DOI: 10.2305/DIHX2111
Research Article Gajah 56 (2023) 4-9

Road for Elephants: Elephant Use of the Karadikkal-Madeshwara Corridor, Southern India

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Abstract. Wildlife corridors play an important role in connecting elephant habitats across India. Monitoring them is essential to assess their usage by elephants and to identify the anthropological risks to their persistence. We present the results of a grid-based survey of elephants for the Kardikkal-Madeshwara corridor in Bannerghatta National Park. Our findings indicated high use by elephants, with more observations recorded within grids which overlay natural habitats of the park than those that overlay human dominated land. The corridor remains under high human pressure, indicating the need for continued attention to maintaining corridor function.

Introduction

Approximately 12,000 Asian elephants (*Elephas maximus*) inhabit southern India, accounting for 40% of the country's population (MoEF & CC 2017). Elephants require extensive habitats. Their home-ranges in India usually vary between 105 to 350 km^2 (Sukumar 1989) but may extend to over 4000 km^2 in highly degraded and fragmented landscapes like those found in Central India (Datye & Bhagwat 1995). The annual rate of forest cover loss in India between 1975–2005 was 5.8% (Reddy *et al*. 2013). Rapid fragmentation and shrinking of their habitat threaten their long-term survival (Sukumar 2006). Consequently, wildlife corridors are increasingly important in connecting tracts of land elephants use (Green *et al*. 2018). A total of 101 elephant corridors have been identified across India (Menon *et al*. 2017).

Establishing and maintaining corridors poses a number of challenges, such as providing legal protection and preventing encroachment, degradation from cattle grazing, and fragmentation by roads. Of the 101 identified corridors in India, 28.7% have been encroached for human settlement, and 66.3% have roads/highways running across them. Only 12.9% of the corridors consist completely of forest, and most are surrounded by agricultural land and settlements, which heighten the risk of human-elephant conflict (Menon *et al*. 2017). Agrarian lands that encroach on elephant corridors represent food sources for elephants, who wait on corridor edges during the day and raid croplands at night, leading to increased human-elephant conflict (Graham *et al*. 2009).

The Bannerghatta National Park (BNP) in southern Karnataka facilitates elephant migration between the Western and Eastern Ghats (Varma *et al*. 2009). BNP possesses three elephant corridors to allow movement of elephants between key areas of the park, one of which is the Karadikkal-Madeshwara corridor (Ramkumar *et al*. 2017).

This study assesses the pattern of use of the Karadikkal-Madeshwara corridor by elephants and identifies threats to the corridor.

Methodology

Study area

The BNP's dominant vegetation is tropical scrub and deciduous forest. The area received

Manuscript Editor: Prithiviraj Fernando

around 625–750 mm rain annually with the main rain fall occurring between June and November. The dry season extends from January to April and the wet season from May to December.

The Karadikkal-Madeshwara corridor (12°41' 29" – 12°42'30" N, 77°33'46" – 77°34'49" E) has an east-west orientation and connects the Harohalli and Anekal wildlife ranges of BNP. The corridor is hourglass shaped and is 1 km in length and 0.5 – 0.7 km in width (Figs. 1 & 2). The corridor lies between the settlements of Jaipurdoddi and Bilanganakuppe, which are connected by a road running through the eastern section of the corridor (Fig. 1). The main livelihoods of the people in these settlements are livestock farming and cultivating *Eleusine coracana* (finger-millet) and *Oryza sativa* (rice), both of which are very attractive to elephants. Livestock grazing is common around the corridor as there are approximately 880 head of cattle in the flanking villages. Elephant barriers consisting of elephant-proof trenches and electric fences have been erected on the boundary of BNP including on either side of the corridor (Fig. 2).

Parts of the natural habitat of the national park have been converted to agriculture (Fig. 2). Such converted land within the park was not protected by the elephant barriers, as the barriers were on the park boundary. Google Earth satellite images were used to identify natural habitat and agricultural lands within survey grids. Scrub and forest vegetation were taken to represent natural habitat.

Monitoring

Monitoring was based on a 1x1 km grid overlay provided by Wildlife Trust of India as part of the national elephant corridor monitoring scheme. It consisted of 24 grid cells covering the corridor and surrounding area. (Fig. 2). Each grid cell was visited three times in 2019, once during the dry season (May/Jun) and twice in the wet season (Aug/Sep & Nov/Dec).

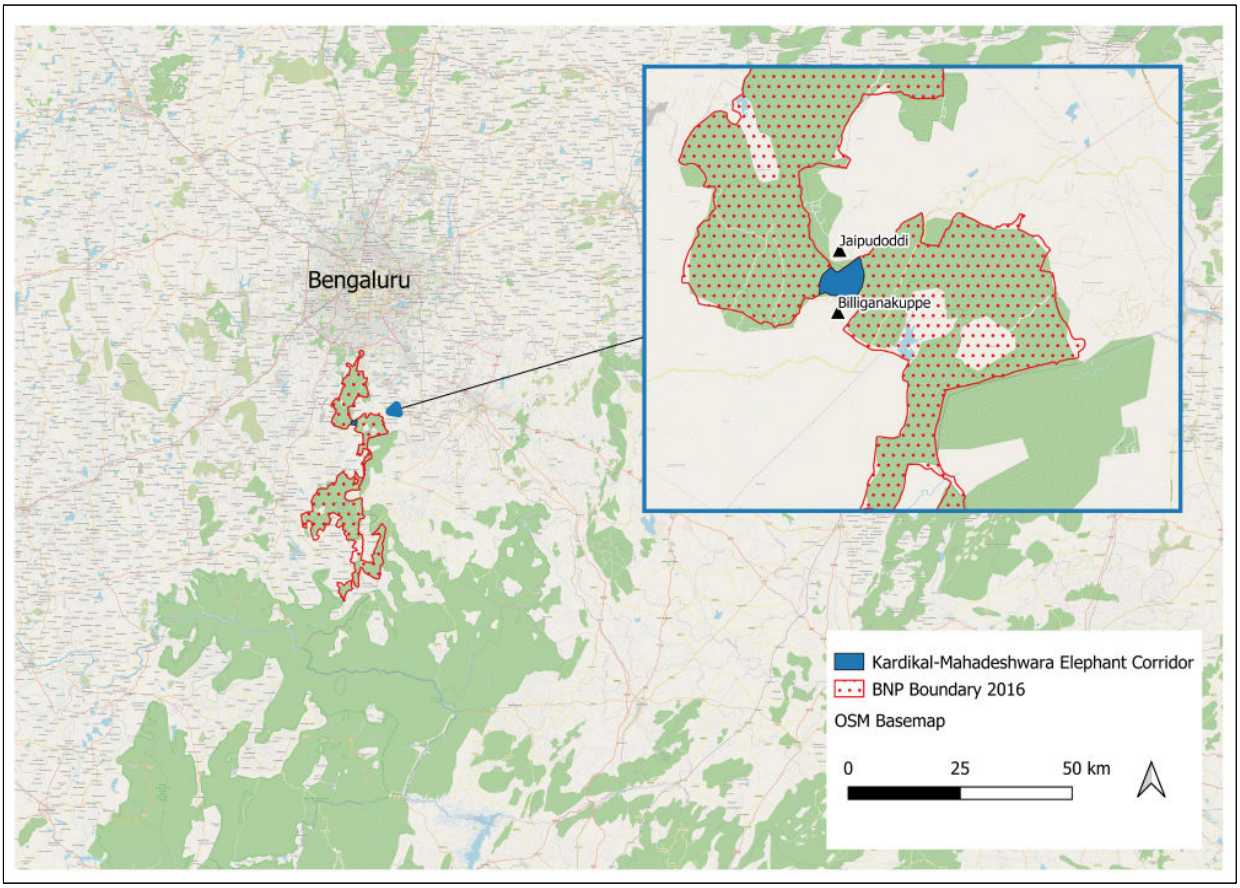

Figure 1. BNP and the Karadikkal-Madeshwara elephant corridor.

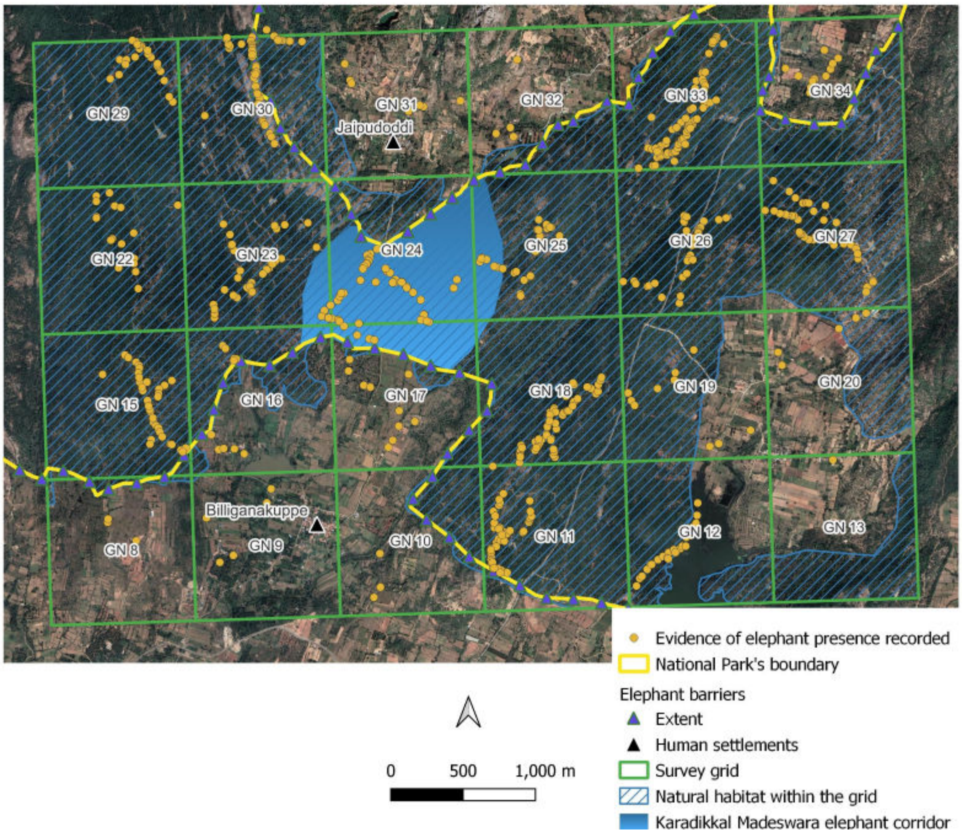

Figure 2. Locations of signs of elephant presence collected across the survey grid.

Four to five grids were surveyed each day, starting at 9 am and ending at 5 pm. Pre-existing animal trails were walked in the natural areas, footpaths were used in developed land and agricultural areas. The distance along the trail was measured using the odometer function in a GPS device. The length of trail surveyed per grid was 1 km. Each trail survey took between 20–40 min. No particular direction was followed in traversing a trail.

Usually four persons consisting of two researchers and two forest-watchers formed the survey team. If the grid surveyed was dense forest or if there was recent elephant movement, a 5th person joined for extra security. One researcher took part in all the surveys, the other participants varied.

On each survey along a trail, the team recorded the presence of anthropogenic pressure and elephant sign. All observations were entered in data sheets. Presence or absence data was recorded based on observation of elephants, dung piles, feeding signs, sleeping areas, feeding evidence, mud baths, urination or footprints.

If a group of elephants were observed, it was taken as a single sighting. When a dung bolus was detected, the boli within 90 cm were examined and if the size and freshness of the boli were similar, then it was counted as a single dung pile. If the size and freshness of boli differed, then it was counted as two dung piles. Only dung deposited within one week, as judged by its appearance of freshness were recorded.

The presence of anthropogenic sign was recorded as indicated by observation of crops, livestock, estate plantations, fences, trenches, linear infrastructure, mining, quarrying or stone crusher units.

The data was analysed in MS Excel and QGIS. Chi-square analyses were conducted to test whether the differences in the number of elephant observations across different grid cells were significantly different. Correlation analyses were undertaken between observations of elephants and human pressure and natural habitat.

Results

Signs of elephant presence were recorded in all 24 grid cells (Fig. 2), while dung was recorded in 19 grid cells. A similar number of dung piles were counted in the dry season and the first wet season visits, but significantly less during the later visit (dry season vs second wet season; p = 5.15 x 10^{-6}, Fig. 3).

There was a positive correlation between the number of dung piles in each grid cell and the percentage of natural habitat within the cell, r = 0.82 (Fig. 4). A significantly greater amount of dung piles was recorded in cells with >50% natural habitat than those with >50% human habitat (p = 1.65 x 10^{-5}) and in grid cells with an area of >50% within the park than those with >50% outside (p = 4.2 x 10^{-5}).

There were a greater number of dung piles in the narrowest part of the corridor (GN24) when compared to the grid cells neighbouring it to the north (GN31 vs GN24, p = 7.07 x 10^{-10}) and south (GN17 vs GN24, p = 1.25 x 10^{-8}), and no difference between GN24 and cells to its East (GN11,18,25,26,27 & 33) (p = 0.88) and West (GN15,22,23,29,30) (p = 0.43).

No significant difference was found in the number of dung piles counted in cells within the park boundary which were cut through by a road and those that were not.

Anthropogenic signs were encountered in all grid cells (Table 1).

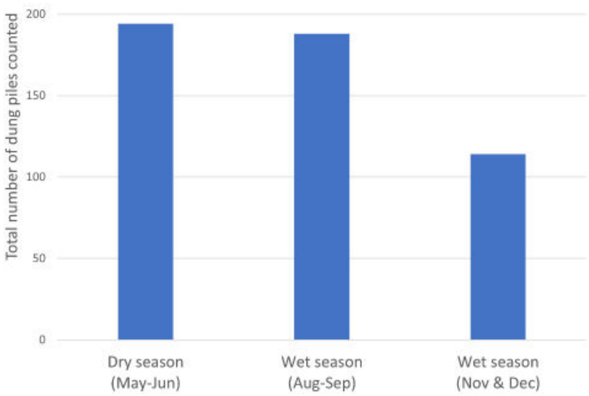

Figure 3. Total number of dung piles counted across the three survey periods.

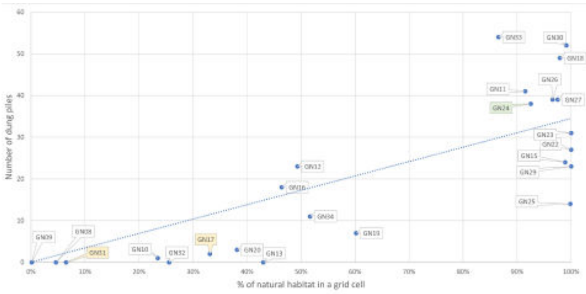

Figure 4. Number of dung piles observed in each grid cell and the percentage of natural habitat.

Discussion

The results from this survey of the Karadikkal-Madeshwara corridor suggest that it is being used by elephants in their movements across the Harohalli and Anekal ranges of BNP. We found a strong correlation between elephant observations and grids with a high extent of natural habitat, which applied to even the narrowest part of the corridor confirming the importance of maintaining natural corridors for habitat connectivity. However, elephants also used agrarian land outside the elephant barriers on the park boundary. Agricultural land in Malaysia was found to represent prime habitats for elephants, rather than marginal areas (de la Torre *et al*. 2021). Therefore, it is possible that a similar situation exists in our study area. The presence of elephants outside the park boundaries, also highlight limits of the elephant barriers currently in place.

We found that the highway that runs through the park, is regularly crossed by elephants and that it did not to affect their use of the area. However, further studies are needed to establish if the road poses a threat due to elephant mortality or injury due to traffic-related accidents.

The number of dung piles observed did not vary between the dry season and the first wet season and decreased in the second wet season. Influx of elephants into the area has been reported during the monsoon when crops are harvested (Varma *et al*. 2009). While this could be expected to increase elephant activity in the survey area and movement through the corridor, hence increase in dung density during the wet season,

Table 1. Presence of anthropogenic signs in grid cells.

Grid number	% within park	% natural habitat	Crops	Live-stock	Planta-tions	Fence/ trench	Linear infra-structure	Mining*	Other infra-structure
GN08	3	5	Yes	Yes	Yes	Yes	Yes	Yes	Yes
GN09	0	0	Yes	Yes	Yes	Yes	Yes		Yes
GN10	21	23	Yes	Yes	Yes	Yes	Yes		Yes
GN11	89	92		Yes					
GN12	100	49	Yes	Yes		Yes	Yes		Yes
GN13	100	43	Yes	Yes	Yes	Yes	Yes		Yes
GN15	97	99		Yes					
GN16	30	46	Yes	Yes	Yes	Yes	Yes		Yes
GN17	29	33	Yes	Yes	Yes	Yes	Yes		Yes
GN18	98	98		Yes					
GN19	100	60	Yes	Yes			Yes		Yes
GN20	100	38	Yes	Yes	Yes		Yes		Yes
GN22	100	100		Yes					
GN23	100	100		Yes					
GN24	74	93		Yes					
GN25	100	100		Yes					
GN26	100	97		Yes					Yes
GN27	100	98		Yes					
GN29	100	100		Yes					
GN30	67	99	Yes	Yes	Yes	Yes	Yes		Yes
GN31	0	7	Yes	Yes	Yes	Yes	Yes	Yes	Yes
GN32	22	26	Yes	Yes	Yes	Yes	Yes	Yes	Yes
GN33	87	87		Yes					
GN34	50	52	Yes	Yes	Yes	Yes	Yes		Yes

* Mining/ quarrying/stone crusher units

this was not the case. The comparatively high number of dung piles observed in the dry season could also be related to low food or water availability, which could cause elephants to move between resource points more frequently.

Livestock grazing was the biotic pressure most often observed within the park. This is a troubling sign that could threaten primary vegetation in the area, by reducing forest cover within the corridor in the long-term through reduced survival of seedlings. The presence of cattle can also lead to complications such as, spread of diseases and man-animal conflict from livestock predation by leopards and tigers.

Anthropogenic pressures were greater and more varied outside park boundaries. The presence of crops such as *Eleusine coracana* and *Musa paradisiaca* adjacent to the park boundary could attract elephants to move outside the park. We found that elephants used forest tracts more than anthropogenic habitat. Yet, the impact of elephant raiding affects the attitudes of the people living around the corridor towards elephants, as they believed that 65% of their crops were damaged every year by elephants (Pavani 2009).

Overall, the patterns of use observed by us, indicates that the corridor is effective as a passage for elephants. However, it may face serious threat from livestock grazing and other biotic pressures in the years to come. Our findings justify the corridor's importance in the national park and argue for its urgent conservation, as there are no alternative movement routes across this landscape for elephants. The issues in the Karadikkal-Madeshwara corridor are likely to be representative of the pressures on many of the 101 elephant corridors that are currently identified across India.

Acknowledgements

We dedicate this publication in the memory of Dr. Ramkumar Kalayansundram (1978–2021) of Wildlife Trust of India, a real crusader for elephant corridors in southern India. We extend our sincere gratitude to the office of the Principal Chief Conservator of Forests (PCCF), Wildlife of the Karnataka Forest Department, for issuing permission (Ref: PCCF(WL)/C2/CR-18/2018-19) to conduct this research in the BNP. We thank the Wildlife Trust of India and A Rocha India for their continued support for the elephant corridor monitoring research in this study area. We thank Mr. Prashant S, Deputy Conservator of Forests (DCF), Mr. A Prakash, Assistant Conservator of Forests (ACF), Range Forest Officers (RFO), Mr. Rajkumar and Mr. Gururaj S of Harohalli and Anekal Wildlife Ranges respectively and the frontline staff of the Bannerghatta division for their support during field work. Our heartfelt thanks to the field team comprising of Shakthivelu, Sonal Devkaran, Saana Benurwar and Sanju Desai for their exemplary contribution in collecting field data for this study. We are grateful to the Whitley Fund for Nature for funding this elephant corridor project.

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