Reliability of a Twelve-Month Retrospective Survey Method for Estimating Parturition and Mortality Rates in a Traditional African Livestock Farming System

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Keywords

Cattle – Sheep – Goat – Birth rate – Mortality – Statistical method – Rapid rural appraisal – Tropical zone – Senegal.

Summary

Parturition and mortality annual rates are basic data for quantifying productivity of livestock populations in tropical extensive farming systems. Herd monitoring with ear-tagged animals is a gold standard for estimating these parameters in the field. Alternatives are cross-sectional retrospective surveys, based on farmers' interviews and their short- or long-term recall of the herds' demography. The present study evaluated a retrospective method (12MO) for estimating parturition and mortality rates over the last twelve months before the survey. The bias of different approximation methods was calculated for different available databases on cattle and small ruminants monitored in Senegal. The main result was the potentially high bias variability (particularly for the mortality rate of small ruminants for which the relative bias ranged from -60 to 96% in age class "0 to 1 year"), although the median bias remained acceptable (the median relative bias was ≤ 6% in absolute value). Retrospective surveys such as 12MO should be used sparingly (for instance to approximate immediate impacts of large shocks or of innovations) and their results interpreted with caution. Whenever possible, herd monitoring surveys (with or without animals' identification) over a period of several years should be preferred.

■ INTRODUCTION

Parturition and mortality annual rates are basic data for quantifying productivity of livestock populations in tropical extensive farming systems (14, 18, 23, 26). These parameters are estimated from data collected in the field. In developing countries, collecting data is a difficult task due to the dispersion and mobility of the herds and the fact that farmers do not keep written records about their herds. Herd monitoring with ear-tagged animals and periodic visits of trained surveyors are a gold standard (12, 35). Alternatives are cross-sectional retrospective surveys, based on farmers' interviews and their short- or long-term recall of the herds' demography (4, 14, 26, 31, 34). Retrospective surveys have been used for a long time (the earliest document found by the author describing the retrospective approach dates back to 1975 although the approach was used before that; 5) and in many contexts (2, 7, 27, 29, 30, 32). Their attractiveness may be related to their ability to implement quick diagnoses, and to be less cumbersome than herd monitoring and more suitable for surveying nomadic herds or large areas.

Nevertheless, retrospective surveys yield approximate results, with two sources of bias: (1) recall errors from the farmers when demographic data are collected (e.g. omission of animals or events for tax avoidance, cultural reasons or lapse of memory), and (2) mathematical approximations used in calculating demographic rates (these approximations are necessary since only partial information is available). Reliability of retrospective surveys has been poorly evaluated in the past, although a few studies are available (6, 20, 21). The present study evaluated a retrospective method whose objective was to estimate the herd's demography over the last twelve months preceding the survey. This method has been known for a long time (14, 18, 26, 34) but it was recently revisited in several research projects in West Africa. A standard tool ("12MO", abbreviation of "12-month retrospective survey") was calibrated and documented (24, 25). One objective was to define and document a robust method simple enough to be implemented in the field so as to allow it being transferred to local structures (research institutes, technical services, NGOs, etc.).

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Quantification of the recall bias is difficult. It requires expensive specific protocols and the bias can be highly variable depending on the capacity of field enumerators. The study only focused on the bias due to mathematical approximations in 12MO.

■ MATERIALS AND METHODS

General approach

Evaluation concerned the bias of parturition and mortality (all deaths except slaughtering) instantaneous hazard rates (Annex 1) when approximated from data recorded with 12MO. Different calculation methods were evaluated and summarized (with notations used) in Table I.

The bias was calculated on available cattle and small ruminant herd monitoring databases (described further on). For each method, in a given 12-month period and animal category (species, sex and age class), a reference rate h_{ref} (gold standard) was calculated and compared to the approximate h. Absolute and relative biases of h were (in percentage) 100 * ($h - h_{ref}$) and 100 * ($h/h_{ref} - 1$), respectively. When the bias was positive, h_{ref} was overestimated.

Reference rate

For the 12-month period and animal category, the reference rate h_{ref} was defined as the sum of the monthly crude rates:

$$h_{ref} = \sum_{j=1}^{12} h_j = \sum_{j=1}^{12} \left(m_j / T_j\right)$$

where m_j and T_j were the number of occurrences of the considered demographic event (parturition or mortality) and the time of presence of the animals in month *j*. This monthly-based calculation overcame the problems of competing risks between demographic events (Annex 1) and of seasonal variations of risks in the 12-month period.

Approximation methods

12MO principle and Lexis diagram representation

In 12MO (24, 25), the field surveyor individually enumerates all the animals present in the herd at the date of survey, describes their characteristics and, for each female, records its reproductive history (number of abortions, parturitions and offspring) over the last twelve months. Then, the surveyor records all the animals' entries (purchases, gifts, etc.) and exits (natural deaths, slaughtering, sales, etc.) that have occurred in the last twelve months in the herd.

The standard 12MO questionnaire is composed of two subquestionnaires (Q1 and Q2) (24, 25). The purpose of Q1 (Figure 1) is to enumerate individually all the animals in the herd and describe their characteristics, and for each female enumerated to record data reflecting its reproductive performance over the last twelve months. The purpose of Q2 (Figure 2) is to enumerate and describe all herd entries and exits over the twelve months preceding the survey. Data are recorded by annual age class: class "0" represents exact ages from 0 to 1 year, class "1" represents exact ages > 1 to 2 years, etc.

In a Lexis diagram (e.g. 33) that plots the age of animals as a function of time, the last 12-month reproductive history of the females present in a given annual age class at the date of survey corresponds to a parallelogram (or, in the case of age class 0, a triangle) (Figure 3) referred to as "vertical cell" in Lesnoff et al. (23). For instance, the vertical cell *j* reflects the 12-month reproductive history of a female of age class *j* (exact age ranging from *j* to *j* + 1 year) at date of survey (Figure 3).

Table I

Notation and formulae of the approximation methods used to estimate parturition and mortality rates with the retrospective method (12MO) data (when the index *i* was omitted, the quantity was the sum over the age classes)

Notation

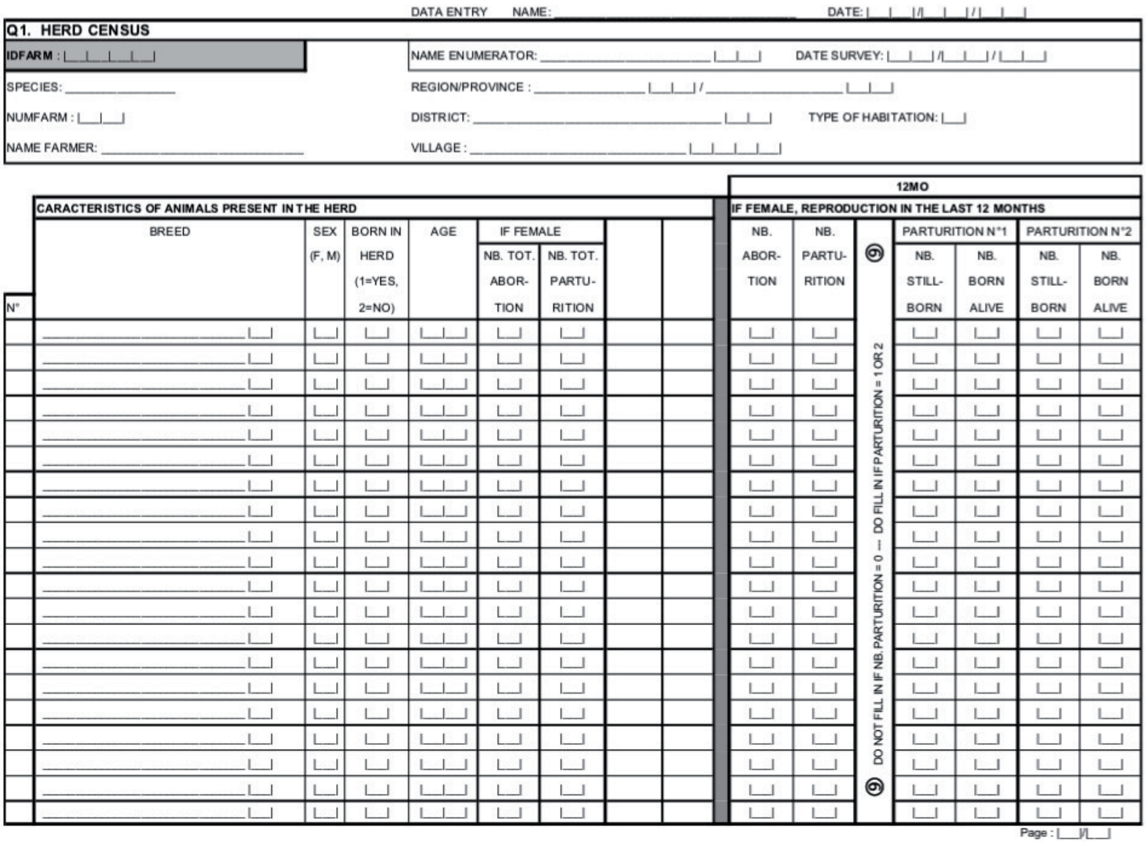
Item	Definition
[*t-1*, *t*]	12-month period between times *t-1* (beginning) and *t* (end). For 12MO data, *t* represented the date of survey
Age class *i*	Exact age between *i* and *i*+1 years
r	Exact age (year) defining the reproductive females
$n_{t-1,i}$, $n_{t,i}$	Num. of animals present in age class *i* at *t*-1 and *t*
m_i	Num. of demographic events related to age class *i* and period [*t-1*, *t*]: vertical cell *i* in Figure 3 for parturition rate, square cell *i* in Figure 4 for mortality and offtake rates
T_i	Time of presence of animals in age class *I* and period [*t-1*, *t*] : vertical cell *i* in Figure 3 for parturition rate, square cell *i* in Figure 4 for mortality and offtake rates
b	Num. of births in period [*t-1*, *t*]

Formulae for parturition rate *h = m / T*

Method	Formula
M1	$m = \left(\sum_{i>r} m_i\right) + \frac{m_r}{2}$, $T = \left(\sum_{i>r} n_{t,F,i}\right) + \frac{n_{t,F,r}}{2}$
M2	$m = \sum_{i \geq r} m_i$, $T = \left(\sum_{i>r} n_{t,F,i}\right) + \frac{n_{t,F,r}}{2}$
M3	$m = \sum_{i>r} m_i$, $T = \sum_{i>r} n_{t,F,i}$

Formulae for mortality and offtake rate $h_i = m_i / T_i$

Method	Formula
M1	$T_i = (n_{t-1,i} + n_{t,i})/2$ where $n_{t-1,i} = n_{t,i}$
M2	$T_i = (n_{t-1,i} + n_{t,i})/2$ where $n_{t-1,i} = n_{t,i} - m_{entry,i} + m_{exit,i}$
M3	$T = (n_{t-1} + n_t)/2$ where $n_{t-1} = n_t - b - m_{entry} + m_{exit}$ and $b = n_{t,0} - m_{entry,0}/2 + m_{death,0}/2 + m_{exit,0}/2$; $T_i = (n_{t,i}/n_t) * T$
M4	$T_i = (n_{t-1,i} + n_{t,i})/2$ where $n_{t-1,i-1} = n_{t,i} - (m_{entry,i-1}/2 + m_{entry,i}/2) + (m_{exit,i-1}/2 + m_{exit,i}/2)$



DATA ENTRY NAME: ______ DATE: |__|__|/|__|__|/|__|__|

Q1. HERD CENSUS

IDFARM : |__|__|__|__|__| NAME ENUMERATOR: ______ |__|__| DATE SURVEY: |__|__|/|__|__|/|__|__|

SPECIES: ______ REGION/PROVINCE : ______ |__|__| / ______ |__|__|

NUMFARM : |__|__| DISTRICT: ______ |__|__| TYPE OF HABITATION: |__|

NAME FARMER: ______ VILLAGE : ______ |__|__|__|__|

N°	CARACTERISTICS OF ANIMALS PRESENT IN THE HERD								12MO IF FEMALE, REPRODUCTION IN THE LAST 12 MONTHS							
	BREED	SEX (F, M)	BORN IN HERD (1=YES, 2=NO)	AGE	IF FEMALE NB. TOT. ABORTION	IF FEMALE NB. TOT. PARTURITION			NB. ABORTION	NB. PARTURITION	DO NOT FILL IN IF NB. PARTURITION = 0 --- DO FILL IN IF PARTURITION = 1 OR 2	PARTURITION N°1 NB. STILLBORN	PARTURITION N°1 NB. BORN ALIVE	PARTURITION N°2 NB. STILLBORN	PARTURITION N°2 NB. BORN ALIVE
	______ |__|	|__|	|__|	|__|__|	|__|	|__|			|__|	|__|		|__|	|__|	|__|	|__|

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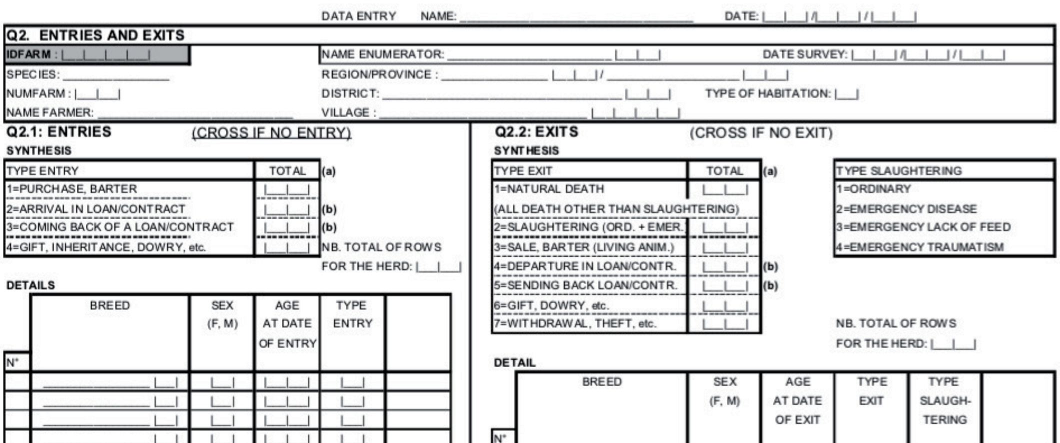
Figure 1: *Subquestionnaire Q1 of the retrospective method (12MO). Information is recorded by annual age class: class "0" represents exact ages from 0 to 1 year, class "1" represents exact ages > 1 to 2 years, etc. Empty columns correspond to eventual auxiliary information recorded during the survey.*



DATA ENTRY NAME: ______ DATE: |__|__|/|__|__|/|__|__|

Q2. ENTRIES AND EXITS

IDFARM : |__|__|__|__|__| NAME ENUMERATOR: ______ |__|__| DATE SURVEY: |__|__|/|__|__|/|__|__|

SPECIES: ______ REGION/PROVINCE : ______ |__|__| / ______ |__|__|

NUMFARM : |__|__| DISTRICT: ______ |__|__| TYPE OF HABITATION: |__|

NAME FARMER: ______ VILLAGE : ______ |__|__|__|__|

Q2.1: ENTRIES (CROSS IF NO ENTRY)

SYNTHESIS

TYPE ENTRY	TOTAL	
1=PURCHASE, BARTER	|__|__|	
2=ARRIVAL IN LOAN/CONTRACT	|__|__|	(b)
3=COMING BACK OF A LOAN/CONTRACT	|__|__|	(b)
4=GIFT, INHERITANCE, DOWRY, etc.	|__|__|	

(a)

NB. TOTAL OF ROWS FOR THE HERD: |__|__|

DETAILS

N°	BREED	SEX (F, M)	AGE AT DATE OF ENTRY	TYPE ENTRY	
	______ |__|	|__|	|__|__|	|__|	

(a) If other type of entry, select the closest within the proposed types

(b) Do not count loans or contracts lasting less than one month (e.g. ploughing contracts)

Q2.2: EXITS (CROSS IF NO EXIT)

SYNTHESIS

TYPE EXIT	TOTAL	
1=NATURAL DEATH (ALL DEATH OTHER THAN SLAUGHTERING)	|__|__|	
2=SLAUGHTERING (ORD. + EMER.)	|__|__|	
3=SALE, BARTER (LIVING ANIM.)	|__|__|	
4=DEPARTURE IN LOAN/CONTR.	|__|__|	(b)
5=SENDING BACK LOAN/CONTR.	|__|__|	(b)
6=GIFT, DOWRY, etc.	|__|__|	
7=WITHDRAWAL, THEFT, etc.	|__|__|	

(a)

TYPE SLAUGHTERING
1=ORDINARY
2=EMERGENCY DISEASE
3=EMERGENCY LACK OF FEED
4=EMERGENCY TRAUMATISM

NB. TOTAL OF ROWS FOR THE HERD: |__|__|

DETAIL

N°	BREED	SEX (F, M)	AGE AT DATE OF EXIT	TYPE EXIT	TYPE SLAUGHTERING	
	______ |__|	|__|	|__|__|	|__|	|__|	

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Figure 2: *Subquestionnaire Q2 of the retrospective method (12MO). Information is recorded by annual age class: class "0" represents exact ages from 0 to 1 year, class "1" represents exact ages > 1 to 2 years, etc. Empty columns correspond to eventual auxiliary information recoded during the survey.*

Information on entries and exits is recorded in a different way and does not correspond to vertical cells in the Lexis diagram. For each event (entry or exit), the surveyor asked the farmer what was the age of the animal at the date of event. This corresponds to a square cell (Figure 4). For instance, square *j* in Figure 4 reflects entries and exits recorded at exact age ranging from *j* to *j* + 1 year.

These Lexis diagram decompositions are used to define the approximation methods.

Parturition rate

The parturition rate was calculated globally for reproductive females (defined by females older than a given exact age *r*). In the Lexis diagram (Figure 3), this reflects the area above the horizontal line defined by exact age *r* (this line divides vertical cell *r* into two equal parts). The parturition rate was approximated by:

$h = m / T$

where *m* was the number of parturitions recorded in the last twelve months for the reproductive females and *T* the time of presence of the reproductive females in the herd. Three methods of approximation (M1 to M3) were evaluated, which varied according to how the data were used in vertical cell *r*. All methods assumed that females enumerated at date of survey lived in the herd during the last twelve months.

M1 assumed that parturitions and time of presence in cell *r* were uniformly distributed in the cell. Half of the parturitions and time of presence in cell *r* were considered:

$$m = \left(\sum_{i>r} m_i\right) + \frac{m_r}{2} \qquad T = \left(\sum_{i>r} n_{t,F,i}\right) + \frac{n_{t,F,r}}{2}$$

M2 assumed that parturitions in cell *r* occurred after exact age *r* (*T* was calculated as in M1):

$$m = \sum_{i\geq r} m_i \qquad T = \left(\sum_{i>r} n_{t,F,i}\right) + \frac{n_{t,F,r}}{2}$$

M3 did not consider vertical cell *r*:

$$m = \sum_{i>r} m_i \qquad T = \sum_{i>r} n_{t,F,i}$$

Mortality rate

The mortality rate was calculated by the annual age class *i*, reflecting the area in square *i* in the Lexis diagram (Figure 4). The mortality rate was approximated by:

$h_i = m_i / T_i$

where m_i was the number of deaths which occurred in the last twelve months, and T_i the time of presence of the animals in the age class *i*. Four methods of approximation (M1 to M4) were evaluated, which varied depending on how T_i was calculated. All methods were based on estimations of time of presence by the mean herd size (20, 23). Mean herd sizes were approximated by arithmetic means between herd sizes at the beginning and the end of the 12-month period. With 12MO data (for which time *t* represented the date of survey), herd sizes twelve months before the survey (time *t*-1) were unknown and had to be estimated.

M1 assumed no size variation in the age class *i* between *t*-1 and *t*:

$T_i = (n_{t-1,\,i} + n_{t,\,i})/2 \qquad n_{t-1,\,i} = n_{t,\,i}$

M2 neglected animals' shifts between age classes between *t*-1 and *t*:

$T_i = (n_{t-1,\,i} + n_{t,\,i})/2$

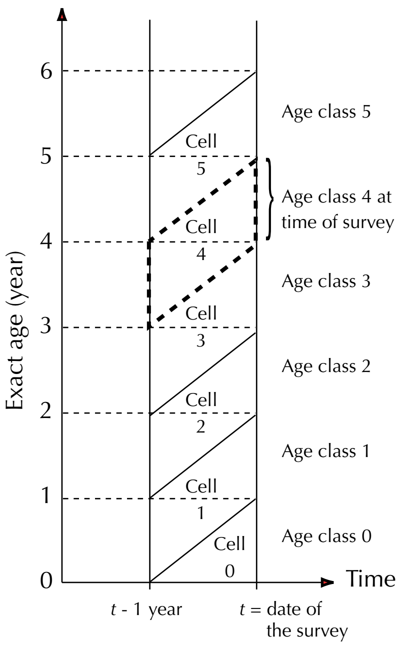

Figure 3: *Vertical demographic cells used for calculating the 12-month parturition rate with the retrospective method data. Cell j reflects the reproductive history over the last twelve months of a female in age class j (exact age ranging from j to j + 1 years) at date of survey (as an example, cell 4 is bounded by dotted lines).*

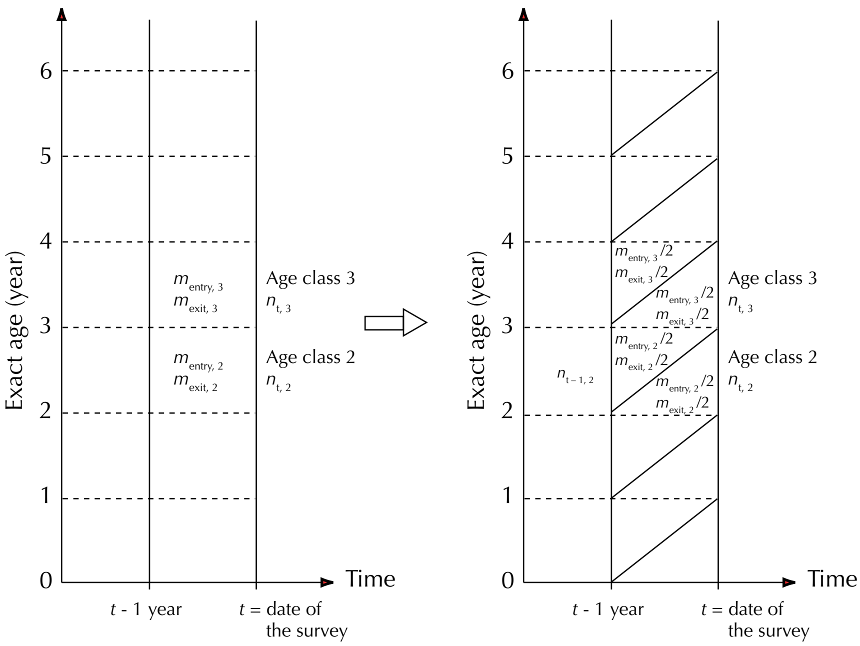

Figure 4: *Left part – Square demographic cells used for calculating the 12-month mortality rate with the retrospective method data. Right part – Breakdown of the squares of the Lexis diagram into two triangles (used in the approximation method M4, and in M3 for calculation of the number of births). For instance, the number of animals present in age class 2 twelve months before the survey was estimated by* $n_{t-1,\,approx,\,2} = n_{t,\,3} - (m_{entry,\,2} - m_{exit,\,2})/2 - (m_{entry,\,3} - m_{exit,\,3})/2$.

$n_{t-1,\, i} = n_{t,\, i} - m_{entry,\, i} + m_{exit,\, i}$

M3 was elaborated by Lesnoff (19). The first step was to calculate $T = (n_{t-1} + n_t)/2$, where $n_{t-1} = n_t - b - m_{entry} + m_{exit}$ (b represented the number of births and was approximated by $b = n_{t,\,0} - m_{entry,\,0}/2 + m_{death,\,0}/2 + m_{exit,\,0}/2$, following the same principle as below in M4). The second step was to assume that the proportion of each age class (relatively to the herd) was constant in the 12-month period, which implied $T_i/T = n_{t,\,i}/n_t$. T_i were then estimated by $T_i = (n_{t,\,i}/n_t) * T$

M4 broke down each square of the Lexis diagram into two triangles (Figure 4), assuming that events occurred uniformly in the square (as in common life table methods), which gave by construction:

$T_i = (n_{t-1,\, i} + n_{t,\, i})/2$

$n_{t-1,\, i-1} = n_{t,i} - (m_{entry,i-1}/2 + m_{entry,\, i}/2) + (m_{exit,i-1}/2 + m_{exit,\, i}/2)$

Data sets

Data used in the study were collected during past research programs in Senegal jointly implemented by the Senegalese Institute of Agricultural Researches (ISRA) and the French Agricultural Research Centre for International Development (CIRAD). Extensively managed cattle and small ruminant herds (located from North to South Senegal) were sampled and monitored using the same protocol (11). For several years, herds were visited every 15 days by trained surveyors; dates and characteristics of all the demographic events that occurred in the herds were precisely reported and stored in a relational database. Data have already been described and analyzed in other contexts (8-10, 13, 16, 17, 19, 28, 36).

Table II

The eleven data sets used to estimate the bias in parturition and mortality rates when using the approximation methods

Site	Species	Monitoring period	Num. of herds[a]	Num. of animals[a]	
				Female	Male
Senegal River	Goat	1987-88	36	1060	304
	Sheep	1987-88	155	923	347
Louga	Goat	1984-95	45	674	162
	Sheep	1984-95	138	1714	593
Kaolack	Goat	1995-96	65	349	85
	Sheep	1995-96	140	2357	826
Kaymor	Goat	1984-93	85	677	249
	Sheep	1984-93	77	489	175
Kolda	Cattle	1994-97	12	450	224
	Goat	1984-95	85	576	247
	Sheep	1984-95	93	632	276

[a] Average number per month (over the study period)

Data were collected in five study sites. Senegal river Delta and Louga are located in North Senegal and are classified in the Sahelian climatic type with an average annual rainfall less than 500 mm. Kolda is located in Upper-Casamance in South Senegal and is classified in the Sudano-Guinean climatic type with an average annual rainfall of 1110 mm. Kaolack and Kaymor are located in Middle Senegal with an average annual rainfall of 800 mm. In each site, herds were monitored continuously with the same protocol (well-trained field surveyors visited the herds every 15 days and recorded all the demographic events that occurred between two visits).

The evaluation used eleven data sets corresponding to five geographical sites (Senegal River Delta, Louga, Kaolack, Kaymor and Kolda) and three species (cattle, goats and sheep) (Table II). The duration of the study periods varied from two to twelve years depending on the site and species (Table II).

Calculations

In each site, species and animal category (sex, age class), calculations were as follows. To take into account possible seasonal variations of the bias, successive 12-month periods were built (within the study period) by moving a 12-month "window" of one month each time (as in the smoothing "moving averages method"; for instance, K=37 successive 12-month periods were built on cattle in Kolda site during 1994-97). Reference rate h_{ref} and approximation h were calculated for each 12-month period. Distributions of observed h_{ref} are presented in Figures 5 and 6. Approximation methods were ranked based on the empirical mean square error of h (MSE, i.e. empirical mean over the K 12-month periods of the squared bias). MSE takes into account both mean and variability of the bias. Noting $B = h - h_{ref}$ and using the sum of squares decomposition:

$$MSE = (1/K) * \sum_{k=1}^{K} (B_k)^2 ,$$

$$= (1/K) * \left[\sum_{k=1}^{K} \left(\frac{\sum_{k=1}^{K} B_k}{K} \right)^2 + \sum_{k=1}^{K} \left(B_k - \frac{\sum_{k=1}^{K} B_k}{K} \right)^2 \right]$$

$$= [\mathrm{Mean}(B_k)]^2 + \mathrm{Var}(B_k).$$

The method showing the lowest MSE was considered as the most reliable. MSE were presented on log scale for reducing range heterogeneities in figures. The distribution (location and variability) of the relative bias was then described with summary statistics and graphical analyses.

For cattle, the bias of the parturition rate was calculated for age class "> 4 years" (in exact age) and, for small ruminants, for age class "> 1 year" (in exact age). The bias of the mortality rate was preliminarily calculated by annual age class and then summarized for two distinct age classes (exact age): "0 to 1 year" and "> 1 year". Results for male small ruminants older than 1 year were not considered (most males were slaughtered or sold by farmers and mortality data were too few to be representative). More generally, goats and sheep showed similar patterns and were grouped under "small ruminants". For the same reason, results were not detailed by geographical site.

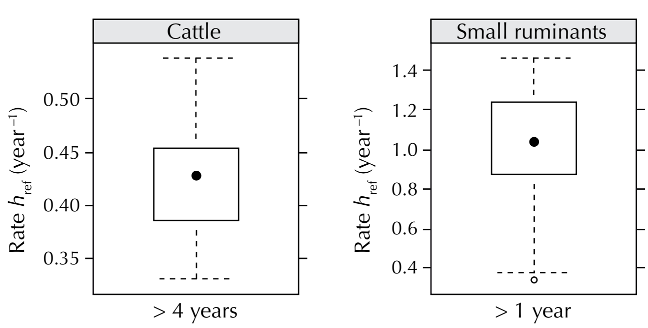

Figure 5: *Box-and-whisker plots of the distribution of the reference parturition rate. The point located in a box represents the median. The two "hinges" of the box are the first and third quartile (the box length is the interquartile range (IQR). The "whiskers" extend out from the box to the most extreme data point which is ≤1.5xIQR away from the box. Data points outside of the whiskers ("outliers") are represented by circles.*

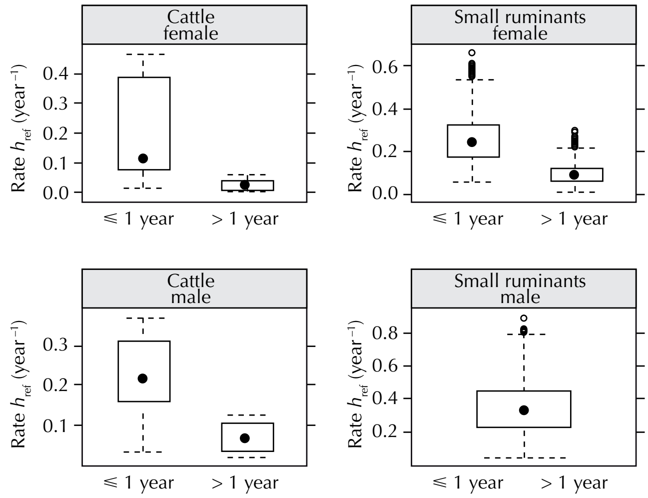

Figure 6: Box-and-whisker plots of the distributions of the reference mortality rate.

■ RESULTS

Parturition rate

M1 showed the lowest MSE for cattle and M3 for small ruminants (Figure 7). Cattle M1 relative bias ranged from -8 to 6%, with a median of 2%. Small ruminants M3 relative bias was higher and ranged from -21 to 23%, with a median of 1% (Figure 7).

Mortality rate

M4 showed the lowest MSE for all species, sex and age class, except for male small ruminants in age class "0 to 1 year" where M3 was slightly lower (Figure 8). Bias results were only presented for M4 which was the retained method (Figure 9). For cattle, the median relative bias was always < 6% in absolute value. Variability was higher for males than for females, and for age class "0 to 1 year" than for "> 1 year". For instance, the relative bias in age class "0 to 1 year" ranged from -15 to 29% depending on sex, while it ranged from -11 to 17% in age class "> 1 year". Small ruminants showed a similar pattern (with the median relative bias always < 7% in absolute value) but with higher variability, particularly for males in age class "0 to 1 year" where the relative bias ranged from -60 to 96%.

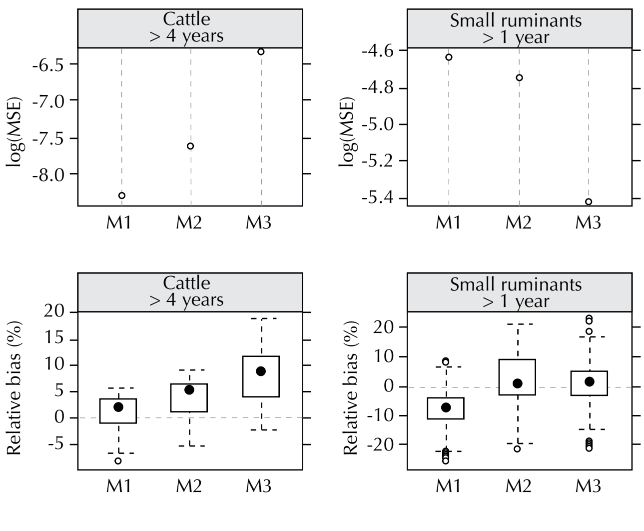

Figure 7: Mean square error (*MSE) (in log scale) and box-and-whisker plots of relative bias (%) for the three approximation methods (M1 to M3) used to estimate the parturition rate with the retrospective method data.*

■ DISCUSSION

For the parturition rate, evaluation results showed that M1 should be recommended for cattle and M3 for small ruminants. For the mortality rate, M4 (or eventually M3 in some cases) should be

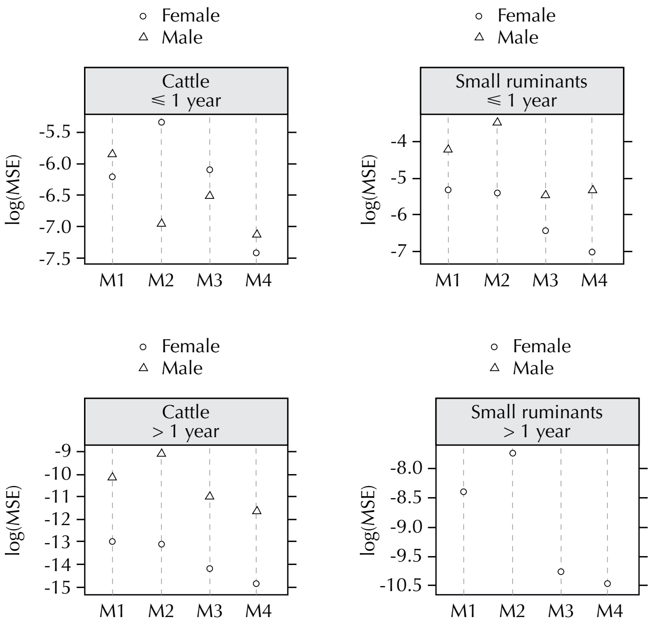

Figure 8: Mean square error (*MSE) (in log scale) of the four approximation methods (M1 to M4) used to estimate the mortality rate with the retrospective method data.*

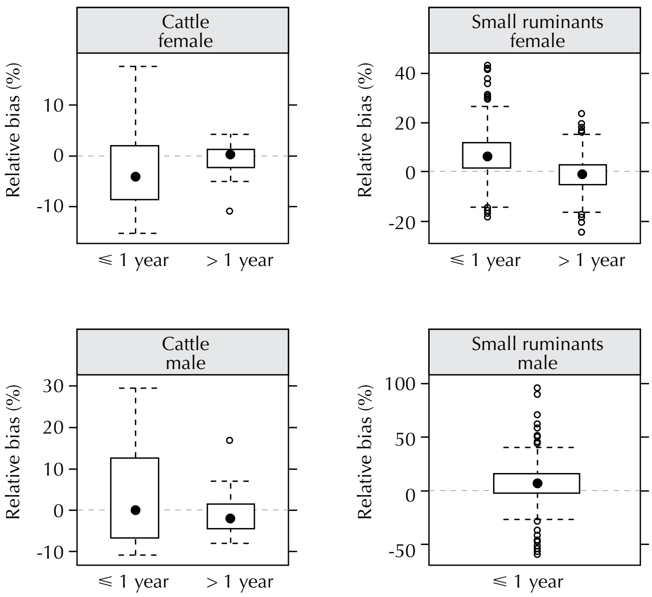

Figure 9: *Box-and-whisker plots of relative bias (%) for method M4 (which showed the lowest* mean square error) *used to estimate the mortality rate with the retrospective method data.*

recommended. These results depended on the demographic traits of the livestock populations and therefore on the data considered, which were limited to sedentary herds extensively managed in agro-pastoral systems in Senegal. More data (in various farming systems) should be analyzed to confirm the conclusions. The rarity of gold-standard longitudinal on-farm data in tropical livestock systems remained, however, a limiting constraint for such evaluations (20).

With the recommended methods, median relative biases were in general negligible (in absolute value: ≤ 2% for parturition rate and, for mortality rate, ≤ 6% in age class "0 to 1 year", and ≤ 2% in age class "≥ 1 year"). Assuming for example true mortality rates of 0.40, 0.20 and 0.10 year^{-1} in age class "0 to 1 year", a positive relative bias of 6% generates estimated rates of 0.424, 0.212 and 0.106 year^{-1}, respectively.

Nevertheless, an important result was that the bias was highly variable, resulting from multiple causes already discussed in Lesnoff (20) and Lesnoff et al. (23) for estimation of times of presence of animals in the herds. Approximation methods used in 12MO considered either herd demographic equilibrium (no size variation) or demographic events uniformly distributed over the 12-month period. In traditional farming systems, however, herd sizes can show high size variations and seasonality in demographic events. Depending on the date of the survey, events have different time distributions (e.g. peaks of parturitions, mortality, etc.) in the defined 12-month period, which generate bias variability. The way of calculating the parturition rate (based on recording the 12-month reproductive history of females present at date of survey) limits this effect, and the bias variability was lower than for the mortality rate. In the study, the highest bias variability was for small ruminants (particularly for the mortality rate in age class "0 to 1 year"), which was not surprising since small ruminant herds have a faster demographic turnover than cattle (due to the high fecundity and mortality) with marked seasonal peaks of events (e.g. massive offtake for Muslim feasts) and size variations (19).

■ CONCLUSION

It must be remembered that cross-sectional retrospective surveys yield approximate results, which was confirmed by the present evaluation. Such surveys are also sensitive to the quality of the field work and the perspicacity of the enumerators, currently faced with cumbersome recording activities, which will worsen recall biases. 12MO could be used to assess immediate (approximate) impacts of large shocks (disease outbreak, drought, etc.) or of innovations on herd productivity in traditional farming systems. In the last case, a "control" herd group (with no innovation) should be compared to a herd group receiving the innovation, assuming an equal bias in both groups. Nevertheless, using 12MO is more questionable (and not recommended by the author) when a "reference" biotechnical diagnosis on the herd productivity is expected. Besides the potential biases, 12MO only focused on the last 12-month period before the survey, while demographic rates varied from year to year. In addition, demographic results limited to a 12-month period can be sensitive to dates delimiting the period (22). When possible, herd monitoring surveys (with or without animals' identification) over a period of several years should be preferred.

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Annex 1

INSTANTANEOUS HAZARD RATE

In the area of demography, rate of occurrence of an event may represent two distinct mathematical parameters: an instantaneous hazard rate (h) or a probability (p). Several terms have been used for h – hazard function, instantaneous hazard rate or intensity of risk. The below description of h uses the example of mortality. The instantaneous hazard rate for mortality $h_{death}(t)$ is the risk of natural death per unit of time, at time t: the quantity $h_{death}(t)dt$ is the expected proportion of surviving animals at time t that will die within the small interval (t, $t + dt$). More formally, one considers the random variable T that represents the lifetime of an animal. In the absence of any other cause of removal apart from death, the probability that an animal surviving at time t will die within the time interval (t, $t + dt$) is $P(t \le T < t+ dt \mid T \ge t)$, where "|" is the conditional operator. To obtain a rate per unit of time, this conditional probability is divided by the length of the time interval dt. The instantaneous hazard rate is the limit of this value when dt tends towards 0:

$$h_{death}(t) = lim_{dt \to 0} \frac{P(t \le T < t + dt \ge t | T \ge t)}{dt}$$

In the area of livestock raising, the instantaneous offtake rate $h_{offtake}(t)$ is defined in the same way as $h_{death}(t)$. The total instantaneous hazard rate of removal (assuming removals arise only from death and offtake) is $h_{total}(t) = h_{death}(t) + h_{offtake}(t)$. An instantaneous hazard rate can be greater than 1 and is expressed in unit time^{-1} (whereas a probability p ranges from 0 to 1 and has no unit).

When rates h are constant, p can be estimated on the basis of h and *vice-versa*. For instance, if one assumes that the only cause of removal is death and that h_{death} is constant for the period (t, $t + \Delta t$), the probability of natural death p_{death} during that period can be calculated based on formulae by Chiang (1984), Cox and Oaks (1984), and Kalbfleisch and Prentice (1980):

$p_{death} = 1 - \exp(-h_{death}\, \Delta t)$.

Hence, an instantaneous hazard rate for death of 0.50 year^{-1} (that means that 0.5 death is expected per 365 animal-days of presence) is associated with an annual probability of dying of 0.39 (with no offtake), which means that 39%, not 50%, of a cohort of animals will die on average in a year.

When there are other causes of removal (e.g. offtake), which are referred to as competing risks for death, the probability of death decreases and becomes an "apparent" probability of death (this is due to the fact that animals removed as offtake will "escape" the daily natural death risk, which here is $h_{death}/365$, in the population). It can be computed based on formulae by Anderson and Burnham (1976), and Chiang (1984):

$$p_{death} = \frac{h_{death}}{h_{death} + h_{offtake}}\left[1 - exp\left(-\left(h_{death} + h_{offtake}\right)\Delta t\right)\right]$$

$$\le 1 - exp\left(h_{death}\Delta t\right)$$

For example, the death rate h_{death} = 0.50 year^{-1} corresponds to an annual death probability p_{deatk} = 0.39 when there is no offtake ($h_{offtake}$ = 0), and to p_{death} = 0.33 when $h_{offtake}$ = 0.40 year^{-1}. In the first case, 39% of a cohort of animals will die on average over the year and, in the second case, only 33%.

When data are grouped by animal category and by period of time and the instantaneous hazard rate is constant, it can be estimated by $h=m/T$, where m is the number of events (of a given type) that occurred in the period, n the number of animals present at the beginning of the period and T the total time of presence of these animals during the period, which in epidemiology is called the time at risk.

Résumé

Lesnoff M. Evaluation d'une méthode d'enquête rétrospective sur une période de douze mois pour estimer les taux de mise bas et de mortalité du bétail dans un système d'élevage africain traditionnel

Les taux annuels de mise bas et de mortalité sont des données de base nécessaires pour quantifier la productivité des cheptels domestiques tropicaux élevés en milieux extensifs. Les suivis de troupeaux avec bouclage des animaux sont une méthode de référence pour estimer ces paramètres sur le terrain. Les méthodes transversales rétrospectives, basées sur des entretiens avec les éleveurs et leur mémoire à court ou long terme de la démographie des troupeaux, sont des alternatives. La présente étude a évalué une méthode rétrospective (12MO) pour estimer les taux de mise bas et de mortalité pour la période des douze derniers mois précédents l'enquête. Le biais de différentes approximations utilisées dans les calculs a été évalué d'après plusieurs jeux de données disponibles et collectées sur les bovins et les petits ruminants au Sénégal. Le principal résultat de l'étude a été la variabilité potentiellement élevée du biais (en particulier pour le taux de mortalité des petits ruminants pour lequel le biais relatif a varié entre -60 et 96 p. 100 dans la classe d'âge « 0 à 1 an »), malgré un biais médian acceptable (la médiane de biais relatif a été ≤ 6 p. 100 en valeur absolue). Les méthodes rétrospectives telles que 12MO devraient être utilisées avec parcimonie (par exemple pour évaluer approximativement l'impact immédiat de chocs importants ou d'innovations) et leurs résultats interprétés avec précaution. Lorsque cela est possible, les suivis de troupeaux (avec ou sans identification des animaux) sur plusieurs années consécutives devrait être privilégiés.

Mots-clés : Bovin – Ovin – Caprin – Taux de parturition – Mortalité – Méthode statistique – Diagnostic rural rapide – Zone tropicale – Sénégal.

Resumen

Lesnoff M. Fiabilidad de un método de encuesta retrospectiva durante un periodo de doce meses para la estimación de las tasas de parto y mortalidad en un sistema de crianza animal africano tradicional

Las tasas anuales de mortalidad y de parto son datos básicos para cuantificar la productividad de las poblaciones ganaderas en los sistemas de crianza extensivos tropicales. El seguimiento del hato con animales marcados en la oreja es la regla de oro para la estimación de estos parámetros en el campo. Las alternativas son encuestas retrospectivas transversales, basadas en entrevistas con los finqueros y su memoria a corto o largo plazo sobre la demografía del hato. El presente estudio evaluó un método retrospectivo (12MO) para la estimación de las tasas de parto y mortalidad durante los últimos doce meses anteriores a la encuesta. Se calcularon los sesgos de los diferentes métodos de aproximación para las diferentes bases de datos disponibles en ganado y pequeños rumiantes seguidos en Senegal. El resultado principal fue el sesgo de variabilidad potencialmente alto (particularmente para la tasa de mortalidad en pequeños rumiantes, para los cuáles el sesgo relativo varió de -60 a 96% en clase de edad "0 a 1 año"), aunque el sesgo medio se mantuvo aceptable (sesgo medio relativo fue ≤6% en valor absoluto). Las encuestas retrospectivas como 12MO deben ser usadas con moderación (por ejemplo para aproximaciones de impactos inmediatos provocados por choques importantes o de innovaciones) y sus resultados deben interpretarse con cautela. Cuando es posible, deben preferirse las encuestas de seguimiento de hatos (con o sin identificación de los animales) durante un periodo de varios años.

Palabras clave: Ganado bovino – Ovino – Caprino – Tasa de parto – Mortalidad – Método estadídtico – Diagnóstico rural rápido – Zona tropical – Senegal.