of females (LaDue *et al.* 2022). After dispersal from their natal family unit, male Asian elephants roam inside and outside their natal population, searching for mates and forming wide-ranging social bonds with other males (Elizabeth & Chiyo 2012). The objective of our study was to observe the behavior of male Asian elephants during their adolescence stage as well as their social integration in an all-male group; further, to observe male-male interactions and long-term associations in the protected forest of north India.

2. MATERIALS AND METHODS

2.1 STUDY AREA

The Rajaji National Park in north India (29,15-30,31°N, 77,2-78,22°E) is one of the crucial wildlife habitats in Uttarakhand State, forming the north-western limit of the range of Asian elephants in the country. The park is part of the Shivalik Elephant Reserve (5.405 km²), maintaining a healthy population of elephants. Rajaji National Park is spread over an area of 820,42 km². Considering the protection of tigers, in the year 2015, 255,63 km² area of adjacent reserve forests were added to it (including parts of Haridwar and Lansdowne forests), making it 1.075 km² and was declared as Rajaji Tiger Reserve under the provision of the Wildlife Act, 1972. The contiguous forest range is one of the most diverse wildlife habitats in the northwestern Shivalik landscape, which constitutes an important repository for the regional mammalian fauna and serves as a crucial wildlife habitat and corridor for elephants to move across Rajaji-Corbett National Parks. The area has great conservation value since it is an important part of the Terai-arc landscape between the Yamuna and Sharda rivers, which is known as the Rajaji-Corbett Tiger Conservation Unit. It falls within the Gangetic Plains biogeographic zone and comprises of northern tropical moist deciduous forest, sub-tropical pine forest, tropical dry deciduous forest, riverine forest and low alluvial Savannah woodland with extensive stands of sal (*Shorea robusta*), kamala (*Mallotus philippensis*), black catch (*Acacia catechu*), yellow teak (*Haldina cordifolia*),

bahera (*Terminalia bellirica*), Indian banyan (*Ficus bengalensis*) and north Indian rosewood (*Dalbergia sissoo*). This entire belt is a natural home to Asian elephant (*Elephas maximus*), tiger (*Panthera tigris*), leopard (*Panthera pardus*), sloth bear (*Melursus ursinus*), striped hyena (*Hyaena hyaena*), barking deer (*Muntiacus muntjak*), spotted deer (*Axis axis*) and sambar deer (*Rusa unicolor*).

Our study was conducted in the Chilla Forest range of the Rajaji National Park and three adjacent forests: Shyampur, Chiriapur (south), and Laldhang (south-east) of the Haridwar and Lansdowne Forest divisions. The forest of Rajaji National Park and Haridwar and Lansdowne Forest divisions are reserve forests, which are managed and protected under the Indian Forest Act, 1927 and Wildlife Act, 1972. Rajaji National Park was notified in the year 1983 under the Wildlife Act, 1972 to manage and conserve its rich biodiversity and to provide the area with a higher degree of protection. In contrast, the reserve forests of Haridwar and Lansdowne Forest divisions are managed under the provisions of Indian Forest Act, 1927 and Wildlife Act, 1972, but are not designated as a protected areas, i.e. National Park or Wildlife Sanctuary.

2.2 METHODOLOGY

To observe the behavior of Asian elephant during adolescent stage, we monitored one sub-adult male elephant for four years (2007-2011) until its separation from the matriarchal group. Observations were made for about 6 hours a day (between 06h00 to 18h00) in all three seasons, summer (April to June), monsoon/post-monsoon (July to September/October-November), and winter (December to March). As elephants perform the maximum of their activities during early morning and evening hours, we divided each day into two-time blocks: early morning (06h00-09h00) and evening (15h00-18h00). We spent a total of 15 days in a month (~three days per week) observing the group and focal adolescent elephant (15 days/month x 48 months), which amounts to 720 days in four years.

To collect data on male-male interactions and associations, observations were made between 2006 and 2017, continuing/following the study conducted by the second author between 2006 and 2010 (Joshi 2015). Field data was collected on a year-round basis from the Rajaji National Park and adjacent forests of Shyampur, Chiriapur forest and Laldhang forest of Haridwar and Lansdowne forest divisions, respectively. Individual male elephants were identified based on morphological features such as tusk and tail size and shape, ear shape, depigmentation on ears, and trunk base (Varma *et al.* 2012). We followed criteria proposed by Sukumar (1985), Arivazhagan & Sukumar (2008), and Varma *et al.* (2012) for estimating the age of the individual elephant. Direct observations of elephants were made across the identified forest areas during early morning hours and in the afternoon hours on a year-round basis. To record the associational behavior of all male elephants, we collected observations for over 11 years (15 days/month x 132 months), which amounts to 1980 days in 11 years. All activities related to the movement of the identified individual elephant, all-male group's movement, and their social behavior were recorded. Local people were also consulted wherever required to record the movement of identified elephants and to strengthen the observations. Lastly, we used field binoculars (Nikon Action Series, 10x50 CF) and a Nikon Coolpix 8700 Camera to observe the elephants from a safe distance and to collect photographic evidence. Geographical coordinates were recorded using a GPS (Garmin 72™).

3. RESULTS

3.1 Adolescence in Male Elephant

We monitored a sub-adult male Asian elephant, aged about 5-6 years for four years (2007-2011) in Rajaji National Park and adjacent habitats. The identified male elephant was one of the members of a group of 14 elephants (matriarchal group), which was identified based on morphological features. The matriarchal group of 14 elephants made it possible to observe the activities of the identified male elephant. During the initial two years (May 2007 to April 2009), the elephant was found moving along with the group (Figure 1 A, B). Thereafter, the individual slightly shifted his activities towards the expansion of the movement area and slowly started moving across the fringes of the group, maintaining a distance from 50-100 m, which lasted for 1,5 years (May 2009 to October 2010). We observed attempts by the elephant to enter the matriarchal group and being chased away by the group members throughout the period. In 2010, at the onset of post-monsoon/winter (November/December 2010 onwards), an adult male elephant arrived near the group and started following the group from a close distance, which could be due to the presence of a reproductively receptive female. We observed that the focal adolescent male elephant attempted to follow the adult male and in response, the adult male chased him away repeatedly, not showing interest in the adolescent male. Some pseudo-fights were observed between them, which influenced arbitrary movement of the adult male elephant with the group. However, any serious conflict was not observed between the elephants. The incident continued for about a week, after which the adult male elephant left the matriarchal group and went to an adjacent forest. The focal adolescent male elephant continued its movement in the periphery of its natal matriarchal group for about 3-4 months (January to April 2011), showing less confidence in moving alone.

Thereafter, for about the next month, the focal adolescent elephant was neither observed with the matriarchal group, nor with the adult male elephant. At the onset of summer in 2011 (May onwards), the focal elephant was observed following a male elephant group comprising six individuals. It is worth mentioning that the adult male elephant, which was observed near the female group some months before, was also part of that male elephant group. Although, the adolescent elephant was observed following that all-male group throughout the year, its movement was confined across the forest stretch along the river Ganges. In 2011, we observed the focal adolescent male elephant performing movements with other male elephants in close contact during winter (November onwards) (Figure 1 C, D). This was the first occasion when the focal adolescent male elephant began learning about traditional tracks from other male elephants and started wandering across the agricultural fields, following the other male elephants. Overall, it took almost two years for the focal elephant to leave the natal family unit and wander on its own during sub-adult stage at the age of about 9-10 years old (Figure 2).



FIGURE 1 A, B. Observations on the focal adolescent male elephant during 2007-2011 in Rajaji National Park and adjoining protected habitats, north India; adolescent male elephant in a matriarchal elephant group having adult and sub-adult female elephants. **1 C, D.** Focal adolescent male associating with an adult male elephant and all-male group, while moving towards the River Ganges.

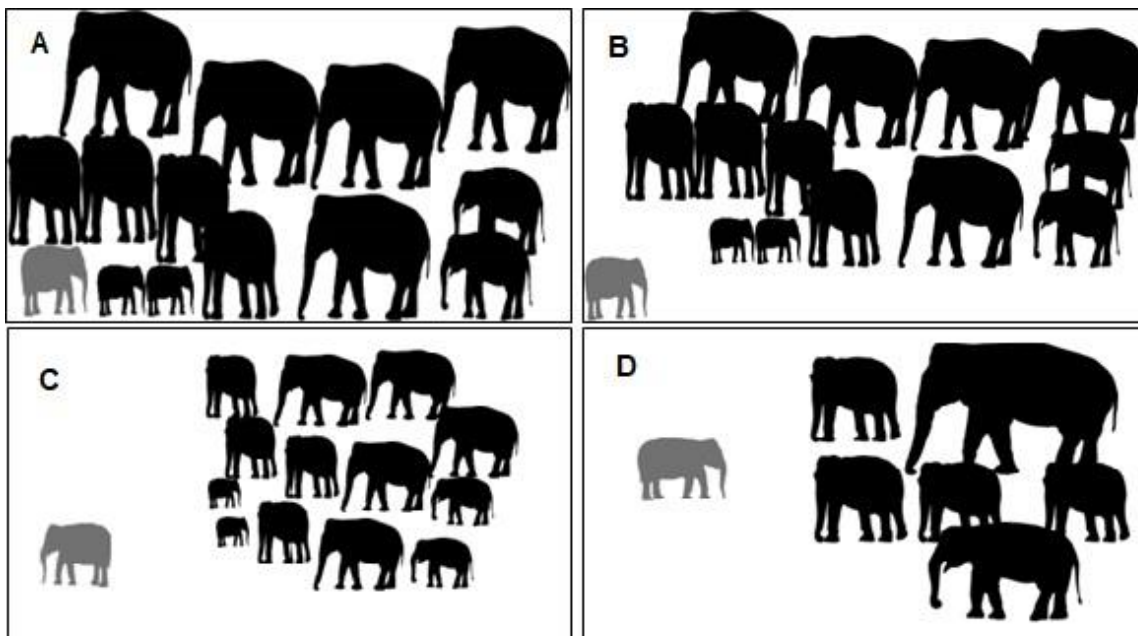


Figure 2. Figures showing timeline of the evolution of adolescence in the focal male elephant (light grey silhouette). **A.** Adolescent male elephant with the matriarchal group (black silhouettes) from 2007 (summer) to 2009 (summer). **B.** Movement of adolescent male elephant on the fringes of the matriarchal group, maintaining 50-100 m distance from the group during 2009 (summer) to 2010 (winter); adolescent male elephant also made random attempts to enter the matriarchal group during this period. **C.** Movement of adolescent male elephant peripheral to the matriarchal group during 2010 (winter) to 2011 (onset of summer). **D.** Expansion of the range of adolescent male elephant and mixing with the all-male group between 2011 (summer) and 2011 (onset of winter). Source: PhyloPic. *Elephas maximus*, Silhouette images. <https://www.phylopic.org/nodes/ec96f916-8220-4ebb-a7ef-0179513937f5/elephas-maximus-silhouettes>

3.2 Long-term association and social behavior among male elephants

We observed an all-male group, comprising 7-10 identified sub-adult and adult individuals for over a decade (from 2006 to 2017) across the Rajaji National Park and adjacent protected habitats. Observations on their co-movements revealed that they have a long-term association and strong strategy for performing movements beyond their natural ranges, exhibiting learned social behaviors. After observing them for almost a decade, it was revealed that while individual elephants from the group roam either alone or with the group for quite a few hours in a day or months in a year, the group remained in close contact with each other. The group of all-male elephants was observed arriving and assembling at the Shyampur and Chiriapur forest of the Haridwar forest division in the afternoon hours and staying there till dusk before they started moving towards the agricultural fields. One of the adult male elephants was always found leading the group, especially when their movements were directed towards the agricultural fields, crossing the populated area (Figure 3 A, B). As male elephants are known to lead a solitary life and move across the outskirts of forest areas and visit crop fields in groups, such associations could be a strategy to get nutritious forage.

We observed that all-male group, often on a year-round basis followed a strategy to enter the agricultural fields and return to the forest before dawn, following fixed routes. Furthermore, from early morning hours to the afternoon hours, we observed individual elephants performing solo movements, which also include hovering near to the group. Sometimes one or two identified individuals from the group stayed with the matriarchal groups for about two-three days. The timings of their movements were primarily dependent on the season and distance that they had to cover. On occasions, when they covered long distances during the night and were not able to return before dawn, we observed them staying in the peripheral forest and sometimes even in the agriculture fields. In situations, when any of the individuals were left behind, all members were always observed waiting for their companion. Our long-term field observations revealed that male elephants form such groups mainly to venture across the agricultural fields to minimize the risk of crop raiding and to access the River Ganges.

The movements of this all-male group of elephants were found confined to the forests of Chilla & Gohri in Rajaji National Park and Shyampur, Chiriapur and Laldhang forests in the Haridwar and Lansdowne Forest divisions, respectively. We also observed a few events of new male elephants joining the group and members leaving the group, which affected the stable size of the group. Male elephant mortality was also one of the reasons, which affected the size of the group. In 2000, a solo movement of recognized two-three adult male elephants was observed for about three years; these elephants were recorded visiting the river Ganges and agricultural fields alone, sometimes in pairs and with the female

groups. Slowly, other male elephants, especially sub-adult males started associating with them and formed a stable group of all-male elephants, ranging from 2-10 individuals. Before this study, the second author documented an all-male group size up to eight individuals firstly during 2006-2010 from the area; but, considering the observations since the year 2010, it appears that the number of individuals in the group is increasing.



FIGURE 3. A, B. All-male group at Shyampur forest; Oldest male elephant, who leaded the group is walking in front in figure 3A and standing on the left side in figure 3B.

During 2006-2007, seven individuals were reported associating together; later, during 2008, one more male joined the group, converting the group to eight. During 2009-2010, only six individuals were observed performing co-movements. During 2011-2012, one new male elephant joined the group and made it a group of seven, followed by the years 2013-2014, when nine male elephants were observed associating in an only male group. It is worth noting that the reports of only male elephant groups, comprising 10-11 individuals were received from the area between 2015-2017. From the trend of the male elephant's association, it appeared that their co-movements were mostly confined to the warm months followed by the wet season. Nonetheless, from January to March, the grouping pattern was observed less, as solo movement of the male elephants was observed close to the matriarchal groups in search of female elephants in estrus. The emergence of this typical and erratic behavior in male Asian elephants can affect their ranging patterns and competition/fighting for mating. Pseudo-fights were also observed on about 40 occasions among the individuals of the only male group, showing playful behavior and a strong social bond displaying novel behavior.

4. DISCUSSION

Adolescence is one of the important life stages among male Asian elephants, stage when young individuals learn new lessons with both physical and behavioral changes. At this stage, elephants start segregating from their natal families and spending more time alone in new environments, having opportunities and challenges and developing social behaviors and skills to survive. Studies conducted on Asian elephants revealed that young male elephants stay within the natal matriarchal group until they are five-six years old (Eisenberg *et al.* 1971) and their behavior differs slightly from that of females in the matriarchal group, they do not participate in allomaternality and do not interact much with

younger calves within the matriarchal group (Rasmussene 1999). Further, Sukumar (1994) and Sukumar & Santiapillai (1996) pointed out that they remain on the fringes of the natal group before sexual maturation exhibits more independence. A study conducted in south Indian elephant range reported that changes in sociality of male Asian elephants are exhibited between 11 and 20 years, as adolescent males disperse from their natal herds transitioning into socially mature adults (Srinivasaiah *et al.* 2019). We observed that the focal male elephant began segregating from his natal family after eight years old and started wandering on its own and associating momentarily with other adult male elephants. At the age of about 10 years, the sub-adult adolescent male elephant became part of an only male group.

In Ceylon (now Sri Lanka), McKay (1973) observed that the young male elephants begin to become peripheral to the female elephants at the age of 6-7 years old and become more peripheral with advancing years and may take up with an older male in a loose association. Though dominating adult male elephants are in close attendance of the reproductive females within the matriarchal group, contests of showing strength by some other younger male elephants may increase during their association with matriarchal groups (Eisenberg 1980). Joshi (2019) indicated that matriarchal groups do not accept any new male elephant in their family quickly and mixing males in the group takes time, which varies from 15-20 days to about a month. Moreover, the attempts of the male elephant don't need to be always successful. During the present study, though some male fights were observed, no conflict was observed concerning mating preferences within the all-male group members. Pseudo-fights were also observed on several occasions among the individuals, showing playful behavior and a strong social bond. Researchers have pointed out that play fights and social interactions are important in developing social behavior among male elephants and new hierarchies help in avoiding serious conflict and acquiring social skills (Desai 1997; Jayantha *et al.* 2009).

In African elephants, the age to leave the matriarchal group by males has been recorded between 8-20 years old (Evans 2006). In Amboseli elephants, the average age of independence has been reported as 14 years, when males spend less than 20 percent of their time with family, however, some males also leave the family early at the age of about nine years, and late at about 18 years (Lee *et al.* 2011; Elephant Voices 2022). As no studies have been conducted on the adolescent behavior of wild male Asian elephants, neither is literature available. Long-term studies need to be conducted to observe their behavior during segregation from their natal families and reach some conclusion.

Studies carried out on male-male interactions and bonds in some of the Asian elephant ranges indicated that the male elephants do have associations, though temporary, ranging from 2-6 individuals, rarely exceeding 3-4 individuals (recorded in Sri Lanka), 2-3 individuals (recorded in southern India), 6-8 individuals (recorded in northwest India) and 2-9 individuals (recorded in southern India; McKay 1973; Sukumar 1994; Joshi & Singh 2008; Joshi 2015; Srinivasaiah *et al.* 2019). We observed an all-male group of elephants, consisting of 6-11 individuals. The size of the group changed seasonally, largely due to the joining of new male elephants, temporary departures of members, and death of individuals. A study carried out in south Indian elephant ranges indicated that male Asian elephants form a stable, long-term all-male group typically in human-modified and highly fragmented areas (Srinivasaiah *et al.* 2019). Another study reported weaker male-male elephant associations, recording significant top associates with most of the males with whom their associations are stronger (Keerthipriya *et al.* 2021).

This long-term observations study has reported a comprehensive understanding of the social structure and behavior of male Asian elephants in the northwestern Indian elephant range. In 2000, before the establishment of Uttarakhand State, large matriarchal groups of elephants were observed moving across their traditional ranges, passing through rural areas, agricultural fields and the River Ganges. Since 2002, gradually, with the increase in human population, expansion of human settlements, and developmental activities, most of such traditional ranges were interrupted, and only adult male elephants continued their movement in their historical ranges. In the recent past, some identified groups of elephants have been observed moving across their traditional corridors in north India, which were interrupted many years ago and changing in feeding preferences of elephants over the years (Joshi 2017a).

Climatic changes might also have an impact on such abrupt movement of male elephants. Moreover, such long-term associations among only male elephant groups, especially to meet their needs, may also be a part of newly developed behavioral strategies. Today, local human communities are habituated to encountering elephants, and elephants are well adapted to moving across human-dominant areas such as national highways, city/rural areas. Though such unwanted encounters between humans and elephants sometimes result in casualties for humans and elephants, these humans-elephants interactions for space will increase the conflict, which may be observed in the coming years.

In the African elephant ranges, such male elephants' associations have been observed at a greater extent, ranging up to 15 individuals (O'Connell-Rodwell 2010; Chiyo *et al.* 2011). Moss & Poole (1983) exposed that males do not form temporally and spatially stable groups, but some individuals do appear to have strong associations with one or more other males. Other reports revealed that young and independent male elephants associate with older males to learn and acquire social behaviors from them and reduce mortality risk (Lee & Moss 1999; O'Connell-Rodwell 2010; Lee *et al.* 2011).

Our study reported that an adult male elephant always leads the group, displaying typical social behaviors and bonds among them. It is noteworthy to mention that an identified adult male elephant was observed leading the group from 2006 to 2009, and later, after the death of that elephant in 2009, another adult male elephant was observed leading the only male group for several years. A similar study carried out on the leadership patterns of only male African savannah elephants in Botswana reveals that the presence of older males in the group, who serve as leaders, is crucial to reducing the vulnerability of the elephant society and in the spatial navigation of younger male elephants in risky environments (Allen *et al.* 2020). It is worth mentioning that G.P. Sanderson has described an instance of two male elephants, who were unconnected with herds, constantly associating together, inseparable companions in their night wanderings, and always remained a mile or two apart during the day (Sanderson 1879). In contrast, in the absence of any comprehensive behavioral study of Asian elephants, the social organization of the species remains poorly understood (Vidya & Sukumar 2005; Mohankumar *et al.* 2011).

Musth is one of the exceptional states in male elephants when males undergo noticeable physiological and behavioral changes. Movements of males exhibiting musth are usually much more than those of non-musth males (Fernando *et al.* 2008). Although male elephants are observed exhibiting musth maximum during the summer and monsoon in Shivalik landscapes, they were observed in musth occasionally during the winter. Considering the field observations, it appears that adult males exhibit musth throughout the year, which is pronounced during the dry period. In southern India, male elephants

show distinct spacing during musth; older and stronger individuals come into musth during the wet season, while younger males show it in other seasons (Sukumar 2008). We observed that musth does not have any influence on the male elephant's grouping. Similarly, as males of different age groups were observed associating together, age also does not have much influence in the male elephants' grouping, unlike in the south Indian elephant ranges, where both musth and age interact to influence male-male group formation and sociality in a male elephants' group (Keerthipriya *et al.* 2021).

It is now widely acknowledged that elephants are intelligent and learn to adapt to their changing natural environments (Holdrege 2003; Rangarajan *et al.* 2010; Plotnik & de Waal 2014; Joshi 2017b). They possess higher levels of intelligence and cognitive abilities and can exhibit novel behavioral responses to the changing environment (Anonymous 2012). Poole & Granli (2009) revealed that elephants have evolved a range of specialized physical and behavioral adaptations, which allow them to cover long distances to meet their ecological, social, and reproductive requirements. Chiyo *et al.* (2012) revealed that the factors that influence learning and the spread of behavior in wild animal populations are important for understanding species responses to changing environments and for species conservation.

Although such social relations among male elephants are considered unstable, long-term field observations on the behavior of male elephants in northwest India indicated that male elephants have strong social bonds. While moving towards the outskirts of the forest or populated area, all-male groups form a stable hierarchy, which facilitates the learning of young male elephants from older male elephants. Since sub-adult male elephants are following old male elephants and are learning about their traditional tracks, it is assumed that only male elephant associations may continue soon. As population and developmental activities are increasing significantly in the region, development and conservation must be ensured together, a comprehensive conservation roadmap is of paramount importance to provide space for this giant species for their better management.

Considering our observations for over a decade, it appears that multiple populations of male elephants are engaging in long-term grouping to move across wider ranges, including agricultural fields. Besides, the increase in the size of the only male group reveals an unusual and newly emerging behavior of the species, which underlies the high cognitive abilities and natural history of the species. Whether all-male group formation is a result of environmental and land-cover change; whether a novel social behavior is developing among the male elephants; and whether such social integration and long-term associations are affecting male-male competition; to answer all such questions, long-term field studies are needed to be conducted on the behavioral ecology of the species.

5. ACKNOWLEDGEMENTS

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