

## Trends and Patterns of Elephant Crop Raiding in Sindhudurg District, Maharashtra, India

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**Abstract.** Range extension of elephants has been observed in northern Western Ghats over the past few decades. The Sindhudurg District is one such area experiencing recent colonization by elephants. We obtained data on crop raiding incidences between 2002 and 2015 from Range Forest Offices in Sindhudurg District. Information was available on 9148 crop raiding cases. Data analysis showed that 36 different crops were damaged and coconut (44%), rice (22%), banana (20%) and areca palm (8%) were the worst affected. Crop raiding frequency was higher during the winter season followed by monsoon and lowest in summer. November and December experienced a peak in crop raiding. Rice was recognized as an attractant for elephants.

### Introduction

Western Ghats also known as Sahyadri (the benevolent mountains) is a mountain range that runs parallel to the western coast of the Indian peninsula. It is a UNESCO World Heritage Site and is one of the eight “hottest hot-spots” of biological diversity in the world.

Western Ghats harbour around 10,000 Asian elephants (*Elephas maximus*), distributed in six different populations over four major landscapes (Baskaran 2013). Sindhudurg and Kolhapur Districts of Maharashtra State form the northernmost limit of elephants' distribution in the Western Ghats (Mehta & Kulkarni 2013).

The states of Maharashtra and Goa, including the Forest Division of Belgaum (Karnataka state) were not part of traditional elephant range. Initially an elephant herd from the Haliyal-Dandeli Forest Division made a short foray into Belgaum Forest Division in 2001 (Baskaran 2013). Since November 2002 wild elephants especially from Dandeli Wildlife Sanctuary, have intruded the forests of Sindhudurg and Kolhapur Districts of Maharashtra. The influx had been continuous and currently elephants have become resident in Sindhudurg District.

This range extension or emigration of elephants into a previously unoccupied range and the consequent human-elephant conflict (HEC) drew a lot of attention in the socio-political spheres of Sindhudurg District. HEC was caused largely due to crop raiding. The present study was conducted to understand trends and patterns of elephant crop damage in human dominated landscapes in the Sindhudurg District.

### Material and methods

#### Study area

Sindhudurg District (15°37' to 16°40'N and 73°19' to 74°18'E) is a southern coastal district in western Maharashtra, having 121 km of coastline. The geographical area of the district is 5207 km<sup>2</sup>. The terrain is hilly with coastal lowlands. Around 52% of Sindhudurg is covered by moist deciduous and semi-evergreen forests, out of which 89% is under the ownership of private landholders and communities (Patil *et al.* 2016). The study area has a sub-tropical climate and the year could be divided into three seasons consisting of summer (February to May), monsoon (June to September) and winter (October to January).

Approximately 87% of the population of Sindhudurg is engaged in agriculture with an

average landholding of one hectare (Census of India 2011). Major crops include rice, millets and pulses. Rice is essentially a *Kharif* crop i.e. grown during the monsoon (June to October). A large proportion of land is under orchards such as mango, cashew, coconut, areca nut, banana, pineapple and bamboo plantations. Spices like nutmeg and black pepper are cultivated within coconut orchards. Home-garden is a widely adopted traditional agroforestry system. The district is subdivided into eight talukas (administrative division) viz. Vaibhavvadi, Devgad, Kankavli, Malwan, Kudal, Vengurla, Sawantwadi and Dodamarg. There are a total of 748 villages spread across these talukas.

#### Data collection

Data on crop raiding between 2002 and 2015 were obtained from compensation records in Range Forest Offices of the Forest Department. We defined a ‘case’ as an entry in the Forest Department Register of Compensation, based on reporting of elephant damage by a farmer. We defined a ‘raid’ as a specific instance of damage of a particular crop. A single ‘case’ where more than one type of crop was damaged would represent a number of ‘raids’, therefore, raids number substantially more than cases. Cases were used for overall analyses and the number of raids for crop-based analyses.

For each crop raiding case, name of farmer, forest range of jurisdiction, taluka, village, date of crop raiding, crop damaged and its magnitude

and compensation paid were noted. Data of area under cultivation for coconut, areca palm, banana and rice was obtained from the Agriculture Department.

#### Data analysis

For variables that could be compared across categories of taluka or years, seasons etc., appropriate tests were used to compare means (ANOVA) and medians (Kruskal-Wallis test). Mann-Whitney U test was used to compare median values of monthly crop raiding intensity. Wherever necessary, chi-squared goodness-of-fit test was also used. We also tested the relationship between elephants’ relative raiding frequency and availability of crops at the scale of District. Data analysis was carried out using Microsoft Office Excel 2010® worksheet and Paleontological Statistics (PAST, Version 3.11) software.

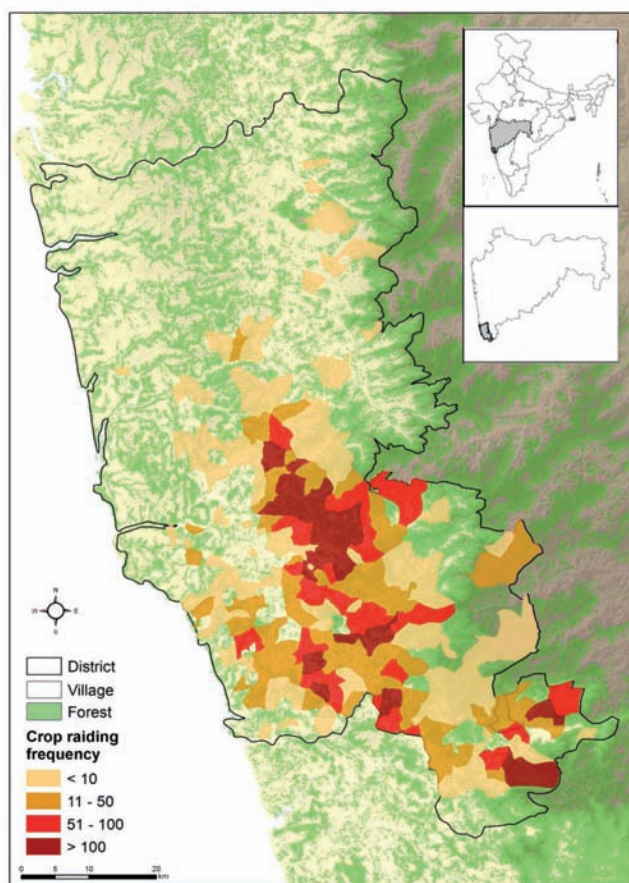
## Results

#### Extent of raiding

From the compensation records, information was available on 9148 cases. The conflict was spread over an area of nearly 4300 km<sup>2</sup> of Sindhudurg District and 244 villages (33% of the total villages in Sindhudurg) were affected by crop raiding (Fig. 1, Table 1). The worst affected talukas in terms of number of villages affected were Kudal (62% of the total CR cases), Sawantwadi (29%) and Dodamarg (14%). Vengurla, Kankavli, Malwan and Vaibhavvadi talukas were comparatively less

**Table 1.** Demographic profile of talukas in Sindhudurg District with villages affected by crop raiding (CR) by elephants (2002–2015). Demographic data sourced from Census of India, 2011 (www.censusindia.gov.in).

Taluka	Area (km <sup>2</sup> )	Villages	Population	Households	Villages affected	CR records
Devgad	787.68	98	120,909	27,800	0 (0%)	0 (0%)
Vaibhavvadi	427.03	59	43,845	11,545	5 (8%)	7 (0.1%)
Kankavli	819.77	105	110,886	27,864	16 (15%)	59 (1%)
Malwan	608.43	135	93,159	24,304	11 (8%)	51 (1%)
Kudal	809.30	124	139,609	34,127	83 (67%)	4837 (52%)
Vengurla	277.12	83	73,409	18,372	20 (24%)	260 (3%)
Sawantwadi	797.85	82	111,924	27,154	62 (76%)	2642 (29%)
Dodamarg	558.08	62	48,904	12,035	47 (79%)	1292 (14%)
Total	5085.26	748	742,645	183,201	244 (33%)	9148 (100%)



**Figure 1.** Elephant crop raiding frequency of villages in Sindhudurg District.

affected while Devgad taluka was not affected. A similar pattern was seen in terms of the number of crop raiding cases per taluka (Table 2).

#### Crop damage extent

A total of 36 crops (fruit and spice crops = 18, field crops = 14, forestry plantations = 4) were damaged. These consisted of:

(i) Fruit and spice crops; coconut *Cocos nucifera*, banana *Musa acuminata*, areca palm *Areca catechu*, mango *Mangifera indica*, cashew *Anacardium occidentale*, jackfruit *Artocarpus heterophyllus*, sapodilla *Manilkara zapota*, kokum *Garcinia indica*, pineapple *Ananas comosus*, papaya *Carica papaya*, bread fruit *Artocarpus altilis*, oil palm *Elaeis guineensis*, jambul *Syzygium cumini*, lemon *Citrus limon*, drum stick *Moringa oleifera*, nutmeg *Myristica fragrans*, custard apple *Annona reticulata* and java-apple *Syzygium samarangense*.

(ii) Field crops; rice *Oryza sativa*, finger millet *Eleusine coracana*, sugarcane *Saccharum officinarum*, chili *Capsicum annuum*, groundnut *Arachis hypogaea*, cowpea *Vigna unguiculata*, horse gram *Macrotyloma uniflorum*, maize *Zea mays*, watermelon *Citrullus lanatus*, lab-lab bean *Lablab purpureus*, sunflower *Helianthus annuus*, jowar *Sorghum bicolor*, bajara *Pennisetum glaucum* and black gram *Vigna mungo*.

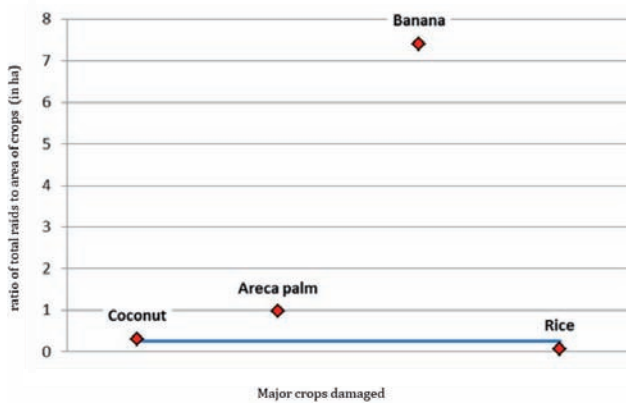
(iii) Forestry plantations; bamboo *Dendrocalamus stocksii*, teak *Tectona grandis*, Pará rubber tree *Hevea brasiliensis* and Indian sandalwood *Santalum album* in descending order of dominance.

Coconut (44%), rice (22%), banana (20%) and areca palm (8%) were the most raided crops. Nearly 50% of the cases involved raiding of a single crop. Of such cases, nearly 50% involved coconut, 39% rice and the rest were other crops.

Of raids in which two or more crops were

**Table 2.** Comparison of elephant raiding frequency (N) and area (in hectares) under major crops in different talukas of Sindhudurg District (2002–2015).

Taluka	Coconut		Areca palm		Banana		Rice		Total N
	N	Area	N	Area	N	Area	N	Area	
Vaibhavvadi	4	335	0	20	4	20	0	4160	8
Kankavli	37	1110	3	58	18	40	17	13,750	75
Malwan	33	3510	4	155	15	40	11	10,990	63
Kudal	4044	4220	496	175	1549	45	1877	13,690	7966
Vengurla	166	3002	30	170	85	30	87	4190	368
Sawantwadi	1872	3402	433	255	1081	120	983	7170	4369
Dodamarg	826	1710	356	178	410	90	457	2670	2049

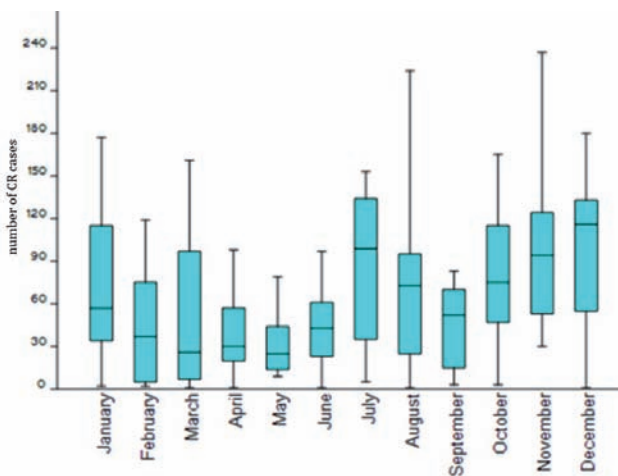


**Figure 2.** Ratio of number of elephant raids to area under crop for major crops in Sindhudurg.

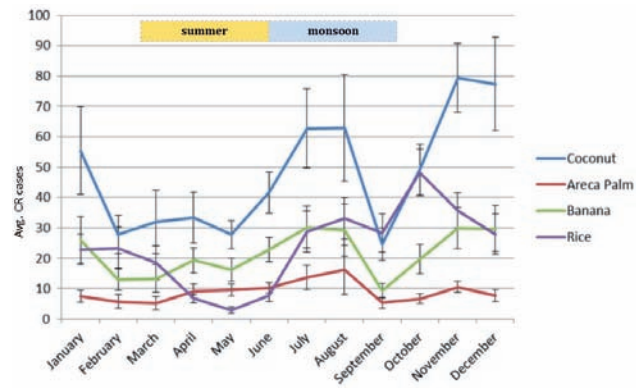
damaged, coconut was the major crop damaged in 92% of raids followed by banana in 65% raids, rice in 37% raids and areca palm in 28% of raids ( $\chi^2 = 2160$ , d.f. = 34,  $p \leq 0.001$ ). Raids on coconut were in proportion to its availability while banana was raided disproportionately more than its availability (Fig. 2).

#### Monthly and seasonal extent

Crop raiding differed significantly among months ( $\chi^2 = 25.58$ ,  $p = 0.007$ ). Distribution of crop raiding cases showed two distinct peaks (i) during July-August and (ii) during November-December (Fig. 3). The average monthly raiding on coconut was higher than of any other crop throughout, except in September where it was lower than rice (Fig. 4). November and December peak was significantly higher than all other months (Table 3).



**Figure 3.** Monthly elephant crop raiding intensity in Sindhudurg District.

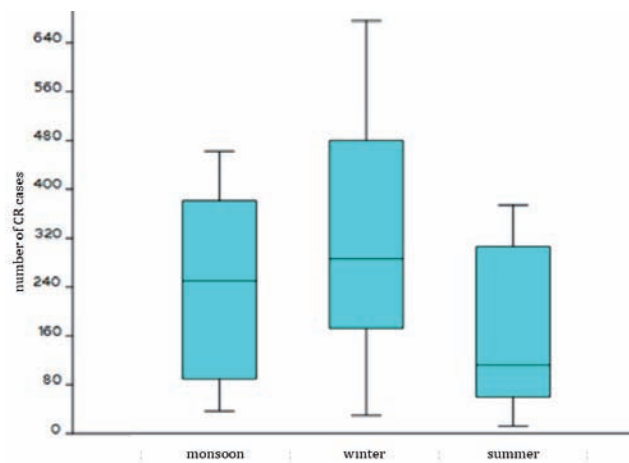


**Figure 4.** Number of crop raiding instances recorded per month in Sindhudurg District.

Among seasons raiding frequency was highest during winter ( $n = 4126$ ) followed by monsoon ( $n = 2959$ ) and summer ( $n = 2063$ ). Median crop raiding intensity was not significantly different among the seasons ( $\chi^2 = 3.005$ ,  $p = 0.22$ ) (Fig. 5).

#### Discussion

We found over 9000 records of crop raiding over the 14-year study period. Mehta & Kulkarni (2013) recorded nearly 7000 cases of crop raiding from Sindhudurg from 2002–2013. Our study recorded nearly 2000 more cases in the two additional years till 2015. Thus, HEC appears to have intensified in Sindhudurg. The study by Mehta & Kulkarni (2013) found that the number of crop-raiding cases in Sindhudurg District was higher than that in adjoining Kolhapur District. The increase in HEC we found in Sindhudurg from 2013–2015 suggests that this pattern maybe



**Figure 5.** Seasonal distribution of crop raiding instances in Sindhudurg District.

**Table 3.** Comparison of monthly crop raiding (CR) intensity by elephants in Sindhudurg District (2002–2015). In the columns, probabilities are shown only for those pairs of months, which showed significant difference.

Months	Median CR intensity	May	July	October	November	December
January	62.5	0.041				
February	41.5				0.010	0.027
March	33.5				0.023	0.049
April	30		0.024	0.017	0.002	0.008
May	25		0.018	0.006	0.000	0.005
June	43			0.026	0.003	0.016
July	99					
August	73					
September	52				0.006	0.039
October	79.5					
November	98					
December	116					

preserved and further strengthened in the future. Informal follow-up by the authors during 2015–2019 has confirmed this speculation. A previous study in Sindhudurg District revealed that only about 64% of the affected farmers reported raids (Patil & Patil 2017). Therefore, the actual number of cases of crop raiding by elephants – hence HEC – is likely to be much higher than observed.

We found all talukas except one in Sindhudurg District and nearly 90% of the total geographical area was affected by elephant crop raiding. Although the number of villages affected was 33% for the district, in the worst affected talukas it reached up to 80% of the villages in the Taluka. Gubbi *et al.* (2014) found 60,939 incidents of crop loss in Karnataka, across 12 districts and 40 talukas covering an area of nearly 19,000 km<sup>2</sup>, over a period of 3 years (2008–2011). The crop raiding incidents recorded in the present study area was 0.14 km<sup>-1</sup> year<sup>-1</sup>, whereas that in the Karnataka study by Gubbi *et al.* (2014) it was 1.07 km<sup>-1</sup> year<sup>-1</sup>. This clearly shows that the elephant crop raiding problem in Karnataka was 7–8 times more intensive.

The Karnataka study was carried out in areas, which were historically affected by HEC and covered three recent years as the study period. HEC started only comparatively recently in the Sindhudurg District and our study period

covers the initial years. As HEC in Sindhudurg is intensifying over the years, it may reach or exceed the levels observed in Karnataka, unless addressed effectively.

Four crops contributed to most raiding incidents. The higher preference for banana stands out among the major crops raided. Whereas rice was raided disproportionately less, banana was raided disproportionately more than its availability. Ekanayaka *et al.* (2011) and Campos-Arceiz *et al.* (2009) also reported elephants preferentially raiding banana in Sri Lanka.

Elephants raided 36 crops which are practically all the crops grown in Sindhudurg. Gubbi *et al.* (2014) recorded that 54 crops were damaged by elephants in Karnataka. Campos-Arceiz *et al.* (2009), found elephants damaged 30 crops in south-eastern Sri Lanka. Thus, elephants appear to damage a wide range of crops everywhere, as seen in other regions and by our study.

We found that raids on rice peaked towards its maturity, which phenomenon is widely observed in Asia (Nyhus *et al.* 2000; Campos-Arceiz *et al.* 2009; Gubbi 2012). Similarly, Zimmermann *et al.* (2009) and Wilson *et al.* (2013) recorded that crop raiding in Assam mainly coincided with harvesting of rice. We observed peaks for banana raids in July-August and November-

December. Campos-Arceiz *et al.* (2009) found that banana was highly damaged in August in Sri Lanka. Therefore, the crop raiding patterns in Sindhudurg were similar to that by Asian elephants elsewhere.

There was a period of lower (February to June) and higher (July to January) overall crop raiding intensity, with lower crop raiding in the summer. The peak of raiding in November-January roughly aligned with the high availability of mature rice crop. Campos-Arceiz *et al.* (2009) and Ekanayaka *et al.* (2011) suggested that higher raiding frequency in certain periods may not be driven by non-availability of natural fodder but availability and preference for crops. The observed pattern of raiding in Sindhudurg could also be for similar reasons.

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