Gajah 28 (2008) 4-7

The Design of Crop-Raiding Studies

Richard F. W. Barnes

Division of Biological Sciences, University of California at San Diego, La Jolla, CA, USA and Environmental Sciences Research Centre, Anglia Ruskin University, Cambridge, UK

Introduction

The conflict between people and elephants continues as farms expand into elephant habitats. As soil fertility falls, more land per capita will be needed, and so the rate of habitat loss will accelerate. Government policy in most countries is to conserve elephants, but farmers must feed their families. More studies of crop-raiding problems are needed, for two reasons.

First, general principles must be clarified. A risk factor is a variable that increases the probability that a farm will be raided by elephants. Some variables always increase the risk that farms will be damaged, whatever vegetation zone you are working in. These are universal risk factors. For example, maize and the number of crops grown on a farm attract elephants in both savannah and forest in West Africa (Barnes *et al.* 2005; Danquah *et al.* 2006, Drabo Adama, pers. comm.).

Second, some risk factors are site-specific, perhaps certain crops grown only locally. In some places elephants eat crops that are ignored by elephants elsewhere. The wildlife manager needs to identify both universal and site-specific risk factors so that he can advise farmers how to minimize crop losses.

If we identify a particular crop as a risk factor, the farmer cannot just stop growing it. His family must eat. But on the other hand, that crop might increase the chance of losing all or part of his farm. He must balance the cost of modifying his behaviour against the risk of crop losses to elephants. The most objective way is to develop multivariate models that describe the probability in terms of several risk factors (Barnes *et al.* 2005). Then one can show the farmer that modifying one variable will reduce his risk by *x* %, and modifying a second will reduce risk by *y* %. Modifying both together will reduce his risk by *z* %. Then the farmer is free to make his own decisions.

The design of a crop-raiding survey is important because it determines the accuracy of the estimates and the validity of predictions. The design will also determine the cost of the fieldwork. The purpose of this note is to bring the choices to the attention of field workers. Here I present three designs, one that looks forward in time, one that assesses the situation now, and a third that looks back into the past.

Designs for crop raiding studies

Cohort study

A cohort study defines a sample of farms (a cohort) and follows it into the future. The ideal cohort will consist of farms randomly selected from the population of farms at risk in your study area. The beginning of the year or the start of the crop-growing season (i.e. planting) is the best time to enrol the participant farms. The hypothesized independent variables (X_1, X_2, X_3 …X_n) are measured on each farm (Table 1). Each farm is observed during the growing season and all raids by elephants (Y) are recorded.

The logistics of monitoring many farms scattered through the bush, especially if there are few roads, complicate this type of study, and could even render it impossible. Therefore a compromise is random cluster sampling: first, randomly select groups of farms. Then monitor the farms, or a random sample of farms, within each group.

This is the most expensive design described here, because you must have a large sample in order to ensure enough statistical power in your analyses. But it is also the design most likely to produce a

Table 1. Data that should be collected for each farm.

Distance to the boundary of the protected area or edge of forest
Distance to the nearest village
Distance to the nearest road
Distance to the next farm (the “nearest neighbour” distance)
Size of the farm
Number of types of food crops (e.g. rice, maize, tomatoes, etc.)
Number of types of perennial crops or tree crops (e.g. citrus, palm oil, etc.)
Area covered by each crop
Other measures of crop abundance (e.g. numbers of maize heads, palm trees, etc.)

large amount of information. This was the design we used around the Kakum Conservation Area in southern Ghana (Barnes *et al*. 2005).

This design will work best where crop-raiding is common. It should not be applied where few farms are damaged. For example, imagine a situation where you followed 100 farms but only 5 were raided. Except for calculating the percentage of farms that were raided, you would not gain much useful information for the effort expended.

There is a variation on this design: grouped cohort study. Imagine that you hypothesize that a particular crop, e.g. sorghum, is the principal risk factor in your study area. You can identify a sample of farms with sorghum and a sample without sorghum and follow these cohorts into the future. Here you have grouped farms by risk factor. This variant is also useful when you suspect that an uncommon risk factor - perhaps an unusual crop type - is particularly attractive to elephants.

Cross-sectional study

A cross-sectional study takes a snapshot of the population of farms at one point in time. One selects a random sample of farms and then records the number of raids (Y). At the same time one records the information on the variables that one expects to be important (X_1, X_2, X_3 …X_n ; Table 1). Thus, in contrast to the other two designs described here, the data on elephant raids (Y) is collected simultaneously - or at least in the same month - with that on the farm variables (X_1, X_2, X_3 …X_n).

For best results, choose the month when you expect the most raids. For example, you might decide to take your snapshot in August. Ideally, you would choose one particular day, perhaps the 15th August, for the snapshot. But it is more practical to choose the whole month of August. For the independent variables (X_1, X_2, X_3 …X_n), you must ensure that you record their values as they stand on 15th August. In fact, on any given farm most of the variables of interest (Table 1) will not change during the month. For each farm you record the number of raids (Y) that occur only during the month of August.

This is the cheapest type of design. It is also the quickest. It will reveal major trends, but is less likely to provide the insights that would come from a cohort study. It is most suitable for students who want to study crop-raiding in a particular area but have limited time and resources. It may also be useful as a pilot study when you are starting out in a new area. The results will generate hypotheses that you can test later with a more rigorous design.

Case-control

In contrast to the designs described above, the case-control is a retrospective design: it looks back into the past. In this type of design you start with farms that have been raided. These are ‘cases’. You can include all damaged farms in your study area as cases. But it may be more practical for you to take just a sample of them.

Then you select, at random from the same area, farms that have not been touched by elephants. These are the ‘controls’ that will be compared to the cases. The controls must come from the same population of farms from which the elephants selected the cases. They must represent the same period - the same months or the same growing season - as the cases. If you have *n* cases, then you need at least *n* controls. However, 4*n* controls will give optimum precision (Young 2005).

You will set up your hypotheses, and establish a data collection protocol, before selecting the cases and controls. Once they are selected, you will look back at each farm to collect the necessary data. You should undertake this study at the end of the crop-growing season, because then you will know which farms were damaged and which were not. You will probably look backwards to the beginning of the crop-growing season if you are dealing with subsistence crops. If you are looking at perennial crops, for example citrus or oil palm, you might look one year into the past, or maybe even two years. But the further back you go, the greater the risk of inaccurate information on the variables that interest you.

Note the difference between case-control and grouped cohort studies. In the grouped cohort study you identify farms by risk factor and follow them forward, into the future, to record whether or not they were damaged by elephants. Thus you look forward from risks to consequences (Young 2005). With the case-control you identify farms that have already been damaged, and you look backwards, into the past, to compare them with farms that were not damaged. In other words, you look back from consequences to potential causes (Young 2005).

This is a design that has been developed in medical research, particularly for the study of diseases that are infrequent, like cancer. It does not seem to be used much in ecology, but it has several advantages. For example, it is a cost-effective design in an ecosystem where only a handful of farms suffer from elephants. Imagine a study site with 1000 farms of which 20 are raided in 2007. If you applied a cohort design and followed a random sample of 100 farms, you would probably get only two afflicted farms in your sample. That would give little useful data. But if you adopted a case-control design you could take all 20 raided farms as your cases, and then select another 80 farms as your controls. Thus you would have 100 farms in your study but obtain more useful data than if you had planned a cohort study.

Note that you can also use this design where crop-raiding is common. It is particularly useful, whether crop-raiding is uncommon or frequent, for testing a hypothesis that has emerged from previous work.

A disadvantage of this design is its susceptibility to selection bias. You must be rigorous in randomly selecting your cases from the damaged farms in your area. Of course this bias will not be an issue if you take all the damaged farms as cases. Another disadvantage is that you cannot calculate the percentage of farms in your study area that are raided. Thus you cannot make year-to-year comparisons about the trend in crop-raiding.

Data to be collected

Table 1 lists the data that must be collected, whatever design you select. This is not an exhaustive list: you might suspect that some other variable, specific to your particular study site, attracts elephants.

If you hope to make comparisons between years for one study area, or to make comparisons between study areas, then monthly rainfall should be recorded. Rainfall influences crop growth and therefore the risk of elephant raids (Barnes *et al*. 2007).

A subsequent paper will describe methods for the analysis of these data. Do not forget to make backup copies of all field data sheets. If you type the data into a computer, then make a backup of the data files as well.

Discussion

Get to know the study area well before deciding upon the design. Walk through it, examine all the crops and talk to farmers. Decide upon definitions: what is a village and what is only a hamlet? What is a road, compared to a track or path?

When funds are limited there is the temptation to limit your studies only to those farms that have been damaged. But the farms that were not raided are as important as those that were raided. One must compare the farms that elephants selected against those that they did not find attractive. That will enable a proper evaluation of the risk factors. Furthermore, estimating the frequency of raided and undamaged farms will enable you to calculate the percentage of farms damaged. You can do this with both the cohort and the cross-sectional designs, but not with case-control studies. The percentage of farms that are damaged is an important indicator of the severity of the problem. If your management recommendations are effective, then surveys in the future will show that the percentage has declined.

With the case-control design you select farms that have been raided and those that have not. In other words, your dependent variable is binary: yes or no. The other two designs will also give you binary data: raided farms and intact farms. But amongst the raided farms there will be those that have been damaged once, twice, thrice or several times. Instead of evaluating factors that determine whether or not a farm will be raided, better use will be made of your hard-won data from cohort and cross-sectional designs if you relate the number of raids to the hypothesized risk factors. Again, the relative frequencies of farms that have been raided multiple times will enable future surveys to show whether your management policy is successful.

The type of design you select depends upon the resources available and the exact questions you are asking. When time is limited, then the choice of design is between cross-sectional and case-control studies. When both time and resources are limited, than choose the cross-sectional. If only a few farms are damaged, then the case-control is the only practical option. If your coffers are overflowing, then the cohort design is the one to use.

We must never forget that people are suffering while we fiddle with our calculators. We must adopt the most time-efficient strategy to minimise crop losses. If you have only one year for a study of crop-raiding, then here is an efficient strategy. During the growing season do a cross-sectional study, with a large sample, perhaps 50 farms. That will give an estimate of the percentage of farms suffering crop-raiding. Analysis of those data will generate hypotheses. At the end of the growing season, when you know which farms have been raided and which are intact, do a case-control study that looks back to the beginning of the growing season. That will enable you to test hypotheses from the cross-sectional study.

If you have two years for a crop-raiding project, then do a cross-sectional study in the first year. That will give you the information to decide upon the sample size for a cohort study that will start at the beginning of the second year.

Acknowledgements

This note arose from the work that the Elephant Biology and Management team undertook around the Kakum Conservation Area in southern Ghana. I am grateful for discussions about crop raiding with Yaw Boafo, Emmanuel Danquah, Umaru Farouk Dubiure, Emmanuel Hema, Mildred Manford, and Awo Nandjui.

References

Barnes, R.F.W., Hema, E.M., Nandjui, A., Manford, M., Dubiure, U.F., Danquah, E.K.A. & Boafo, Y. (2005) Risk of crop-raiding by elephants around the Kakum Conservation Area, Ghana. *Pachyderm* **39:** 19-25.

Barnes, R.F.W., Dubiure, U.F., Danquah, E.K.A., Boafo, Y., Nandjui, A., Hema, E.M. & Manford, M. (2007) Crop-raiding elephants and the moon. *African Journal of Ecology* **45:** 112-115.

Sam, M.K., Danquah, E., Oppong, S.K. & Ashie, E.A. (2005) Nature and extent of human-elephant conflict in Bia Conservation Area, Ghana. *Pachyderm* **38:** 49-58.

Young, T.K. (2005) *Population Health: Concepts and Methods. 2nd Edition.* Oxford University Press, New York.

Author's e-mail: rfbarnes@ucsd.edu