Do cattle determine elephant distribution in the Red Volta Valley of northern Ghana?

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Abstract

Elephants use the forest reserves along the Red Volta River as a refuge and raid fields in the nearby farmland. This study tested the null hypothesis that cattle have no effect on elephant distribution by measuring on transects the dung piles of both species. Having controlled for other variables, we show that increasing numbers of cattle reduce the probability of finding elephants outside the forest reserve. We suggest that cattle grazing could be manipulated to reduce the risk of crop raiding by elephants.

Résumé

Les éléphants utilisent les réserves forestières le long du Nazinon comme refuges et dévastent les champs des fermes voisines. Cette étude a testé l'hypothèse zéro selon laquelle le bétail n'aurait aucun effet sur la distribution des éléphants, en mesurant des crottes des deux espèces le long de transects. En tenant les autres variables sous contrôle, nous montrons que l'abondance croissante de bétail réduit la probabilité de trouver des éléphants en dehors de la réserve forestière. Nous suggérons qu'il est possible de gérer le bétail de façon à réduire les risques de dommages dus aux éléphants.

Introduction

Elephants (*Loxodonta africana*) are found in about a dozen ranges in Ghana (Wildlife Division 2000). The northernmost is the Red Volta Valley, which lies adjacent to the frontier with Burkina Faso. Elephants move along the valley between Ghana and Burkina Faso and raid crops on both sides of the border. On the Ghanaian side, the rural population lives in extreme poverty and elephants are the farmers' bane (Sam et al. 1997; Sam 1998). We have long suspected that elephants in the Red Volta Valley avoid places used by the other common large herbivore: cows.

In this paper, data collected in the 1999 planting season were used to test the hypothesis that elephant density was inversely proportional to cattle density. For each species, dung was used as a measure of abundance. Since many variables could influence elephant distribution, we developed a multivariate model to explain elephant distribution. If cattle dung made a significant contribution to the model, then the null hypothesis (that cattle have no effect on elephant distribution) could be rejected.

Study area

The study area falls within White's (1983) Sudanian centre of endemism but the vegetation has been much modified by human activities (Boateng 1970). Rainfall is about 1000 mm per annum, falling in a single wet season, between May and November. A detailed description is given by Sam et al. (1996) and Sam (1998).

The Red Volta flows southwards from Burkina Faso (where it is called the Nazinon) into Ghana to its confluence with the White Volta (fig. 1). The river banks are protected by forest reserves that are up to 14 km wide. Thus if one walks due east from the river, one will pass first through the forest reserve, then successively a belt of bushland, cultivated land, and

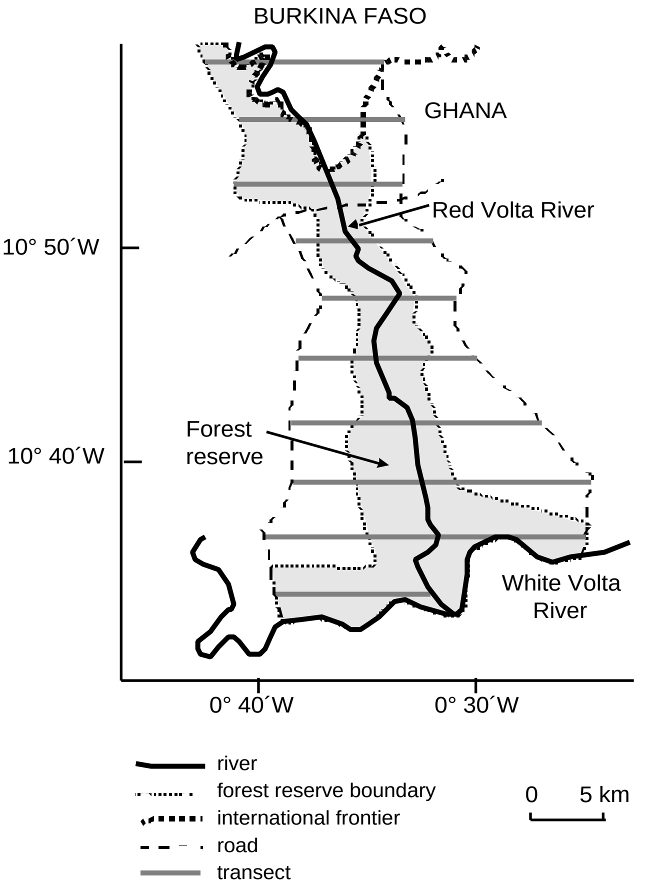

Figure 1. The Red Volta River flowing southwards from Burkina Faso to its confluence with the White Volta, the forest reserve that lines its banks, and the east–west transects spanning the Red Volta Valley. Villages lie along the roads, and farms are found between the roads and the forest reserve boundaries.

a village lying on a road that runs roughly north–south and parallel to the river (fig. 1). The same habitat types are encountered when one walks due west from the river.

Elephants move up and down the valley, taking advantage of the cover that the forest reserve provides. Farmers and Wildlife Division staff seldom know where the elephants are at any particular moment until they emerge from the forest to raid crops. After feeding in the fields, the elephants return to the forest reserve, and the next report of raiding may come from the other side of the valley and far to the north or south.

Farmers hand over their cattle to Fulani herdsmen, who graze them in large herds. Though Fulani families are known to possess firearms they do not usually carry them while herding. A typical herd may range widely, moving across the farmland of many villages. Sometimes herders will corral the cattle, especially when they are close to the family base. Otherwise they will camp out and continue foraging the next day.

Methods

Ten east–west transects crossed the valley from the road on one side to the road on the other (fig. 1). Since we could not ford the river in the wet season, we considered the east and west halves as separate transects, each running from the Red Volta River to the road.

The transects were walked in the 1999 planting season between May and July. Standard line-transect methodology was used (Buckland et al. 1993) and all elephant and cattle droppings were recorded. Habitat and features such as roads and water sources were noted.

The data were first analysed by complete transect (river to road). Next, only the segment that passed through the forest reserve was examined; finally, only the segment outside the forest reserve (that is, from the boundary of the forest reserve to the road).

We saw too few elephant droppings to enable us to estimate density, because the distance method requires a minimum of 60 sightings (Buckland et al. 1993). Instead, we assumed that the visibility profile was constant throughout, and we used the number of droppings seen on each transect as the index of elephant abundance.

Typical count data included integers, no negative numbers and a high proportion of zeroes; the counts were not normally distributed. Therefore, generalized linear models with Poisson errors were fitted with the GLIM package (Francis et al. 1993; Crawley 1994). The models were of the form

$$E = \exp(a + b.L + c.x_1 + d.x_2 + e.x_3 \ldots m.x_n)$$

where E was the expected number of elephant droppings, L was the length of the transect in kilometres, $x_1 \ldots x_n$ were independent variables, a was a constant, and *b, c, d, e* and *m* were coefficients fitted by maximum likelihood.

For the complete transects, the following variables were entered into the model: length of transect passing through farmland, length of transect passing through fallow, length of transect passing through bush, length of transect segment within the forest reserve, number of water courses, and number of cattle dung piles.

Inside the forest reserve, independent variables were the number of water courses and of cattle dung piles.

Outside the forest reserve, independent variables were length of transect passing through farmland, length of transect passing through fallow, length of transect passing through bush, number of water courses, number of cattle dung piles, and distance from the mid-point of the transect to the river.

In each case the number of cattle dung piles was transformed to $C = \ln(1 + \text{number of cattle dung piles})$.

For each analysis, all the independent variables were entered into the model. Each variable was then examined in turn and its contribution to reducing model deviance evaluated by χ^2 (Crawley 1994). Then the variable that made the least contribution was dropped and the remaining variables were each examined in turn. This process was continued until only those variables remained that made a significant contribution to the reduction in deviance.

Results

Complete transects

Thirty-five elephant droppings were recorded on 19 transects. No droppings were seen on 7 transects. Three variables significantly reduced the deviance: length of transect in forest reserve, F ($P < 0.001$); cattle dung, C ($P < 0.01$); and water sources, W ($P < 0.01$). The final model was

$$E = \exp(2.05 + 0.08L + 0.25F - 0.50C - 0.43W)$$

Forest reserve

Twenty-four elephant droppings were recorded on 17 transect segments. No droppings were seen on 10 transect segments. Only length of transect segment, L, had a significant effect ($P < 0.001$):

$$E = \exp(-1.19 + 0.24L)$$

Outside forest reserve

On the 16 transect segments outside the forest reserve, 11 elephant droppings were recorded. No elephant droppings were seen on 12 transect segments. Three variables made a significant contribution to reducing the deviance: length of transect segment, L ($P < 0.05$); distance to the river, R ($P < 0.01$); and number of cattle dung piles, C ($P < 0.001$):

$$E = \exp(9.82 + 1.38L - 1.66R - 2.26C)$$

Varying the value of C while holding L and R constant at their median values shows that increasing cattle numbers will reduce the probability of spotting elephant dung piles (fig. 2).

Discussion

Transect length was significant both inside and outside the forest reserve. As one would expect, the longer the transect, the greater the probability of spotting droppings. This was the only significant variable inside the forest reserve. This means that either the variation between transects is random within the forest reserve or more likely, we failed to identify and measure the variable(s) that influence elephant distribution within the forest reserve.

Elephants must depend on water, but the presence of water sources reduced the probability of recording their droppings on the complete transects. It is likely that there is more human activity around water—for example, Sam (1998) recorded illegal gold-panning

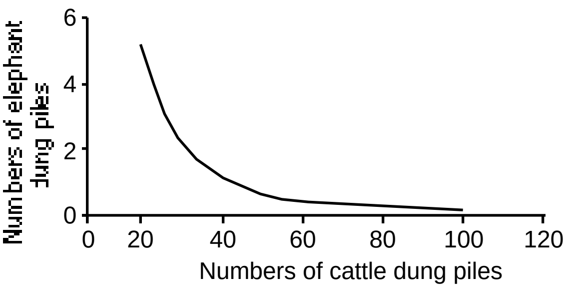

Figure 2. The predicted number of elephant dung piles that will be seen on the average transect outside the forest reserve in relation to cattle dung piles, according to the model when transect length and distance to the river are held constant at their median values.

activities (*galamsey)* along portions of the river. When habitat and water sources were taken into account, cattle had a marked effect in reducing the probability of spotting elephant droppings on the complete transects. Similarly, after accounting for distance to the river, cattle had a strong effect ($P < 0.001$) on reducing the probability of spotting elephant droppings outside the forest reserve (fig. 2). This is an especially important result because it is outside the forest reserve that elephants raid crops. Figure 2 shows that only a few cattle dung piles were needed to bring a rapid reduction in the expectation of finding elephant droppings. At present we do not know the actual numbers of cattle, or the number of cattle-days, that correspond to the observed numbers of cattle dung piles.

We have shown the inverse relationship between cattle and elephants, but we do not know whether elephants are avoiding the cattle or the herdsmen, nor whether they are avoiding the noise, the smell of the cattle that lingers after they have passed through, or the grazing land itself, tainted by the smell of cattle. If elephants are avoiding noise, then the presence of cattle is not likely to deter them during the night, when they usually raid crops. But if they are avoiding the smell of cattle or the tainted grazing land, then the presence of cattle in an area during the day will deter elephants both by day and by night. Since elephants usually leave the forest reserve at night, and there is a strong inverse relationship between cattle and elephants outside the forest reserve (fig. 2), it seems likely that elephants are avoiding the smell.

This analysis suggests a possible method for mitigating the risk of crop raiding. We propose that cattle be managed to reduce crop raiding by elephants. If the presence of elephants is detected in a particular sector of the forest reserve, and if the Fulani herdsman can be persuaded to move their cattle into the area between the forest reserve and the farmland, elephants will be deterred from moving out of the forest and into the fields.

For this method to work well, one needs to be able to detect the north–south movements of elephants in the long forest reserve. Recently the Cornell Laboratory of Ornithology, Conservation International and the Wildlife Division of Ghana have been experimenting on elephant infrasound detection in Kakum National Park in southern Ghana. This technique could lead to a method for remote detection of elephants in different sectors of the forest reserve.

It is possible, however, that elephants that avoid one area tainted by cattle may simply head towards farmland where no cattle have recently grazed. In that case, one is simply displacing the problem rather than mitigating it.

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References

Boateng, E.A. 1970. *A geography of Ghana.* Cambridge University Press, Cambridge.

Buckland, S.T., Anderson, D.R., Burnham, K.P., and Laake, J.L. 1993. *Distance sampling: estimating abundance of biological populations.* Chapman & Hall, London.

Crawley, M.J. 1994. *GLIM for ecologists.* Blackwell Scientific Publications, Oxford.

Francis, B., Green, M., and Payne, C. 1993. *GLIM 4: the statistical system for generalized linear interactive modelling.* Clarendon Press, Oxford.

Sam, M.K. 1998. An assessment of crop damage by elephants in the Red Volta area of Ghana. MSc thesis, University of Kent at Canterbury.

Sam, M.K., Haizel, C.A.K., and Barnes, R.F.W. 1997. Crop-raiding by elephants during the 1996 harvest season in the Red Volta Valley, Upper East Region, Ghana. Unpublished report. Wildlife Department, Accra.

Sam, M.K., Okoumassou, K., and Barnes, R.F.W. 1996. A preliminary survey of the elephants of northeastern Ghana and northern Togo. Unpublished report, Wildlife Department, Accra, and Direction des Parcs Nationaux, des Reserves de Faune et de Chasses, Lomé.

White, F. 1983. *Vegetation of Africa.* UNESCO, Paris.

Wildlife Division. 2000. *Strategy for the conservation of elephants in Ghana.* Wildlife Division, Forestry Commission, Accra.