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Population structure of wild Asiatic elephant in Patharia Hills Reserve Forest, Karimganj, India: A plea for conservation

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Abstract
Population estimation of wild animal is necessary for having an idea of their status which is helpful for having conservation related decisions. In most studies, population estimation of large size animal is done by line transacts, block count, dung count method etc. which though are suitable to large areas but in small areas those method provides biased results due to limitation of methods. With a view to determine the population status, age and sex of Asiatic elephant (*Elephas maximus*), we employed total count in Patharia Hills Reserve Forest (RF). Besides, semi-structure interviews were conducted, in which the respondents were fringe villagers, forest staffs, hunters and elderly people. A total of seven individuals of *E. maximus* were encountered throughout the study. Male and female ratio observed is 0:7; while adult, sub adult and juvenile ratio is 6:1:0. Both corridor and habitats were found under serious threat; subsequently Human-Elephant Conflict (HEC) is on increase. Ceasing developing activities, commercial felling of tress, extending legal protection of corridors and improvement of status of Reserve Forest to Wildlife Sanctuary has been suggested.

Keywords: Asiatic elephant, conservation, southern Assam, total count, wildlife

1. Introduction
Wildlife plays diverse roles in forest ecosystem. They help in maintaining the forest structure, productivity, nutrient cycling, soil structure and succession [1-3]. They also influence the ecosystem services by changing the magnitude and temporal continuity through which energy and materials circulate in the ecosystems. Thus, in this sense Diaz *et al.* (2006) [4] mentioned that the effects of biodiversity loss on ecosystem are very spacious.

Over the last few centuries, over population, modernization, globalization and industrialization is causing major destruction of forest all over the world, and tropical countries are the worst victim of these. These changes have lead to radical increase in land use intensity, which drastically deteriorate the forest ecosystems. In addition, the intensification of land use with monoculture activities has made homogenization of the remaining world forest. World's major forests are in tropical regions and the maximum countries belonging to these regions are poorly developed and having high population pressure, hunger, poverty etc. All these stand as the comprising factor for the wildlife conservation in the area [5].

North-East India occupies 8% of the total geographical area of Indian province, consisting of eight states. The forest cover of the region is 65.59% that is diversified with six different types of forests [6]. The region falls under two global important hotspots viz, Indo-Burma and Himalyan [7, 8]. The region is very rich in wild flora and fauna because of topographic condition, high rainfall and congenial environment [9]. However, from the last a few decades wildlife of the region is facing numerous threats. Conversion of land, habitat loss and fragmentation, hunting, poaching and illegal trade are the major ones [10-12]. In order to conserve the wild areas, long term conservation strategies need to be implemented. This includes assessment of Human-Elephant Conflict, habitat analysis and management strategies. Decision about management of a species in an area is depend on population status of the species [13, 14]. Multiple species monitoring approach are important for reliable, trends and correlation to conserve biodiversity [15]. It has thus become the trend in management of biodiversity and wildlife in highly protected area. Earlier literature, however, reveals that a good diversity of species are existed in various Reserve Forest (RF) of North-East India [16].

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Due to insufficient administrative vigilance in these sensitive forests, biodiversity is facing numerous threats and even some are on the way to become extinct. The Patharia Hills RF is one such example. This reserve forest has a significant diversity of species and it is the last hope of wild Asiatic elephant (*Elephas maximus*) in Barak valley districts of southern Assam. Due to lack of research and management activities, many animals have already become extinct and those which are available are facing numerous threats [9]. In order to assess status of the available pachyderm species in the area, the present study has been carried out with special focus on status, age, and sex of Asiatic elephants.

Population estimation of large animal through direct observation in tropical dense forest is problematic [17] due to poor visibility in dense tropical forest [18] as well as due their reclusive and cryptic nature [19]. Many procedures have been developed to overcome these problems including indirect sign of animals such as dung, tracks, trails and feeding residue observation [20, 21] as proxy for the species existence and population. Now a days, most survey procedure for

population estimation of large animals are camera traps [22, 19], video recording [23], and line transect method [18, 24, 25]. Due to limitation of dung count [26] block count and total count in paddy field were employed in this study.

2. Methodology
2.1 Study Area
The Patharia Hills Reserve Forest (PHRF), covers an area of 76.4730 square kilometers (Fig. 1). PHRF (24°38′0″N, 92°15′0″E) is a part of a continuous forest that runs into neighbouring country, Bangladesh. Altitude of PHRF varies between 40 MSL to 243.84 MSL. The reserve forest has diverse topographic features which support a large number of species. Besides Asiatic elephants, eight primate species are available in the area. Other important wildlife in the area are Indian Muntjac, Clouded Leopard, Chinese Pangolin etc. [9]. The endangered spectacled monkey *Trachypithecus phayrei* which is only found in south Assam, Tripura and Mizoram [11] is commonly found in the RF.
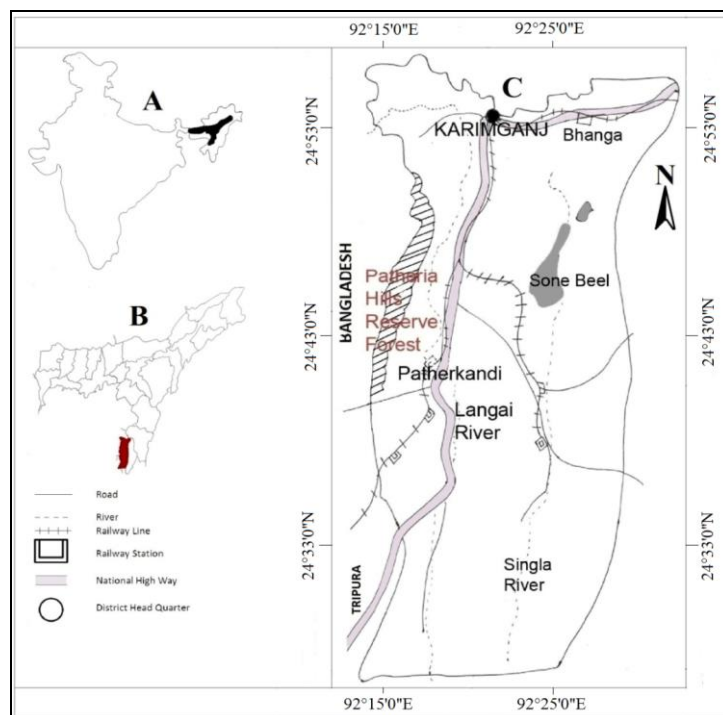

Fig 1: Map of the study area: A: Map of India highlighting the state of Assam. B: Map of Assam highlighting Karimganj district. C: Map of Karimganj District highlighting the Patheria Hills Reserve Forest.

Climate wise the area is having moderate temperature and is high humidity. The area receives tropical monsoon with a hot and wet summer and a cool and usually dry winter. Annual average rainfall is more than 3068 mm [9]. The warm humid climate of the area is characterized by a dry winter from November to February, hot dry summer from March to May, and a long rainy season from June to September. Highest rainfall occurs in June (572 mm) and least rainfall occurs in December (7 mm). Temperature is highest in August with an average temperature in this month is 28.3°C. Lowest temperature occurs in January with an average temperature is 18.4°C, which is lowest average temperate of the whole year. Relative humidity ranges from 89% - 90% in the morning and 40% - 81% in the afternoon. The annual potential evapo-transpiration is 1757 mm [9].

2.2 Field Method
Study was carried out during October 2016 to January 2017.

Population estimation of elephants was determined by direct observation. Indirect evidences were also counted such as, tracks and trails, footprints and dung, and by interviewing with the forest staffs, villagers and hunters. Block count in forest and paddy field count was employed for direct observation in the Reserve Forest besides regular observation in the tea garden.

2.3 Block Count
Study area was conveniently divided into 15 sectors of 5 square kilometers in each. The sectors were serially numbered. The block areas were marked on map and the area of each block were demarcated. The sectors were covered by 4 enumerators, spaced at a distance of 100 meters, within four hours. The average enumerator covered nine kilometers total distance within four hours. Counting was done on two consequecutive days in winter season" by "15 and 16 December of 2016 from 6.00 to 10.00 hr during which the

enumerators counted the elephant seen by them. Simultaneous counting was done by all the enumerators by starting from a base line and maintaining a distance of 100 meters between themselves so as to see one enumerator to the other. Individual enumerator recorded only those elephants which were seen to their left. During the count, details regarding photograph of elephant, age, sex and other related evidences (e.g., dung, tracks and trails) were also recorded in the block count data sheet.

2.4 Paddy Field Count

This technique is similar to water hole count but here *machaan* or watch tower was made near the road through which elephants go to paddy field. Since, elephant often uses the same route, so this method promises significant results. We selected five routes, out of which our team positioned on different *machaans* on three routes in different subsequent days. Elephant visiting to the paddy field were observed between 16.30 to 20.00 hours and 3.30 to 5.30 by a team positioned on a *machaan*. During this period all elephants went the paddy field were counted, aged and sexed.

For age and sex determinations of elephants, protocol of Verma *et al.* (2012) [27] was followed. Whenever elephants were sighted, photographs were taken, keeping the nearest tall trees in the frame. Later on, height of the tree was measured with a measuring tape. This helped to avoid duplication and have accuracy of the elephant population. Elephants with same heights were considered as the single individuals. The direct sighting of elephant herd was then compared with the

captured photographs.

Crude density is defined as the number of elephants present to the total habitat of elephant. Ecological density is the number of elephants present to the core area, (Core area is the area where elephant can sustain throughout the year).

3. Results

A total of seven Asiatic elephants were encountered throughout the study. Both the block count and paddy count provided similar results. Details of their height, age structure are shown in table 1. All of the individuals were females. About 50% individuals were found less than 30 years old. The ratio of adult, sub adult and juvenile was 6:1:0.

Table 1: Age structure and sex of Asiatic elephant in the study area

Serial No.	Height in cm	Age	Sex
1.	270	40+	F
2.	258	40+	F
3.	257	40+	F
4.	252	40+	F
5.	242	40+	F
6.	230	20+	F
7.	207	13	F

Crude density and core density of the species is 0.05 and 0.175 per km^2 (Table 2) which is very low compared to other studies in India. Bandipur Tiger Reserve 1.8/km² [28]; Mudumalai Tiger Reserve 3.1/ km², Nilgiri north 0.5/km², and Wayanad Wildlife Sanctuary 1.75/km² [30].

Table 2: Sex ratio, crude density and ecological density of Asiatic elephant in the study area

Population Size	Male	female	Sex ratio (M:F)	Total habitat area in km²	Core area in km²	Crude density in km²	Ecological density in km²
7	0	7	0.7	140	120	0.05	0.175

It was found that both corridor status and population structure of Asiatic elephant are significantly ($p < 0.05$) related each other. Around 1970, corridor areas were highly affected by various anthropogenic pressures and subsequently population

structure of the Patharia Hills Reserve Forest declined (Fig. 3). It has been observed that after 2000, migratory corridors are almost remains stable and hence population structure of Asiatic elephant.
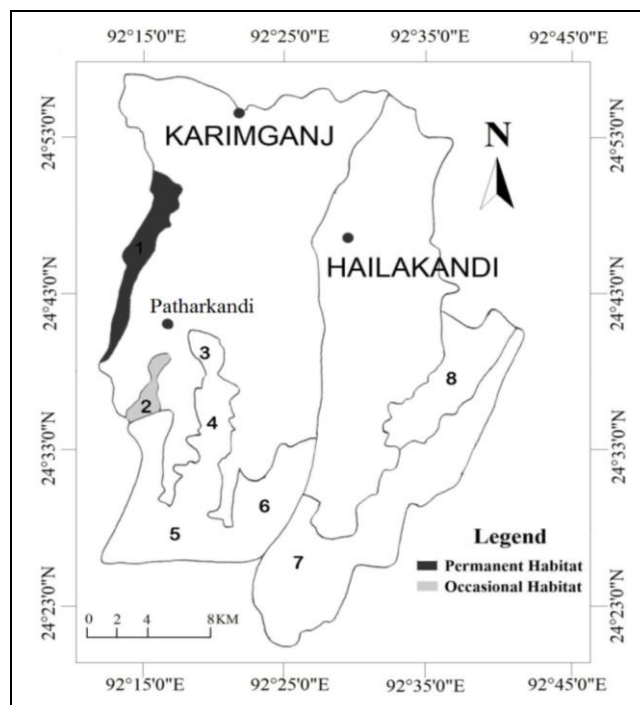

Fig 2: Map showing the past and present migratory corridor of Asiatic elephants of Patharia Hills RF. Past migratory corridor is from 1) Patharia Hills RF, to (2) Tilbhum RF, (3) Duhalia RF, (4) Badshah Tila RF, (5) Longai RF, (6) Singla RF, (7) Inner Line RF and (8) Katakhal RF. Presently, migration is limited from 1) Patharia Hills RF, to (2) Tilbhum RF.
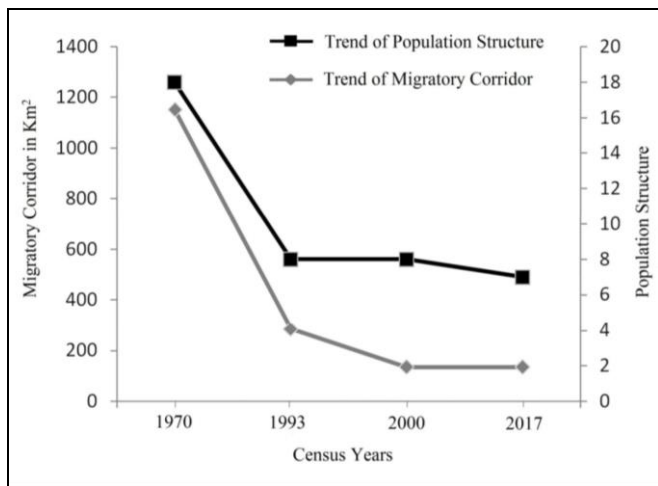
Fig 3: Trend of population structure and migratory corridor of Asiatic elephant in the study area.
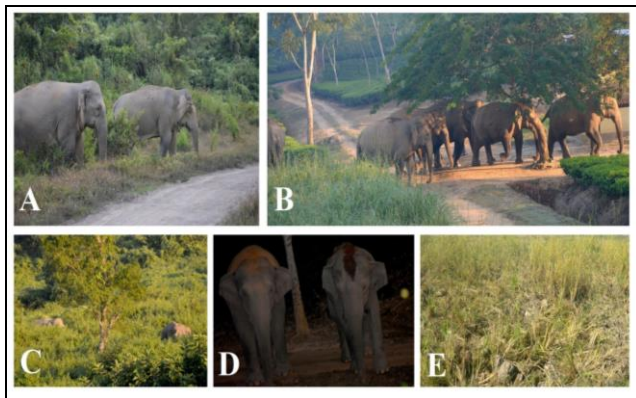

Fig 4: Elephants of Patharia Hills Reserve Forest. (A) Elephants herd crossing the road within the forest (B) Elephant herd returning from paddy field through Medli tea garden to reach Patharia Hills Reserve Forest, (C) Elephants were in forest, (D) Elephants were reaching to paddy field at night, (E) Paddy damaged by elephants.

4. Discussion

Throughout our study seven individual elephants were found in the PHRF. During recent past, however, eight elephants were reported during March 1993 census, conducted by department of Forest and Environment, Assam. Surprisingly, after 23 years of census (from 1993 to present census), the population size was not found to increase. Previous census [31] reported that out of total eight elephants, six were immature and two adults, of which, one was male and the other female. However, in present study, it has been found that all the encountered elephants are female. Among them, five are more than 30 years, and remaining two are 25 and 14 years old (approx.) (Table 1). The differences in the age-sex differences between the two observation over a period of 23 years confirms addition in their population through new birth, although absence of male in the herd, suggest its possible mortality, during past 13-14 years or so.

It was gathered from local people that the adult male recorded during previous study was shot dead by a Border Security Forces (BSF) in 2012 for his self defense. Two sub adult female elephant found in the present study were born after 1993 census and remaining five elephants were included in 1993. So, it is clear that out of six immature elephant in 1993, one was absence in the present study. This individual was perhaps lost due to accidental death or disease, or might have been illegally captured for domesticating as. The domestication of wild elephant in the region has been stated by other researcher too [31].

Most important factor for the conservation of these elephant is absence of male elephant in the herd. The study revealed that there is no juvenile or calves in herd. As transborder migration of the species is a phenomenon, the observation clearly justifies that no male elephant exist in the Bangladesh side of the same reserve forest as well. This is a serious issue for the conservation of elephants in this area. Under such situation, only solution is to translocate an adult male elephant into RF from any neighboring area. Studies confirm that the translocated elephants can adapt into new areas within a short period of time as has been observed in many countries [32-36]. Habituated and well behaved bull should be selected to live and display the same behavior at the new location [37].

Other study in this RF [9] found that habitat loss and fragmentation are the main threats following human population explosion and developmental activities. Comparatively hunting is not a major threat due to regular patrolling by Border Security Forces of India (BSF) along the trans-boundary border which lies within the RF. The loss and fragmentation of habitat impels Human-Elephant Conflict (HEC) in the study area (Fig. 3).

It was observed that the area lies between Patharia Hills RF and Tilbhum RF are under serious threats and hence more prone to HEC. Most of those areas are adjacent to, but outside the Patharia Hills RF (namely Kalabil, Medli, Kurti, Tirmiti, Lalkira, Hatikira and Sonakira). HEC includes in the area are riding crop, damages home garden plants, houses and even human death [9].

Elephant of the Patharia Hills RF had long home range during 1970 (Fig. 2). At that time elephant herd used to migrate from Patharia Hills RF to Katakal RF through Longai RF - Singla RF-Inner Line RF. The long corridor had broken and fragmented in 1970 due to sugarcane cultivation and human habitation in new areas [31]. In 1990, their home range was observed between Patharia Hills RF to Tilbhum RF and occasionally to Longai RF [31]. Presently, the home range of these elephant is only 140 km^2 combining Patharia Hills RF and Tilbhum RF. Till then, there is no report on migration of these elephants to Longai RF over the past seven years. Currently, the home range is 140km^2, covering 120 km^2 of Patharia Hills RF and 20 km^2 of Tilbhum RF (Fig. 2). However, the corridor between Tilbhum RF and Patharia Hills RF although has not been completely ceased but tea plantation and human habitat between the RFs are extremely threatening the passage. The herd very seldom moves to Tilbhum RF. This aspect deserves serious attention from their conservation point of view.

It was observed that the corridor between Patharia Hills RF and Tilbhum RF are facing numerous threats and almost ceased. This area includes tea estate and human habitation. In one hand, the forested areas under tea estate have been converted to tea and rubber plantation, while on the other hand, human population have started to settle in new areas. Elephants do not harm to both tea plantation and rubber plantation. In fact, it was observed that they avoid entering the rubber plantation areas. This conversion of forest land which lies within corridor invites more HEC as the elephant direct come to crop land (Fig. 4)

If further conversion of land is not stopped, movement of elephant from Patharia Hills RF to Tilbhum RF will be permanently stopped within a few years as that of Longai RF, where it has already ceased and also HEC will be more intense between Patharia Hills RF and Tilbhum RF areas.

4.1 Conservation Issues

Habitat loss and fragmentation is the major threat has been found in the area, which impel the HEC, especially, during cropping season. Corridor fragmentation and damage is the prime reason for HEC. The HEC is limited to those cropping area which fall between the Patharia Hills RF and Tilbhum RF. Choudhury (1999) [31] recommended that the corridor areas between these two RF should be conserved. Land use pattern should not be allowed to change within the conjunction between these two RFs (Fig. 2). The following recommendations may be considered for the conservation of Asiatic elephant and their habitat:

- **Ceasing Activities within the Reserve Forest:** Along with the control of forest fragmentation, encroachment should be strictly controlled. Areas under encroachment should be evicted immediately to save the habitats. Commercial felling in the forest should be completely ban to maintain tree cover and ecology of forest. Within the Forest Boundary, Oil and Natural Gas Company (ONGC) should not be allowed to enter within the Reserve Forest Boundary.
- **Compensation to wildlife victim:** Quick payment for loss of life and property result of Human-Elephant Conflict. Wildlife Trust of India initiated a campaign "Grain to Grain" to mitigate HEC in many areas where crop lost families are provided grain as by elephant supplementary of losses by elephant. It helps to reduce erosion of people attitude on elephants. The same campaign can be applied to HEC prone areas.
- **Supplementary Facilities to fringe household:** Large-scale installation of bio-gas (Deenbandhu model only) to fringe household to reduce pressure on fire-wood.
- **Precautionary Measures:** Sonitpur Model should be applied to reduce Human Elephant Conflict in fringe areas. In Sonitpur, WWF-India (www.wwfindia.org) is implementing the Asian Rhino and Elephant Action Strategy (AREAS) and has evolved a model for HEC management (called as Sonitpur Model). Geographic Information System (GIS) and Remote Sensing (RS) along with elephant monitoring and guarding employing trained tame elephants for chasing off wild herd.
- **Translocation of adult male elephant:** Since there is no male elephant in the Reserve Forest, the translocation of adult male may be considered immediately with top priority.
- **Legal Protection of corridor:** Legal protection of elephant corridor from Bangladesh side of Patharia Hills RF to Tilbhum RF is recommended. Subsidies should be given to private land and tea estate owner to avoid land use change within the narrow corridor.
- Long term assessment of habitats and HEC throughout the affected areas.
- The improvement of status of the Patharia Hills Reserve Forest to Wildlife Sanctuary which will help to conserve the wildlife of the area within legal arena.
- **Awareness:** The government and Non-Governmental Organisation (NGO), ecologist and environmentalist should come forward to aware local people for the conservation of wildlife of PHRF.

4.2 Implication for Conservation

Seven numbers of elephants were encountered in the forest. Trend of population was found significantly declining with the declining of migratory corridor and conditions of the Reserve Forest. A few recommendations has been highlighted above can be taken care for the conservation and preservation of the last hope of Asiatic elephant in the southern Assam. Improvement of the status of the Reserve Forest may be vital solutions besides other suggestions. Due to negligence of the government, Asiatic elephant extirpated from the Barail Reserve Forest, which was recognized as wildlife sanctuary in 2004, after the extirpation of the species around 2000 [38]. So, it is the urgent need to improve the status of the Patharia Hills Reserve Forest into "Patharia Hills Wildlife Sanctuary" for protection of the area.

Since the details about age, sex, population structure of PHRF was not available now; the data reported in this article is useful for future enumerating elephant population dynamics and designing conservation strategies accordingly.

6. Conflicts of Interest

The authors declare no conflict of interest. The founding sponsors had no role in the design of the study; in the collection, analyses or interpretation of data; in the writing of the manuscript; nor in the decision to publish the results.

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