Case study 10: Impact assessment of the effect of tsetse control on livestock productivity

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Contents

Summary

This case study describes how tsetse control interventions were planned to see whether trypanosome prevalence in village cattle could be reduced in an area in south western Ethiopia where there was widespread drug resistance to all available trypanocidal drugs. The study was organised as a longitudinal monitoring study conducted over periods without tsetse control followed by periods with tsetse control. Two methods were applied: (1) a set of insecticide-impregnated black-cloth targets that attract and kill tsetse (see photograph), and (2) an insecticidal pour-on applied to the backs of cattle once a month. The latter method involved participation by farmers who decided when to bring cattle for treatment and which animals to bring.

The case study describes how it was impossible to study two separate areas simultaneously for this type of research, one area with and one without tsetse control. It shows instead how researchers were required to design a 'before-after' study with an intervention following a period without control.

Such trials are beset with the problems of confounding, however, with some of

the variation occurring from one year to the next being associated with changes unconnected with tsetse control.

Interpretation of the results of such studies therefore needs to be made with caution.

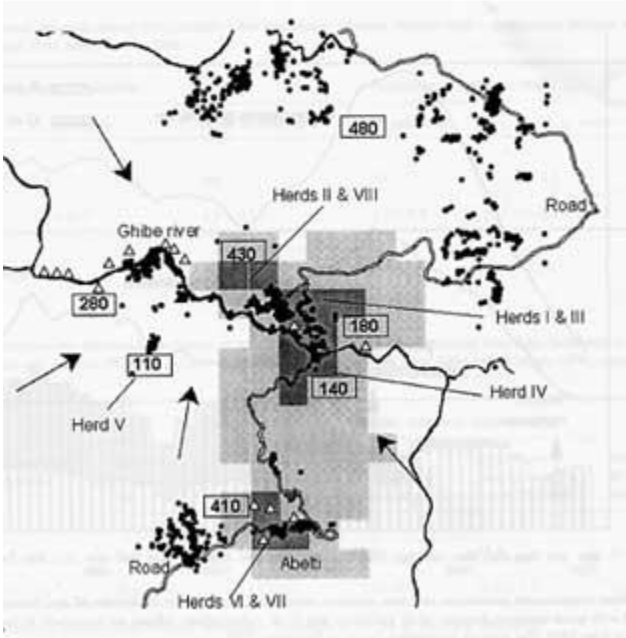
Monthly data were collected for the presence or absence of trypanasomes in the blood, for packed blood cell volume and for body weight. Calvings, deaths, sales etc. were also recorded. The case study shows how, by programming in SAS, the monthly data were summarised into 6-monthly observational averages. These were then used as observational units by GenStat to calculate least squares means for each 6-month period. These least squares means were finally used in a simple statistical model to compare means in periods with and without tsetse control.

Background

Trypanosomosis is a serious constraint to livestock production and agriculture in much of southwest Ethiopia. The parasite that causes this disease is known as a trypanosome and is carried by the tsetse fly. For many years ILRI has researched the various factors affecting levels of trypanosomosis in village cattle in the Ghibe valley, about 180 km south-west of Addis Ababa.

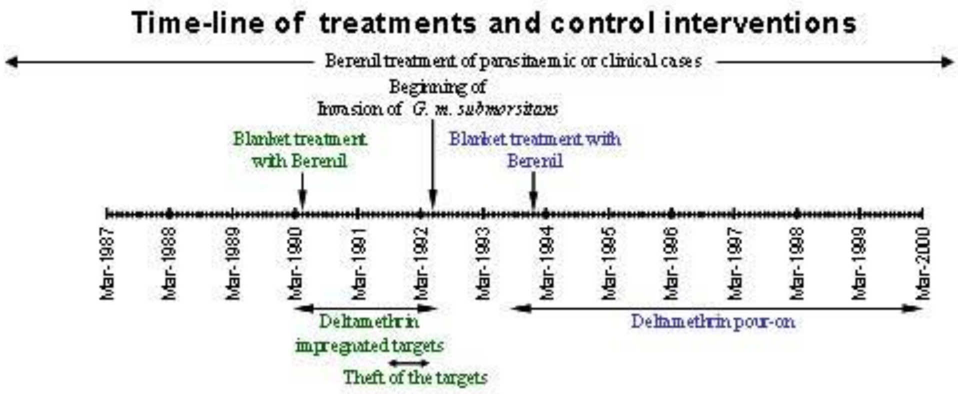
The persistently high prevalence of trypanosomes found in cattle has been shown to be associated with a high level of resistance to all available trypanocidal drugs (Codjia et al., 1993; Rowlands et al., 1993). Whilst treatment with diminazene aceturate (a trypanocidal drug used to treat trypanosomosis in cattle) was found to maintain cattle in reasonable health, it was clearly not possible, in the presence of multi-drug resistance, to eliminate infection.

The only possible approach to alleviate the problem was to reduce tsetse fly challenge by controlling the population of the tsetse (Glossina spp.) vector, and to see whether, by doing so, the prevalence of drug-resistant infections could be reduced.



Two tsetse control campaigns have been reported in the valley where the herds that are the subject of the present case study are resident (see Video 2). The first used 'targets' (rectangular sheets of black material impregnated with insecticide - tsetse flies are attracted to black and blue colours) erected around the area (Leak et al., 1995). The second used insecticide in the form of a 'pour-on' applied monthly to the backs of cattle (Rowlands et al., 2000).

Problems occurred during the first trial when targets were stolen, resulting in early curtailment of the trial. Thus, a second trial was initiated using the pour-on treatment method. Tsetse control was maintained over a sufficiently long period of time in this second trial to allow, together with the results of the first trial, a statistical assessment of the impact on livestock productivity. This is the subject of this case study.



Research strategy

Before embarking on an impact assessment study, as discussed in the Study Design guide, it is important to consider beforehand

- how the data might be analysed
- how observational units are to be defined for the purpose of analysis
- what approach should be used for defining appropriate baseline values against which the results of the intervention can be compared.

One method for obtaining baseline data is to collect data from a parallel set of subjects that do not receive the intervention. One herd of cattle used for tsetse control purposes at Ghibe (not one of those in the present case study) was raised on a plateau in an area above a valley where the remaining monitoring herds grazed. Tsetse control applied to the plateau area had no effect in the valley where tsetse control was not being applied at the time. Thus, it was decided to use data collected from herds in the valley as controls. Mean values from these 'neighbouring' herds were used as a covariate in an analysis of covariance to adjust for random year-to-year variations in each of the response variables.

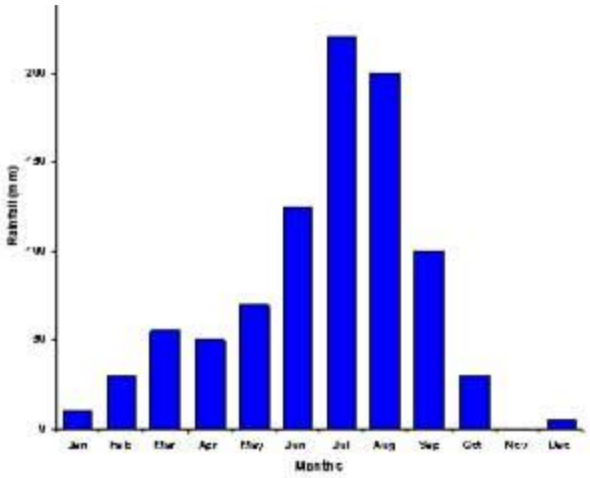
But the values in the two areas were poorly correlated presumably reflecting differences in environment and in management practices. Likewise the terrain and vegetation grazed by the herds also could not be considered identical in every respect. Thus, this approach was of no value.

Another problem that can arise when control and intervention farmers are studied in parallel is that that the intervention starts to be adopted by the control farmers when they see the benefits of the intervention (see Case Study 6).

When it is not possible to use another set of farmers as controls one needs to devise a strategy whereby study farmers can provide their own form of control.

This can be achieved by setting up a longitudinal study that provides for an 'intervention' period to follow a 'baseline control' period. Such a study needs to be long enough, however, to allow adequate numbers of observational units to be defined over time to provide a sound statistical analysis. There could be significant levels of confounding with uncontrollable random fluctuations over time.

The observational unit in such 'before/after' comparisons needs to be some form of unit in time. In agronomic or livestock production systems this unit of time is likely to be as much as one year. Crops tend to be planted once a year at the onset of the rains. Livestock, especially in livestock crop systems, will also tend to follow an annual pattern of production. Furthermore, the contrasting wet and dry seasons that occur within years need to be taken into account.



Cattle were monitored monthly in the present study. Thus, a unit of time could be defined as little as one month.

However, the resulting statistical model is likely to be highly complex and will need to take into account seasonal variations, changing ages of cattle, changes in physiological status, such as pregnancy and lactation, serial correlations between successive measurements, and so on.

Simpler models based on wider time units over which the different performance variables can be summarised are easier to analyse and interpret.

In the present study it was decided to define 6-month time intervals over which data would be summarised. These intervals would match wet and dry seasons, respectively.

Before contemplating a study to evaluate a 'before/after' intervention the researcher needs to be satisfied that a sufficient period of time can be allowed for the study.

The length of period that will be needed will depend on the likely impact of the intervention and to what extent formal statistical analysis is required.

An immediate, clear, major impact will not require formal statistical analysis, just a careful evaluation of the likely levels of influence of alternative seasonal or management factors. A few years, however, are needed to confirm the impact of an intervention such as tsetse control, especially on animal performance variables.

To summarise, when considering a research strategy for assessing the impact of a treatment the researcher needs to:

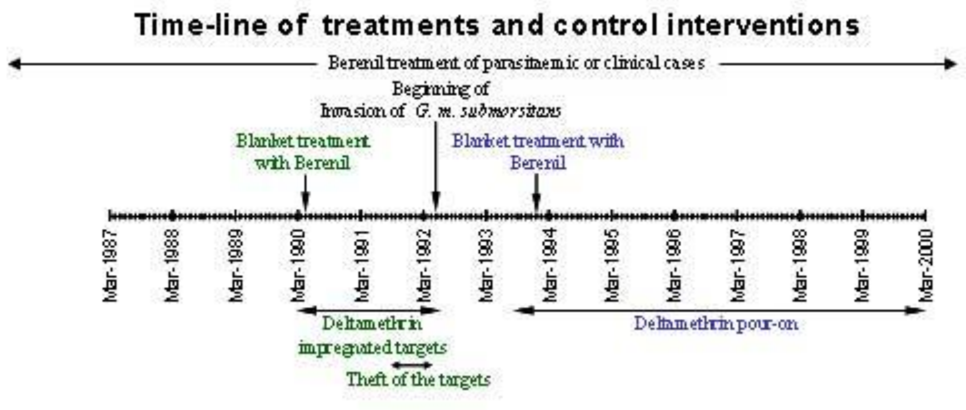
- decide whether it is possible to plan a study with parallel sets of intervention and control farmers,
- if not, decide what lengths of baseline control and intervention periods will be necessary and the likely effects of uncontrollable factors over time,
- decide on an appropriate time interval definition for the observational unit,
- consider other data that may be useful to collect - such a rainfall or other meteorological or environmental data - that may correlate with variations in the response variables under investigation.

Study design

Two impact assessments of tsetse control were planned:(see Video 2)

- the first in 1989 following three years of baseline measurements on livestock health and productivity
- the second in 1994 following two further years of baseline measurements following the collapse of the first method of control in 1991.

The purposes of the studies were to investigate the effect of tsetse control on levels of trypanosome prevalence in cattle in the presence of high levels of drug resistance using as baselines the two previous non-control periods of three and two years, respectively. The impact on animal performance was also to be assessed.



It was anticipated that between two and three years would be required to confirm that tsetse control did indeed reduce tsetse numbers, and that a reduction in trypanosome prevalence in cattle would also follow.

However, the impact of the second tsetse control project was less than expected and the study was extended to allow researchers to investigate the reasons for the poor performance of the intervention on tsetse numbers. This allowed assessments to be made on the impact of the intervention on levels of livestock productivity over a comparatively long period of time.

Eight herds raised under traditional village management were monitored monthly. Blood samples were collected and analysed for packed blood cell volume (PCV) and for the presence of trypanosomes. A low PCV is indicative of trypanosomal infection. Animals found to be infected or observed to be clinically sick were treated with the trypanocidal drug diminazene aceturate (Berenil).

All animals were weighed. Information was also collected on recent calvings, deaths and disposals. Tsetse flies were also trapped once a month.

Calves born to cows monitored in the study were ear tagged and monitored subsequently along with their mothers. During the study the numbers of animals being monitored reached over 700. This was an excessive number to sample for the purpose of this particular study but they were nevertheless valuable for other purposes.

The study was, in a sense, participatory, as it relied on farmers bringing their cattle regularly for weighing and blood sampling. They in turn received free treatment for infected and sick animals. Indeed some farmers worked with the researchers in weighing the cattle and giving the treatment.

Farmers received pour-on treatments free monthly during this trial, but, in a parallel trial, farmers paid (Rowlands et al., 1999). That trial depended on farmers' willingness to pay, which in turn depended on their recognition of the benefits of treatment objectives.

Thus, when working in such an environment, it is often important to consider both the research objectives themselves and the interests of the community within which one is working. Indeed the researchers often relied on the perception of the participating farmers on how the project was progressing.

The objectives of the analysis within this particular study are to determine the effects of tsetse control on livestock productivity of village cattle in south west Ethiopia exposed to high levels of trypanocidal drug resistance. The particular variables that are to be used in the analysis are:

- tsetse apparent density
- body weight, packed cell volume, trypanosome prevalence, trypanocidal drug treatment, separately for male and female adult cattle

- growth rate in calves, body weight at 12 months of age
- mortality rate in adult males, adult females and calves
- abortion rate and calf/cow ratio to reflect fertility rate
- herd size to reflect overall change in animal numbers

These variables are based on previous experiences in the analysis of such data (Rowlands et al., 1999)

Questions to be addressed

The precise ways in which the data collected were to be analysed were not specified when the original protocols for the studies were prepared. In hindsight this could possibly have been done.

When such situations arise it is important to prepare an addendum to the main protocol setting out the data to be used, the calculations to be done, the hypotheses to be tested and the methods to be used for statistical analysis. Such a framework allows the researcher to follow a step-by step approach to the analysis. We have decided under Study design to use time units of six months to coincide with the main wet and dry seasons.

The questions that we shall address in the Data management section are:

- How to reduce the raw data to provide mean values for the different time units?
- What criteria should be used to decide whether data from individual animals should be included or not?
- How to include the effects of other factors such as age and sex in the process?
- What terms to include the final statistical model to test the null hypothesis of no effect of tsetse control on livestock productivity variables?

An impact of an intervention may not necessarily be immediate and make take a few months to be seen. This has indeed been found to be the case with tsetse control (Leak et al., 1995). In the final analysis we shall make decisions on how to relate periods of control with the timing of impact outcomes.

Source material

The final data set used for this case study originates from a larger data set consisting of monthly recording of body weight, parasitaemia, packed cell volume and tsetse apparent density. Animal deaths, abortions, births and weaning ages were recorded as they occurred. Animals with PCV <26% were treated with diminazene acetate and recorded. The data were entered into a Dbase IV database using an in-house data entry system with inbuilt error checking and validation features. A portion of this Dbase data file is stored in CS10Data1 for illustration purposes. The columns are described in CS10Doc1. Users may like to try out further statistical analysis on these data and are welcome to discuss these analyses further with the authors. However, no results may be published without permission from ILRI.

The above data were then reduced to smaller datasets as described in the Data management section. Individual animal adult mean 6-monthly body weights, PCVs, percentage of months found with trypansomes and percentage of months treated are stored in CS10Data2, documented in CS10Doc2. Individual mean calf growth rates are stored in CS10Data3 (documented in CS10Doc3) and 12-month body weights in CS10Data4 (documented in CS10Doc4).

These intermediary data sets were then used to calculate overall 6-monthly mean values for the various variables. These are store in CS10Data5 (documented in CS10Doc5). This is the summary file that is used for the final statistical analysis of the effect of tsetse control.

Data management

Before deciding on how the data should be processed we first need to consider the way that the data are structured. A number of measurements (up to 6 for measurements such as tsetse density, trypanosome prevalence, body weight, etc, or at most one for such events as calving, death etc.) are collected on each animal over a 6-month period. In order to compare means during and before the intervention we need to assemble the results into 6-monthly mean values.

It was decided at the outset that, because of the annual cyclic nature of crop/livestock production systems, a 6-month interval, defined according to seasonal rainfall patterns, was the smallest observational unit that could be used for assessing impact of tsetse control. Thus, the raw data first needed to be reduced to mean values for each animal and then these means summarised over 6-month periods.

It was decided to commence each 'year' in March for the purposes of this analysis since this was when the rains generally commenced. The months from November to February were generally dry. Thus, for example, year 1990 in this case study refers to the period from March 1990 to February 1991 - with means calculated from March to August and September to February, respectively.

The data management process was divided into two steps:

- Determine for each variable which 6-monthly periods could be used during the study to calculate mean values. (As will be seen on the next page, mean values could not be calculated for all periods for some variables.)
- Describe for each variable the steps to be taken to reduce the data to 6-month animal values

Step 1. The table shows the years used for calculation of mean values for each variable. The study commenced in March 1986 but it took a little time for data collection to reach the desired level of quality.

This is an important point to remember when commencing a new field study with participating farmers. Often it

Year	Adult productivity	Adult mortality	Calf growth, body weight	Calf mortality	Abortions, calf/cow ratio	Herd size
1986	r	r	r	r	r	r
1987	a	a	a	a	a	a
1988	a	a	a	a	a	a
1989	a	a	a	a	a	a
1990	a	a	a	a	a	a

takes a little while for the system for data collection to settle down.

Sometimes it is worth organising a preliminary, pre-study period of data collection to iron out any problems before the main study begins.

Note that calf body weights were calculated at 12-months of age for all calves that survived to 12 months. The table shows that calves born during 1998 could not be used for this calculation as these calves would not have reached 12 months of age until the following year which was beyond the end of the study. Similar reasoning applies to the calculation of calf mortality.

1991	a	a	a	a	a	a
1992	a	a	a	a	a	a
1993	a	a	a	a	a	a
1994	a	a	a	a	a	a
1995	a	a	a	a	a	a
1996	a	a	a	a	a	a
1997	a	a	a	a	a	a
1998	a	a	r	r	a	a

When this study commenced the data were entered into flat dBase files; data checking was time consuming. Subsequently a data management system was developed that checked that dates of calvings, deaths and disposals were in line with existing animal information and that animal identification was correct.These checks are similar to those included in a more general system developed by Metz et al. (1999)

For the above reasons data collected during 1986 were not included in the analysis. Furthermore to ensure for the purposes of this case study that all variables are calculated over the same period only values calculated up to 1997 will be used. Thus, we shall use data collected for eleven years from 'year' 1987 to 'year' 1997 inclusive.

Data sheets were filled in monthly when animals were brought to the crush. The data sheets were headed with the date of recording and the herd to which the animals belonged (see Video 1).

Part of the dBase data file is contained in CS10Data1 and documented in CS10Doc1.

Two sets of animal numbers were recorded for each animal. These corresponded to a small metal tag and a larger plastic tag attached to the animal's ear. It was important for an animal to be given two ear tags since sometimes an animal loses one. The importance of double experimental unit identification is also addressed in Case Study 5 in relation to Napier grass experimentation.

An animal's weight, PCV and trypansomal (or parasitaemic) status (negative or positive) was then written alongside. When microscopic examination found the blood sample to be infected the species of trypanasome was also recorded (see Video 1).

An animal was treated when it was infected and had a PCV below 26% or when the farmer requested treatment because the animal was sick. Details of the treatment were recorded on the data sheet.

Records of any calvings or births and disposals were recorded on a separate data sheet.

Step 2 The methods used to reduce the data to 6-monthly values are described as follows.

Tsetse annual means
Six-monthly tsetse apparent density estimates were calculated from the average of the monthly estimates recorded in each period.

Adult body weight, PCV and percentage time parasitaemic or treated

Mean values of body weight, PCV and the percentage of occasions found to be parasitaemic or to be treated were calculated for each 6-monthly period from 1987 to 1997.

This was done for each animal that was 36 months of age or over on 1st March or 1st September, respectively, and recorded at least 3 times over the next six months. The choice of 3 was arbitrary but it was felt that mean values calculated with fewer observations would tend to give an imprecise estimate of a mean value. Part of the SAS program used for this is shown in CS10SAS.

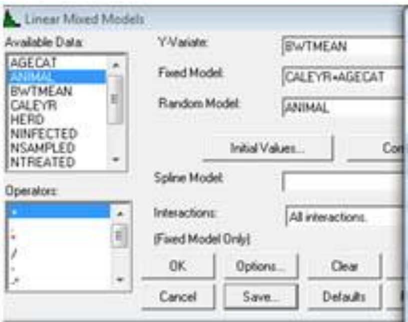
A subset of data from 1989 onwards for animals with actual or estimated dates of birth was first analysed to determine the effect of age on these variables. Precise ages of animals older than five years of age that entered the study in 1986 were unknown.

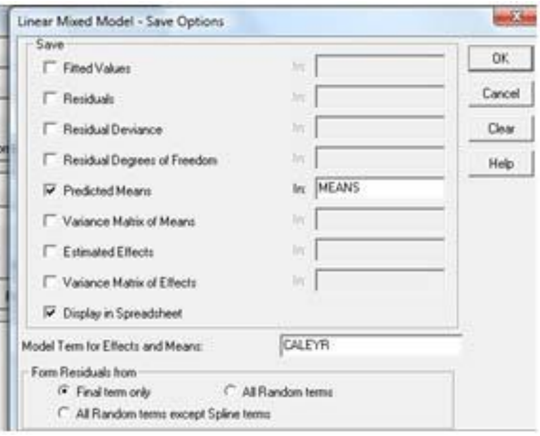
From this preliminary analysis five age classes were defined: 3-4, >4-5, >5-7, >7-10 and >10 years of age. These classes represented suitable proportions of variation associated with age.

The results are stored in CS10Data2 and documented in CS10Doc2.

Least squares estimates were then calculated in GenStat using REML separately for bulls and cows with terms for age class and 6-month period as fixed effects and animal as a random effect.Herd was not necessary as this was included within the animal term.

To do this it was necessary to include just data for bulls, likewise subsequently for cows. This was done by first using **Spread → Restrict/Filter → Subset on Update** to ensure that the restricted data set only was used for analysis, rather than just for display purposes, and then by using





Spread

Restrict/Filter → To Groups (factor levels)... to include only values with Sex=1. The data analysis **(Stats → Mixed models (REML) → Linear mixed models…)** was then conducted as shown by the dialog boxes below for body weight - saving the predicted mean values for seasonal period (CALEYR) in a spreadsheet. It is then a simple matter to copy and paste the column of mean values into the appropriate column in CS10Data5. This process was repeated for each of the variables, both for males and for females.

A part of the output for the analysis of body weight for males is shown below. The predicted 6-monthly values for CALEYR are stored in CS10Data5.

Predictions from REML analysis
Response variate: BWTMEAN

```
*** Table of predicted means for CALEYR ***

CALEYR   198703   198709   198803   198809   198903   198909   199003   199009
          238.1    248.0    221.7    221.0    223.9    234.6    239.0    255.8


CALEYR   199103   199109   199203   199209   199303   199309   199403   199409
          245.2    251.1    251.4    236.7    229.7    223.7    229.8    242.9


CALEYR   199503   199509   199603   199609   199703   199709
          237.4    255.2    254.9    256.5    253.2    255.9
```

Calf growth

Growth rates between March and September were calculated each year (1987-1997) by linear regression of body weight on age in months for all calves less than 24 months of age on 1st March and for which at least 4 weights were recorded. Calves born later during March or April of the same year were also included.

The period from March to September was chosen because growth rate had been shown to be approximately linear during the wet season. Growth during the remainder of the year was more unpredictable and hence was not calculated.

The results are stored in CS10Data3 and documented in CS10Doc3.

Least squares estimates for growth rates each year were then calculated by the method of general least squares **Stats → Regression analysis → Generalized Linear Models…**with year (March-September) (CALFCLS) herd and sex as fixed effects together with linear (agemth) and quadratic (agesqr) covariate terms for age.

By then clicking the 'Predict' button to estimate and save in a spreadsheet predicted values for each year, these can also be copied into an appropriate column in CS10Data5.

Response variate: GRTHRATE

CALFCLS	Prediction	s.e.
198703	0.28220	0.00638
198803	0.14714	0.00555
198903	0.26310	0.00731
199003	0.25842	0.00754
199103	0.22728	0.00515
199203	0.22224	0.00503
199303	0.18971	0.00576
199403	0.23427	0.00736
199503	0.22015	0.00643
199603	0.19946	0.00561
199703	0.22841	0.00522

12-month body weight

Twelve-month body weights were calculated for all calves born in each 6-monthly period each year between 1987 and 1997 that survived to 12 months of age.

Body weights at 12 months of age were estimated by interpolating between the two weights recorded either side of this age.

The results are stored in CS10Data4 and documented in CS10Doc4.

Six-monthly least squares estimates were then calculated by general least squares **Stats → Regression analysis → Generalized Linear Models...**with period of birth (BYYMM), herd, sex and season of birth (BRTHSEAS) as fixed effects (see next page). This was done separately for periods March to August and September to February each year by first using the **Spread → Restrict/Filter command.**

The four seasons of birth were March-May, June-August (for the first period) and September-November and December-February (for the second period). Rains tended to commence in March with the highest rainfall between June and August. Rains ceased in October and the remaining months were dry.

The means and the standard errors in the tables were achieved using the GenStat 'Predict...' button in the dialog

Regression analysis
Response variate: CFWT121
Constant + BYYMM + HERD + SEX + BRTHSEAS

BRTHSEAS	1		2	
	Prediction	s.e.	Prediction	s.e.
BYYMM				
198703	75.05	1.98	79.19	2.33
198803	64.80	2.70	68.95	3.03
198903	73.17	4.45	77.32	4.73
199003	71.68	1.99	75.83	2.25
199103	74.88	1.82	79.03	2.24
199203	65.75	2.06	69.90	2.41
199303	53.73	4.37	57.87	4.56
199403	63.55	2.70	67.69	3.02
199503	74.95	2.52	79.09	2.44
199603	71.42	2.08	75.57	2.16
199703	78.46	2.30	82.61	2.51

box produced during the least squares analysis and then completing the next dialog box that appears by entering BYYMM and BRTHSEAS.

BRTHSEAS	3		4	
	Prediction	s.e.	Prediction	s.e.
BYYMM				
198709	68.31	1.71	64.53	1.69
198809	78.66	2.35	74.87	2.45
198909	81.27	1.94	77.49	1.89
199009	78.67	1.65	74.88	1.54
199109	79.31	1.78	75.52	1.75
199209	64.72	1.91	60.93	1.89
199309	73.90	2.44	70.11	2.36
199409	79.27	1.65	75.48	1.68
199509	78.62	1.79	74.83	1.85
199609	76.58	1.64	72.79	1.65
199709	75.99	1.46	72.20	1.51

Adult mortality

Six-monthly mortalities were calculated each year (1987-1997) based on the number of animals that were alive on 1st March or 1st September, respectively, and those that died during the following six months.

Calf mortality and abortion

Calf mortality to six months of age was calculated for calves born during each year from March to August and September to February, respectively. These were separated into abortions and calf deaths.

Deaths included still births and disappearances (which could be due to natural death or possibly due to predators or possibly theft)

Herd size and calf/cow ratio

The numbers of calves ≤ 12 months of age, weaners (12-36 months of age), adult males and adult females (≥ 36 months of age) alive on 1st March, 1st June, 1st September and 1st December each year (from 1987 to 1997) were calculated.

The two pairs of months (March and June) and (September and December) were then averaged to give average numbers over the two halves of the year. The numbers of animals in each category were then summed to give a total average herd size for each 6-month period.

The average number of calves alive during each 6-month period was divided by the number of adult females to estimate the average calf/cow ratio. This statistic gives an overall measure of cow reproduction/calf survival.

It was found easier to perform most of the calculations of the 6-month animal averages described in the previous pages in SAS rather than GenStat. However, the REML analyses and the least squares analyses of variance that used the 6-month animal averages as average observational units were done, as has been illustrated, in GenStat.

The various annual means taken from the GenStat REML or least squares outputs, or, in the case of animal numbers and mortalities, from the original SAS computations, were then put together in CS10Data5. A full documentation is given in CS10Doc5.

The first columns in this data file are used to describe the situation at each 6-monthly period concerning tsetse control. Thus, periods between 1989 and 1991 and between 1994 and 1997 have been coded 1 to signify that tsetse control was being applied over each of these periods. The other years are coded 0. Selected columns from CS10Data5 are shown below.

Year	Season	Tsetse control	Lagged	Study period	Tsetse density	No. bulls	Body weight (kg)	PCV (%)
1987	1	0	0	1	0.61	40	238.1	26.73
	2	0	0	1	2.32	109	248.0	24.34
1988	1	0	0	1	0.82	108	221.7	24.18
	2	0	0	1	1.98	106	221.0	20.51
1989	1	1*	0	1	2.18	107	223.9	22.77
	2	1	1	1	2.88	100	234.6	22.44
1990	1	1	1	1	1.02	101	239.0	25.70
	2	1	1	1	1.28	111	255.8	25.18
1991	1	1	1	1	1.10	127	245.2	25.21
	2	1	1	1	0.87	139	251.1	23.65

*Targets installed in May

It has been shown previously (Leak et al., 1996) that tsetse control often takes a little while to achieve impact. Notice that the changes in tsetse apparent density, body weight and PCV tended to take effect the year after tsetse control was implemented. A similar tendency was also apparent for many of the other variables.

We thus define a second column (headed lagged) in which the (0, 1) codes have been moved down one line. Since the study involved separate methods of tsetse control and different periods without control we have also define a third column (headed Period) with codes 1 and 2. (see CS10Data5). We shall use these two variables (lagged and period) in our statistical modelling.

Year	Season	Tsetse control	Lagged	Study period	Tsetse density	No. bulls	Body weight (kg)	PCV (%)
1987	1	0	0	1	0.61	40	238.1	26.73
	2	0	0	1	2.32	109	248.0	24.34
1988	1	0	0	1	0.82	108	221.7	24.18
	2	0	0	1	1.98	106	221.0	20.51
1989	1	1*	0	1	2.18	107	223.9	22.77
	2	1	1	1	2.88	100	234.6	22.44
1990	1	1	1	1	1.02	101	239.0	25.70
	2	1	1	1	1.28	111	255.8	25.18
1991	1	1	1	1	1.10	127	245.2	25.21
	2	1	1	1	0.87	139	251.1	23.65

*Targets installed in May

Statistical modelling

We are now ready to fit statistical models to compare tsetse control and non-control periods. We shall apply the model:

$y_{ijk} = \mu + s_i + p_j + c_k + (pc)_{jk} + e_{ijk}$

where y_{ijk} is the dependent variable, μ = mean, s_i= season (i =1,2), p_j = period (j=1,2), c_k =

non-tsetse versus tsetse control (k=1,2), $(pc)_{jk}$ = interaction between period and effect of tsetse control and e_{ijk} is the residual or error term.

We shall start with adult male body weight and use the lagged values under the tsetse control column in CS10Data5. When fitting the above model with **Stats** → **Regression analysis** → **Generalized Linear Models...** we find that the interaction (Period.Lagged) is non-significant. Repeating the analysis without the interaction and clicking the 'Options' button followed by 'Accumulated' we find that the effect of tsetse control is significant (P<0.001)

Regression analysis
Response variate: AM_WEIGHT
Accumulated analysis of variance

Change	d.f.	s.s.	m.s.	v.r.	F pr.
+ Season	1	231.08	231.08	2.56	0.127
+ Period	1	762.28	762.28	8.46	0.009
+ Lagged	1	1579.05	1579.05	17.52	<.001
Residual	18	1622.40	90.13		
Total	21	4194.81	199.75		

Note that the effects of season and period are non-significant whether added before or after lagged (i.e. the effect of tsetse control) in the model (See accumulated analysis of variance).

If we click the 'Predict' button and then click 'Lagged' we get estimates of least squares means. We find that, the average weight of bulls increased from 231 to 248 kg after tsetse control was introduced. As there was no interaction of period and effect of tsetse control we can conclude that similar effects occurred both when targets and pour-on were used.

Regression analysis
Response variate: AM_WEIGHT
Fitted terms: Constant + Season + Period + Lagged
Accumulated analysis of variance

Change	d.f.	s.s.	m.s.	v.r.	F pr.
+ Season	1	231.08	231.08	2.56	0.127
+ Period	1	762.28	762.28	8.46	0.009
+ Lagged	1	1579.05	1579.05	17.52	<.001
Residual	18	1622.40	90.13		
Total	21	4194.81	199.75		

Fitted terms: Constant + Period + Lagged + Season
Accumulated analysis of variance

Change	d.f.	s.s.	m.s.	v.r.	F pr.
Period	1	762.28	762.28	8.46	0.009
Lagged	1	1680.01	1680.01	18.64	<.001
Season	1	130.12	130.12	1.44	0.245
Residual	18	1622.40	90.13		
Total	21	4194.81	199.75		

We can similarly analyse annual adult mortality figures. We find once more a highly significant effect of tsetse control on annual mortality of bulls. Tsetse control decreased average annual male mortality from 0.22 to 0.08 (SED 0.03). Note that we use the standard error of the lagged parameter estimate for the standard error of the difference between the two predicted least squares estimates. There was no significant interaction with period when the interaction was first included in the model and so we can conclude that similar reductions in mortality occurred when either of the two control methods was applied.

The other variables contained in CS10Data5 can be analysed in a similar way. The student can tackle these in the study questions.

```
***** Regression Analysis *****
 Response variate: AM_MORTALITY

Fitted terms: Constant + Season + Period + Lagged

*** Estimates of parameters ***
              estimate      s.e.     t(18)  t pr.
Constant       0.1239     0.0286     4.33  <.001
Season 2       0.0692     0.0284     2.43  0.026
Period 2       0.1171     0.0288     4.06  <.001
Lagged 1      -0.1409     0.0293    -4.81  <.001

 Response variate: AM_MORTALITY
               Prediction        s.e.
       Lagged
       0.0000       0.2223      0.0224
       1.0000       0.0815      0.0185
```

Findings, implications and lessons learned

This case study has demonstrated various difficulties that can arise when attempting an impact assessment study.

- The length that impact assessment studies can take should not be underestimated, especially when the study is in the form of a 'before/after' study
- Before embarking on such a study it is important to make sure that there are sufficient resources to complete the study in the time planned.
- Sometimes, as here, it may be impossible to identify and utilise a set of parallel control subjects (e.g. herds or farmers) to which the intervention is not applied.
- There are potential problems, especially in 'before/after' studies, in distinguishing the impact of an intervention from other confounding factors
- Statistical analysis can be complicated unless data are summarised over longer observational periods (in this case six months) than the frequency at which data are collected (in this case one month).
- Data collection can get out of hand unless the project has strong data management support and there are well-designed data collection systems with appropriate data checking routines in place.

Study questions

1. Repeat the analyses conducted in this case study but using the unlagged instead of the lagged tsetse control codes. Comment.
2. Repeat the REML analyses described using CS10Data2. Why do you think the component of variance for animal is zero? Repeat the analysis without animal in the model. Comment.
3. Select a few other variables in CS10Data5 that have not been analysed. Carry out the

same analyses with GenStat and report your findings in a few sentences.

4. In groups of two or three present a Power Pont presentation based on the results of Question 3 to other members of your class. You can divide the talk between yourselves. The other students should discuss your presentation and the suitability of the slides.
5. Discuss the choice of 6 months for the average unit of measurement for the statistical analysis. Consider alternatives, such as 1 month, 3 months and 12 months and comment on the advantages and disadvantages of each.
6. List the types of data checks that you think should be made each month when the data were originally entered into the data base. One example could be a weight recorded for an individual animal that is much less than measured on previous occasions. Think of others.
7. Prepare suitable data sheets to record the data collected in this case study.

8. Over the years the number of cattle being sampled has expanded to over 700. This is primarily because each calf that is born to a cow in the study is ear-tagged and joins the study. It is decided to reduce this number to half. These cattle belong to various farmers with each farmer owning a minimum of about six head of cattle, and with some farmers many more. Bearing in mind that the success of this study has depended on the participation of farmers, say how you might go about doing this.

9. Insecticide impregnated traps and pour-on appeared to have similar effects on animal productivity. If you were an agricultural development officer which technology would you recommend? List the pros and cons for each technology.
10. CS10SAS shows how mean 6-monthly body weights etc. were calculated for each animal. See how far you can program GenStat to do the same calculations. Examples of some GenStat program statements are given in Case Study 2 and Case Study 6.

Related Reading

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