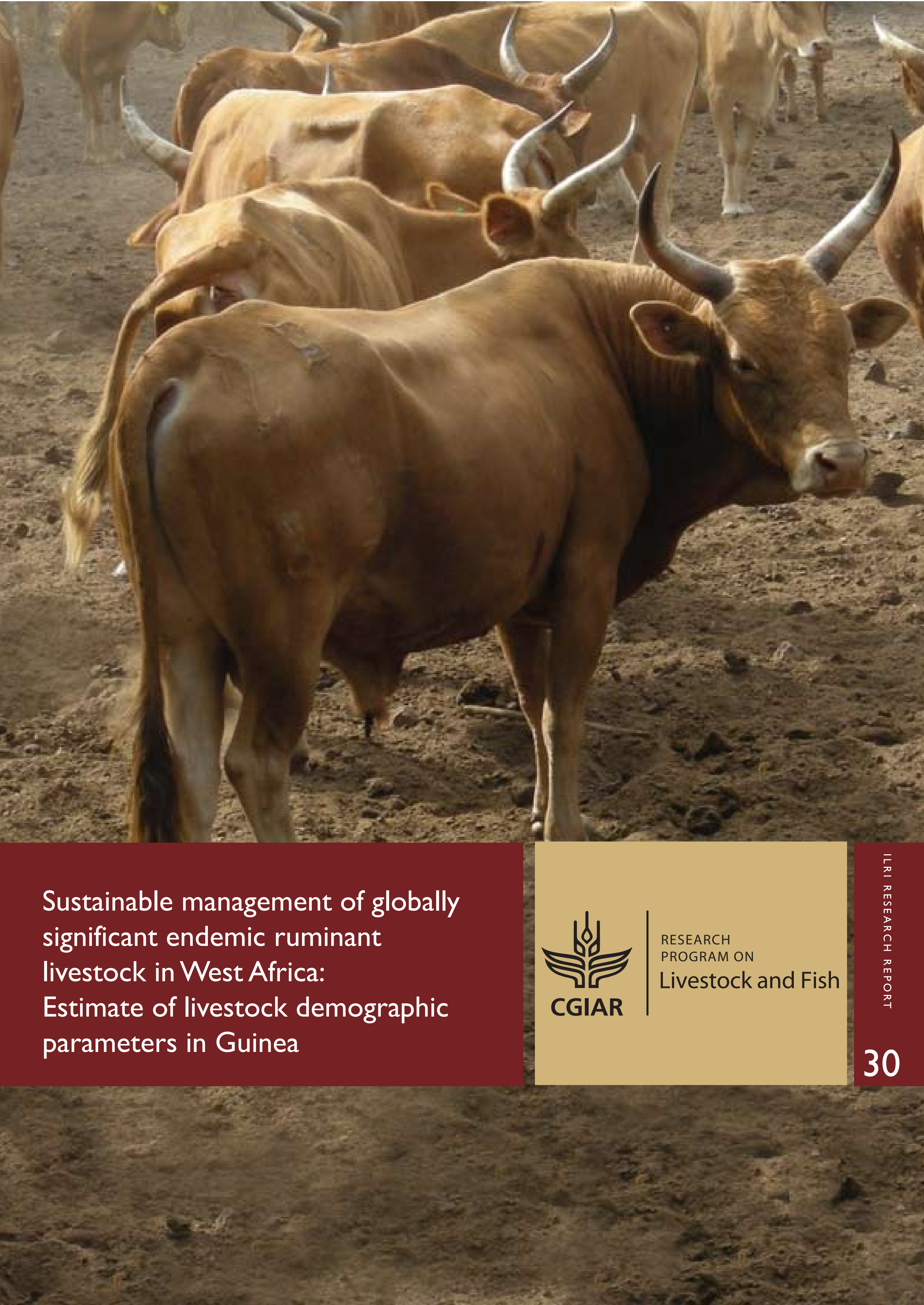

Sustainable management of globally significant endemic ruminant livestock in West Africa: Estimate of livestock demographic parameters in Guinea

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30

Sustainable management of globally significant endemic ruminant livestock in West Africa: Estimate of livestock demographic parameters in Guinea

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Acronyms

ERL	Endemic Ruminant Livestock
NARS	National Agricultural Research System
PPR	Peste des Petits Ruminants
PRA	Participatory Rural Appraisal
PROGEBE	Projet Regional de Gestion Durable du Betail Ruminant Endemique (Sustainable Management of Globally Significant Endemic Ruminant Livestock in West Africa)
WAD	West African Dwarf

Executive summary

Introduction

This report describes the results of a 12-month retrospective survey for estimating livestock demographic parameters of endemic ruminant livestock (ERL) kept by smallholders in selected sites in Guinea. The demographic parameters estimated included natural rates, such as parturition, abortion and mortality rates, as well as management rates, such as offtake and intake rates.

The survey was carried out as one of several baseline surveys under the PROGEBE-Guinea project. At the onset of the survey, it was expected that the output (demographic parameter estimates) would serve the following functions:

- as an information source (to be combined with other information sources) for prioritizing project interventions,
- for quantitative comparison of the demographic parameters between ERL and non-ERL, and
- to provide indications of the baseline status of livestock demographic parameters, which in combination with other baseline data and consideration for year effect can be used for evaluating the impact of project interventions.

However, as there were very few non-ERL within the surveyed sites, quantitative comparison of demographic parameters between ERL and non-ERL has not been possible.

Methodology

The methodology used was a 12-month retrospective survey, as described in full in Lesnoff et al. (2010a). The survey was carried out between the 16th October 2010 and 21st January 2011, and thus encompasses the 12 month period prior to this.

Suitable herds/flocks for enumeration were first identified within the project sites. These were considered those of size 5 to 30 animals (including juveniles) for a single household owned herd/flock, and 15 to 50 animals (including juveniles) for a multiple household owned herd/flock (though on occasion smaller or larger herds/flocks were surveyed). A trained enumerator then interviewed the farmer in relation to their herd/flock, in the presence of the animals. These animals were enumerated exhaustively for a number of basic data (such as breed, sex, age, parity etc.). The interviewee was also asked to recall all demographic events (such as births, deaths, slaughters, sales, purchases) that have occurred in the last 12 months.

From the data collected, two types of demographic parameters are estimated (Lesnoff et al. 2010a): variables describing the state of the herd/flock at the time of survey (such as herd size, sex by age structure), and annual demographic rates (including natural rates, such as parturition, abortion and mortality rates, as well as management rates, such as offtake and intake rates).

The demographic parameters referred to as a rate (for example mortality rate, parturition rate) are instantaneous hazard rates. These are estimated as the number of events (e.g. number of mortalities) that have occurred in the last 12 months, divided by the total 'time at risk' (time spent by animals in the category over the last 12 months).

It should be noted that the demographic parameters were calculated for pure-breed ERL only (due to the absence of non-ERL in the data). Further the estimated parameters should be considered approximate and interpreted with caution, due to several reasons (such as being based on recall) as discussed further in the main report.

Sample characteristics

The survey was carried out in three sites in Guinea, namely Beyla, Dinguiraye and Gaoual. Fifty-four cattle herds were surveyed in total; 14 from Beyla, 18 from Dinguiraye, and 22 from Gaoual. The total number of animals within these herds at the time of survey was 686, of which all were pure-bred N'Dama. All interviewees, but one, were male.

One hundred twenty five sheep flocks were surveyed in total; 35 from Beyla, 41 from Dinguiraye, and 49 from Gaoual. The total number of animals within these flocks at the time of survey was 979, of which all were pure-bred Djallonke. Ninty-eight per cent of interviewees were male.

One hundred sixteen goat herds were surveyed in total, 32 from Beyla, 42 from Dinguiraye, and 42 from Gaoual. The total number of animals within these herds at the time of survey was 839, of which all were pure-bred West African Dwarf (WAD). Ninty-seven per cent of interviewees were male.

Interviewees' perception of 12 month study period

The 12-month period prior to the survey was generally rated as worse than an average year for Beyla, worse than average to average for Dinguiraye, and average for Gaoual, across species, according to the perception of the interviewees.

Key results

Herd size and structure

The mode and mean of herd size for cattle was 10 and 12.7 animals, respectively, with an overall herd structure of 19% calves (≤ 1 year), 37% subadults (> 1 to ≤ 4 years) and 29% adult females and 15% adult males (> 4 years). For sheep the mode and mean of flock size was 5 and 7.9 animals, respectively, with an overall flock structure of 36% lamb (≤ 1 year), 47% adult females and 17% adult males (> 1 year). Finally, for goats the mode and mean of herd size was 5 and 7.5 animals, respectively, with and overall herd structure of 40% kids (≤ 1 year), 43% adult females and 17% adult males (> 1 year).

All three species had animals not born within the herd/flock. However, the proportion of introduced animals was low (1–4%) for all species/age/sex groups except female sheep and goat > 1 year of age (21% and 10%, respectively).

Reproduction

The age at first calving for cattle was found to generally be 4 to 6 years, whilst for sheep and goats animals were mostly 1 to 3 years at first lambing/kidding.

The interval between parturitions was estimated to be from 1.1 to 2.4 years for cattle, and 0.8 to 1.5 years for sheep and goat. The prolificacy rate (average number of offspring born alive per parturition) was 1.00 for cattle, 1.31 for sheep and 1.43 for goat.

The annual abortion and stillbirth rates ranged from 0.03 to 0.09, depending on species.

Natural mortality

The mortality rates for cattle were found to be moderately high for animals less than one year of age, at 0.17 for females and 0.11 for males. For the small ruminants the mortality rates were found to be high for sheep less than one year of age, at 0.24 for females and 0.22 for males, and moderately high for goats less than one year of age, at 0.18 for both females and males. Estimated losses for a typical herd/flock of 10 cattle, 5 sheep or 5 goats (assuming constant herd/flock size over the year) were 0.5, 0.65 and 0.6 animals per annum respectively.

Offtake and intake

The overall annual offtake rate was 0.12 for cattle and 0.18 for both sheep and goats. Thus for a typical herd of 10 cattle (assuming constant herd size over the year) the number of exits via offtake (rather than death) expected annually is 1.2, whilst for a typical herd of 5 small ruminants 0.9 exits via offtake are expected annually. For all species, the highest single event offtake rate was sale, followed by slaughter.

The annual intake rate was 0.06 for cattle, 0.07 for sheep and 0.09 for goats. Thus for a typical herd/flock of 10 cattle, 5 sheep or 5 goats (assuming constant herd/flock size over the year), 0.60, 0.35 and 0.45 animals, respectively, are expected to enter the herd/flock (by means other than birth) annually. The main type of intake was purchase/barter for all species. Mainly animals >1 year of age were purchased.

The overall *net* offtake rates per annum were 0.07 for cattle, 0.11 for sheep and 0.09 for goats.

Conclusions and key recommendations

The findings of this survey clearly indicated that N'Dama cattle, Djallonke sheep, and WAD goats are the prominent breeds in the PROGEBE-Guinea project areas and suggests that some level of controlled breeding seems to be applied in most herds/flocks, primarily through sire selection (although these may or may not be implemented with a specific breeding objective in mind). There seem to be a considerable scope for improvement of the mortality rate, as well as particular reproductive parameters such as age at first parturition, through improved herd/flock management in the short term, and breeding strategies in the long term.

Specifically, it can be recommended that PROGEBE consider/prioritize the following issues for future project activities or interventions:

- Interventions towards lowering the natural mortality rates should be prioritized. This should mainly be through changes in management practices in the short to medium-term, for example, by better disease control and improved feed. In the much longer term (20 to 50 years) it may be possible to reduce mortality by genetically improving disease resistance of the animals through a breeding program.

- Interventions to improve reproductive parameters should be prioritized, including age at first parturition. Again, this should mainly be through changes in management practices in the short-term, such as improved feeding, while in the longer term these parameters could potentially be improved through genetic improvement.

- Capacity building programs to improve awareness of traditional and alternate management and breeding practices and the effect these have on livestock production and productivity.

- A modelling study using the demographic parameters estimated here, combined with other data from the household surveys, and literature to determine the expected impact of potential PROGEBE interventions (such as improved healthcare, feeding and/or animal genetic improvement) on livestock production over different time horizons.

1 Introduction

Livestock play a central role in rural development in West Africa (Agyemang 2005). However, traditional livestock systems are in general characterized by high mortality rates, low reproductive rates and low offtake rates (Otte and Chilonda 2002). Furthermore, the presence of trypanosome-infected tsetse flies in the subhumid and humid areas seriously affects the potential for livestock production (Murray and Trail 1984 ; Snow et al. 1996; Osaer et al. 1999). Endemic ruminant livestock (ERL) such as N'Dama cattle, Djallonke sheep and West African Dwarf (WAD) goats are, however, highly adapted to the local environmental conditions and are able to survive and remain productive in tsetse infested areas with minimal inputs where other breeds succumb (Wilson 2007; Murray and Trail 1984 ; Snow et al. 1996; Osaer et al. 1999). Conservation and improvement of these breeds therefore have the potential to unlock the role of livestock in improving the livelihoods of livestock keepers in West Africa.

The 'Sustainable Management of Globally Significant Endemic Ruminant Livestock in West Africa' (PROGEBE) project aims at developing and implementing models for community-based conservation and management of critical habitats for three endemic ruminant livestock (ERL) species (namely, N'Dama cattle, Djallonke sheep and WAD goats), and to demonstrate strategies for preserving the unique genetic trait/habitat complexes that are of global importance. Specifically, the objectives of the project are: 1) to ensure sustainable populations of targeted ERL breeds in four West African countries; and 2) to contribute to food security improvement and poverty reduction. These objectives will be accomplished through reaching the following outcomes: i) conservation of ERL genetic traits and improvement of their productivity; ii) facilitating improved market development and incentives for ERL and their products; iii) promoting sustainable management of natural resources for ERL; iv) facilitation of the implementation of policies, legal and institutional frameworks favourable to ERL development; and v) improve cooperation, knowledge management and information sharing (UNDP 2007).

In order to characterize the exiting ERL production and management system, as well as other key indicators relevant to the five strategic intervention areas, a number of baseline surveys were carried out in the three project sites in Guinea. These included a Participatory Rural Appraisal (PRA) Survey, a household questionnaire survey, a market actor survey and a retrospective survey of livestock demographic parameters.

This report describes the results of the 12-month retrospective survey for estimating livestock demographic parameters of endemic ruminant livestock (ERL) kept in mixed crop–livestock systems in Guinea.

These parameters have to some extent been reported in the literature for cattle (Agyemang et al. 1997; Otte and Chilonda 2002; Ba et al. 2011), sheep (Wilson 1991; Lesnoff 1999; Otte and Chilonda 2002) and goats (Wilson 1991; Ba et al. 1996; Otte and Chilonda 2002). However, the data are typically 10–40 years old and have limitations in terms of livestock species and breeds, farming system or country/region. Hence, this survey was carried out to collect up-to-date, site and breed specific data on livestock demographic parameters in the PROGEBE-Guinea project sites.

Three main survey approaches are used in practice for collecting data on livestock demographic parameters in smallholder systems in the developing world. These are individual animal follow-up, herd follow up and cross sectional retrospective surveys (Lesnoff et al. 2009). The retrospective survey is based on farmer interviews and their recall of past herd demographics. Compared to the other two methods it has the advantage of quick results and being

relatively low cost. The main drawback is that the method relies on farmers' recall of past events and therefore will not be as accurate at the two other approaches. The 12MO (12 months) retrospective survey is a methodology designed to provide a standardized methodology for estimating livestock demographic parameters, which is affordable and easily implementable in the field in order to be easily transferable to local structures (NARS, NGOs etc.) (Lesnoff et al. 2009). Being based on farmers' recall of the past 12 months, the survey is sensitive to between year variation, which can be considerable (Lesnoff 1999). This survey methodology was, however, still found to be the most suitable for the purpose, due to the reasons given above and since no up-to-date site and species/breed specific data were available. The results of the survey should be interpreted with consideration of the interviewees' perception of the 12 month study period and cannot be considered as averages over years. They can, however, provide a useful and site/breed specific estimation of the productivity of livestock herds in the year prior to the survey. The advantages and disadvantages of the 12MO survey methodology are further discussed in the following section.

The specific objectives of the survey were as follows:

i. To serve as an information source that, combined with other information sources, can be used for prioritizing project interventions,

ii. To enable quantitative comparison of the demographic parameters between ERL and non-ERL, and

iii. To provide indication of the status of livestock demographic parameters in the project sites that, in combination with other baseline data and with consideration of year effect, can be used for evaluating the impact of project interventions.

However, as there were very few non-ERL within the surveyed sites, the second objective could not be fulfilled.

The report first describes the methodology used for the survey, as well as the sample surveyed for each of the three species (cattle, sheep and goats) (Section 2). Hereafter the results of the survey are presented by species (Sections 3, 4 and 5), followed by an overall discussion (Section 6). Finally, a conclusion and summary of recommendations for future PROGEBE interventions are given in Section 7.

2 Methodology

2.1 Overview of survey methodology and demographic parameters estimated

The methodology used was a 12-month retrospective survey, as described in full in Lesnoff et al. (2010a). The survey was carried out between the 16th of October 2010 and the 21st of January 2011, and thus encompasses the 12 month period prior to this.

The survey was carried out as follows. Suitable herds/flocks for enumeration were first identified within the project sites. These were considered for those of size 5 to 30 animals (including juveniles) for a single household owned herd/flock, and 15 to 50 animals (including juveniles) for a multiple household owned herd/flock (though on occasion smaller or larger herds/flocks were surveyed). These herd/flock sizes were chosen as a compromise between fully representative of all herd/flock sizes, and practical issues related to survey time (the overhead associated with surveying smaller herd/flocks was considered too great, and it was too time-consuming to survey larger herd/flocks). The results of the PROGEBE Guinea household survey showed that the proportion of households managing different numbers of cattle, sheep and goats was 38, 61 and 53% for 1–4 animals; 55, 37 and 45% for 5–30 animals; and 7, 2 and 2% for > 30 animals, respectively. Difference in demographic parameters may exist between these two major groups of households, which should be considered when interpreting the results. Ba et al. (2011) did not find a significant difference in mortality and offtake rates between different herd sizes for cattle in mixed crop–livestock systems in Southern Mali. The main differences found were that a herd of 1–5 cows had a significantly higher parturition rate compared to herds of 6–19 and ≥20 cows, as well as significantly higher intake of subadult and adult animals. A trained enumerator then interviewed the farmer in relation to their herd/flock, in the presence of the animals. These animals were enumerated exhaustively for a number of basic data (such as breed, sex, age, parity etc.). The interviewees were also asked to recall all demographic events (such as births, deaths, slaughters, sales, purchases) that have occurred in the last 12 months. A full list of the data recorded is given in Table 1.

From this data two types of demographic parameters were estimated (Lesnoff et al. 2010a):

i. variables describing the state of the herd/flock at the time of survey (such as herd size, sex by age structure);

ii. annual demographic rates (including natural rates, such as parturition, abortion and mortality rates, as well as management rates, such as offtake and intake rates).

Table 1. Data recorded for the 12 month retrospective survey

Level	Data
For each survey	Generic: survey date, survey location (site, village and GPS coordinates)
	Interviewee: name, gender, type (household head, other household member, herder, or other), livestock owner (yes, no)
	Seasonal effect over the last 12 months compared to the previous five years (choices of 'much worse than average', 'somewhat worse than average', 'average', 'somewhat better than average', 'much better than average', with respective scores of 1,2,3,4 and 5
	Total number of households with animals within the herd/flock
For each animal present in the herd/flock at the time of survey	Breed or breed-cross: based on phenotype, and as jointly agreed by the interviewee and enumerator
	Sex
	Born in herd
	Born from AI
	Age: as age class, where age class 0 corresponds to animals 0 to ≤ 1 year of age, age class 1 corresponds to animals > 1 and ≤ 2 years of age etc.
For each female present in the herd/flock at the time of survey	Number of lifetime parturitions (where a parturition is defined as the process of giving birth)
	Number of parturitions over the last 12 months
	For each parturition over the last 12 months the number of offspring born alive
	For each parturition over the last 12 months the number of offspring stillborn
	Number of lifetime abortions
	Number of abortions over the last 12 months
For each animal that has entered the herd over the last 12 months	Breed or breed cross (as above)
	Sex
	Age (as above)
	Type of entry: purchase or barter; arrival in loan or contract; returned from loan or contract; gift, inheritance of dowry
For each animal that has exited the herd over the last 12 months	Breed of breed cross (as above)
	Sex
	Age (as above)
	Type of exit: natural death; slaughter; sale or barter; departure in loan or contract; sending back from loan or contract; gift or dowry; withdrawal or theft
	Type of slaughter or sale: ordinary; emergency due to disease; emergency due to lack of feed; emergency due to traumatism

A full list of demographic parameters is given in Table 2. Stillbirth rate, prolificacy rates and fecundity rates are not included in this report, since the data used for estimation of these rates were only collected for a small number of animals (n = 4–28, depending on species and rate). A number of demographic parameters in Table 2 (i.e. abortion, parturition, mortality, offtake and intake) are given as an instantaneous hazard rate (h). The instantaneous hazard rate can be estimated for a particular category of animals and event (e.g. males over one year of age and offtake via slaughter) as:

$$h = m/T$$

where m is the number of events that have taken place in the last 12 months, and T is the total 'time at risk' (time spent by animals in the category over the last 12 months).

T is approximated by averaging the estimated number of animals in that category 12 months ago (n_{t-1}), and the current number of animals in that category (n_t). n_{t-1} for a particular age class (i) is calculated as:

$$n_{t-1,i} = n_{t,i+1} - ((m_{ent,i} - m_{exi,i})/2) - ((m_{ent,i+1} - m_{exi,i+1})/2),$$

where m_{ent} and m_{exi} are entries and exists into age class *i* in the last 12 months, respectively. $n_{t,i}$ is known from the data.

Note that calculation of *T* via this method assumes a uniform distribution of events (mortalities, number of animals entering the herd etc.) over the 12 months. If this assumption does not hold and there is a non-uniform event rate *T* will be biased: if an intensive event rate occurs close to the beginning of the year *T* will be over-estimated, and if an intensive event rate occurs close to the end of the year *T* will be under-estimated. In practice this assumption cannot be expected to be met fully. It has, however, been shown that this method of estimating *T* is less sensitive to herd size variations over the year than other methods (Lesnoff 2008). See Lesnoff et al. (2010a) for further details on the calculation of instantaneous hazard rates, and Appendix 1 for an illustrative example.

Table 2. Demographic parameters estimated for the 12 month retrospective survey[1]

Natural rates	
Abortion rate	Annual instantaneous hazard rate of abortion (expected number of abortions per female when spending all the year in the herd; an abortion is a gestation that has not reached its term). Also calculated over the complete reproductive female histories (as the slope of the regression line fitted between ages and parities of the females present in the herd)
Parturition rate	Annual instantaneous hazard rate of parturition (expected number of parturitions per female when spending all the year in the herd). Also calculated over the complete reproductive female histories (as the slope of the regression line fitted between ages and parities of the females present in the herd)
Prolificacy rate	Average number of offspring (stillborn or born alive) per parturition
Stillbirth rate	Probability that an offspring is a stillborn (stillbirth is not included in the mortality rate, which only concerns animals born alive)
Mortality rate	Annual instantaneous hazard rate of natural death (natural death refers to all types of death except slaughtering)
Management rates	
Offtake rate	Annual instantaneous hazard rate of offtake (slaughtering, sales, loans, gifts etc.)
Intake rate	Annual instantaneous hazard rate of intake (purchases, loans, gifts etc.)
Additional demographic rates derived from the basic annual demographic rates	
Net prolificacy rate	Average number of offspring born alive per parturition, calculated directly or by: Prolificacy rate * (1-stillbirth rate)
Fecundity rate	Average number of offspring (born alive or stillborn) per reproductive female and year, calculated directly or by: Parturition rate * Prolificacy rate
Net fecundity rate	Average number of offspring born alive per reproductive female and year, calculated directly or by: Parturition rate * Net prolificacy rate

1. Taken from Lesnoff et al. (2010a).

Furthermore, it should be noted that the data produced using this methodology should only be considered approximate and should be interpreted with caution for several reasons. Firstly the data is based on a memory of events for the 12 month period preceding the time of survey, and thus is likely to contain a certain level of error, which could bias the results. Secondly, an underlying assumption for the annual hazard rates is that there is a uniform distribution of demographic events over time, with violation of this assumption again biasing the results. In particular, this may apply to adult male small ruminants as these are often slaughtered or sold during a short time period (e.g. Tabaski) but also to whole herds/flocks during the occurrence of seasonal disease outbreaks, such as PPR for sheep and goats. Thirdly, herds and flocks were selected based on a specific size range, meaning that results

are less applicable to herds/flock smaller or larger than that targeted here. Finally, the results relate to the specific environmental conditions of the 12-month period surveyed, rather than being an average over many years. The best option for validation of the demographic parameters presented here, if required, is a long-term longitudinal survey.

All analysis, bar interviewees' perception of 12 month study period, was performed combining data over sites.

2.2 Cattle survey sample

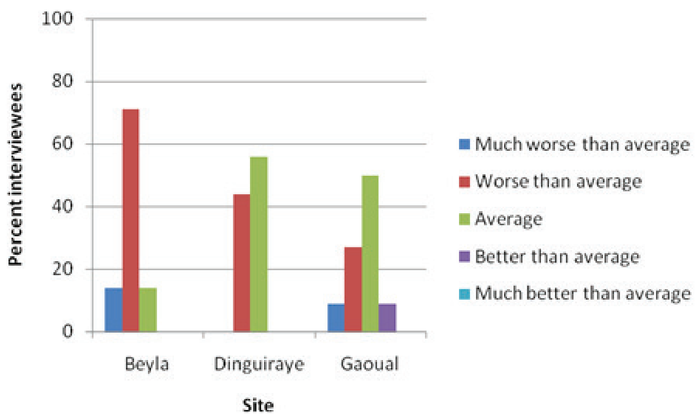
A total of 54 herds were surveyed; 14 from Beyla, 18 from Dinguiraye, and 22 from Gaoual. All herds bar five were single-household owned: the 5 multiple owner herds had 2, 2, 2, 3 and 4 owners. The total number of animals within these herds at the time of survey was 686, all of which (100%) were pure-bred N'Dama. It should be noted that of the 686 animals there were 398 females, of which 391 had the number of lifetime parturitions recorded, 357 had the number of parturitions in the last 12 months recorded, and 339 had the full set of reproductive records. In addition, there were a total of 40 entries (other than birth) and 126 exits of pure-bred N'Dama recorded.

All but one of the interviewees were male (98%), with all of the interviewees being a household head. All household heads were livestock owners, barring one reported exception (a male household head who was not the livestock owner).

Interviewees' perception of 12 month study period

The distribution of scores for the interviewees' perception of the 12 month study period is given in Figure 1. Across all sites, the majority of interviewees found the year to be 'worse than average' (44%) or 'average' (43%). In Beyla, the most common response was 'worse than average' (71%), in Dinguiraye the most common response was 'average' (55%) closely followed by 'worse than average' (44%), whilst in Gaoual the most common response was 'average' (50%) followed by 'worse than average' (27%).

Figure 1. *Interviewees' perception of 12 month study period for cattle herds in the three sites*



2.3 Sheep survey sample

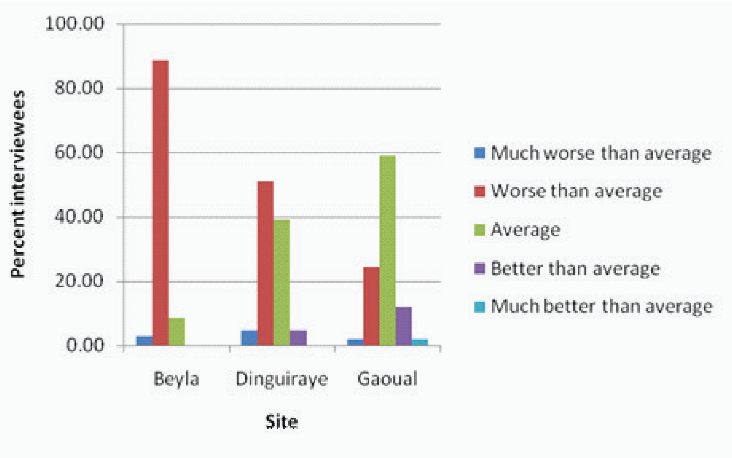
In total 125 flocks were surveyed; 35 from Beyla, 41 from Dinguiraye, and 49 from Gaoual. All flocks were single-household owned. The total number of animals within these flocks at the time of survey was 979, all of which were pure-bred Djallonke. It should be noted that of the 979 animals there were 657 females, of which 646 had the number of lifetime parturitions recorded, 622 had the number of parturitions in the last 12 months recorded, and 596 had the full set of reproductive records. In addition, there were a total of 59 entries and 303 exits recorded of pure-bred Djallonke.

Of the 125 interviewees, 98% (121) were male and only 2% (4) were female. Of the male interviewees, 98% (118) were livestock owners as well as the household head. Of the female interviewees, all were livestock owners as well as the household head.

Interviewees' perception of 12 month study period

The distribution of scores for the interviewees' perception of the 12 month study period in each site is given in Figure 2. Across all sites, the majority of interviewees found the year to have been 'worse than average' (51%) or 'average' (38%). In Beyla, the most common response was 'worse than average' (89%), in Dinguiraye the most common response was 'worse than average' (51%) followed by 'average' (39%), whilst in Gaoual the most common response was 'average' (59%) followed by 'worse than average'(25%).

Figure 2. *Interviewees' perception of 12 month study period for sheep flocks in the three sites*



2.4 Goat survey sample

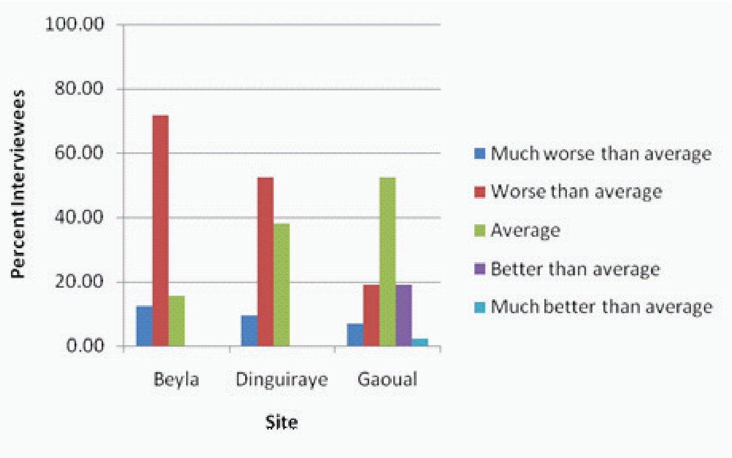
A total of 116 herds were surveyed; 32 from Beyla, 42 from Dinguiraye, and 42 from Gaoual. All herds were single-household owned. The total number of animals within these flocks at the time of survey was 839, all of which were pure-bred West African Dwarf (WAD). It should be noted that of the 839 animals there were 538 females, of which 523 had the number of lifetime parturitions recorded, 494 had the number of parturitions in the last 12 months recorded, and 472 had the full set of reproductive records. In addition, there were a total of 68 entries and 241 exits recorded of pure-bred WAD.

Of the 116 interviewees, 97% (113) were male and only 3% (3) were female. Of the male interviewees, 94% (106) were livestock owners as well as the household head. Of the three female interviewees, all were household heads and two of the three livestock owners.

Interviewees' perception of 12 month study period

The distribution of scores for the interviewees' perception of the 12 month study period in each site is given in Figure 3. Overall, the majority of interviewees found the year to have been 'worse than average' (46%) or 'average' (37%). In Beyla, the most common response was 'worse than average' (72%), in Dinguiraye the most common response was 'worse than average' (52%) followed by 'average' (38%), whilst in Gaoual the most common response was 'average' (52%) followed equally by 'worse than average' and 'better than average' (19 % each).

Figure 3. *Interviewees' perception of 12 month study period for goat herds in the three sites*



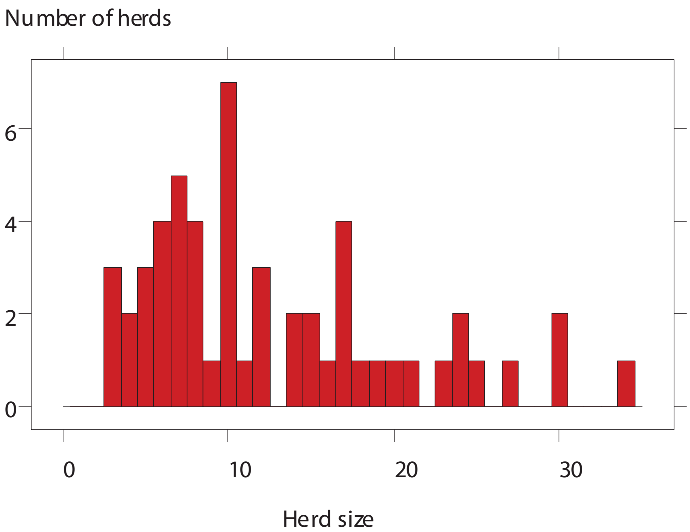
3 Cattle results

3.1 Herd sizes and structure

Herd size

The surveyed cattle herd sizes ranged from 3 to 34 animals, with a mode (most frequent herd size) of 10 animals and a mean of 12.7 animals (Figure 4). All herds bar five were single-household owned: the five multiple household owned herds had 2 (3 cases), 3 or 4 (1 case each) owners. 89% of female cattle and 87% of male cattle were born in the herd.

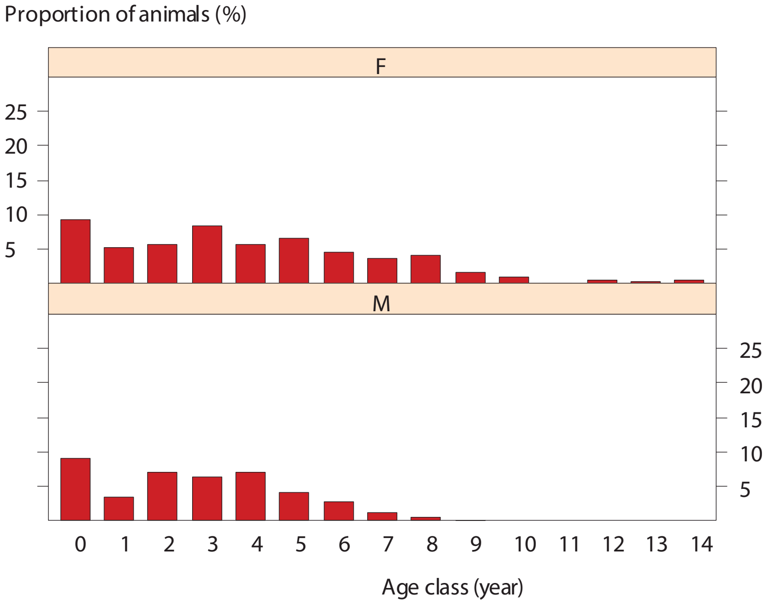
Figure 4. *Distribution of cattle herd sizes*



Age-by-sex structure

The age-by-sex structure is shown in Figure 5. The combined herds comprised 19% calves (≤ 1 year of age), 37% subadults (> 1 and ≤ 4 years of age), 29% adult females and 15% adult males. Overall there were 58% females. The majority of females (95%) were ≤ 10 years of age, and the majority of males (90%) were ≤ 7 years of age. The reasons for the drop in percentage of animals in age classes 1 and 2 are not clear, though possibilities are survey bias due to inaccurate recall, a low number of births the one or two years before the 12 month period, high mortalities in year 0–1, exits of age class 1 animals by loan with return in later years.

Figure 5. *Age-by-sex structure in the surveyed cattle herds for females (F) and males (M)*



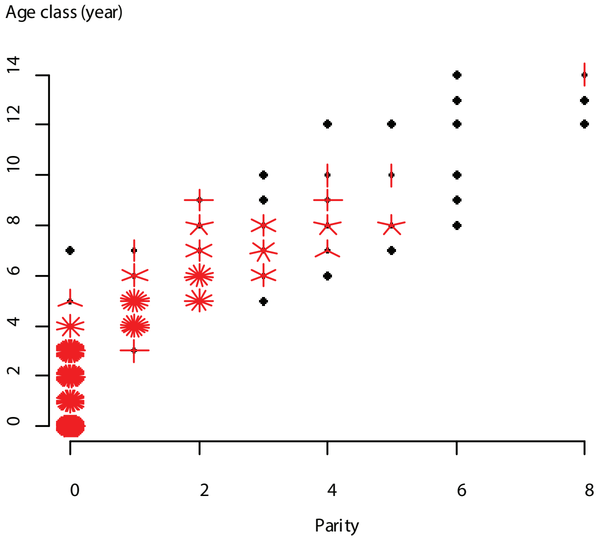
Age class 0 = animals of ≤ 1 year of age, age class 1 = animals > 1 year and ≤ 2 years of age etc.

3.2 Reproduction

Parity in relation to age–class

Figure 6 shows age class vs. parity (i.e. number of births per cow) for the full reproductive history data. The average age at first parturition cannot be accurately determined from these results (as, for example, an animal of parity 1 and current age 6, may have given birth when she was 6, 5 or 4 years old), but it appears the earliest age at first parturition is 4 to 5 years (and very infrequently 3 years). Other studies (Agyemang et al. 1997, Otte and Chilonda 2002) reported an average age of first parturition of 4.0–4.2 years. Animals of second parity were mostly 5 to 6 years of age. There were few animals of higher parity, with the highest parity recorded being 8. Overall the % of females of parity 0, 1, 2, 3, 4 and 5-or-more was 56, 15, 12, 6, 5 and 6%, respectively. It can be noted that in a study of N'Dama cattle raised under extensive management conditions in Southern Senegal, the average age of first calving was reported to be 5 years, with a range of 4 to 9 years (Ezanno et al. 2002).

Figure 6. *Parity in relation to age class for cattle (a sunflower plot where multiple points are shown as 'petals')*

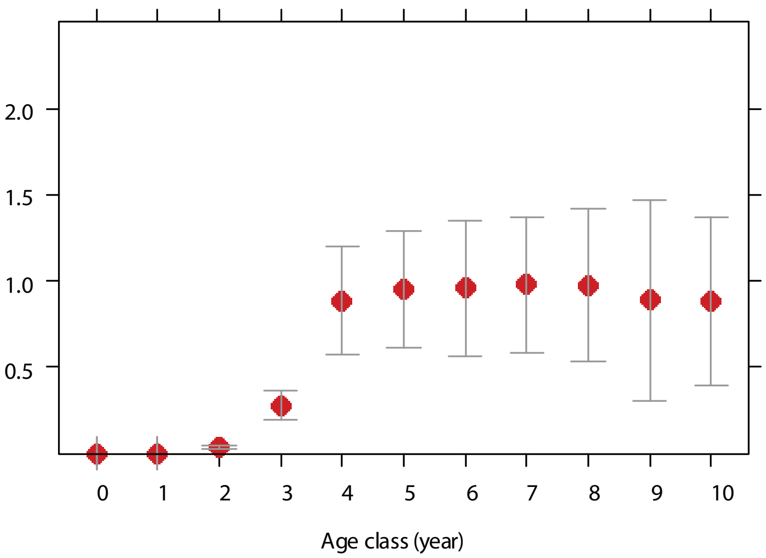


Age class 0 = animals of ≤ 1 year of age, age class 1 = animals > 1 year and ≤ 2 years of age etc. Cattle of age class > 8 were discarded due to the potential unreliability of this data.

Parturition rates

Parturition rate by age class for the 12-month data is shown in Figure 7. It should be noted that from the age group >4 to > 10 years the parturition rate remains relatively constant.

Figure 7. *Annual parturition rates of female cattle, with 95% confidence intervals indicated*



Age class 0 = zero refers to animals of ≤ 1 year of age, age class 1 = one refers to animals > 1 year and ≤ 2 years of age etc. Cattle of age class > 10 were combined into age class 10.

Estimates of annual parturition rates, for both the 12-month data for females ≥ 3 and 4 years of age and the complete reproductive history of the females, are presented in Table 3. The estimates using the 12-month retrospective resulted in a higher parturition rate (and thus short interval between parturitions) than the lifetime reproductive history data. The parturition rate of 0.94, estimated for females ≥ 4 years of age, is higher than that previously estimated. In comparison, Agyemang et al. 1997 found an average parturition rate at 0.54, while Ba et al. 2011 found the parturition rate to be 0.72 for herds with 1–5 cows and 0.51 for herds with 6–19 cows. In the South Senegal study (Ezanno et al. 2002) the average interval between parturitions was reported as 27 months, corresponding to an annual parturition rate of 0.44.

Table 3. Various estimates of the annual parturition rates for female cattle

Data	Annual parturition rate (standard error)	Interval between parturitions, in days[3] (years)
12 month, all females ≥ 3 years of age[1]	0.79 (0.06)	462 (1.27)
12 month, all females ≥ 4 years of age[1]	0.94 (0.08)	388 (1.06)
Lifetime reproductive history of females[2]	0.41 (0.02)	890 (2.43)

1. Average annual rate of parturition based on number of parturitions of all females ≥3 or 4 years during the last 12 months.
2. Average annual rate of parturition based on total number of parturitions of all females born in herd, and ≤ 9 years of age.
3. 365/parturition rate.

Other reproductive parameters

Estimates of other reproductive parameters (i.e. abortion, stillbirth, prolificacy and fecundity rates) are given in Table 4. Of note is that the abortion rate is low (at 0.03), the stillbirth rate moderate (at 0.07) and that the prolificacy rate was 1.0 as all parturitions were single births.

Table 4. Estimates of abortion, stillbirth, prolificacy and fecundity rates of cattle (standard errors)

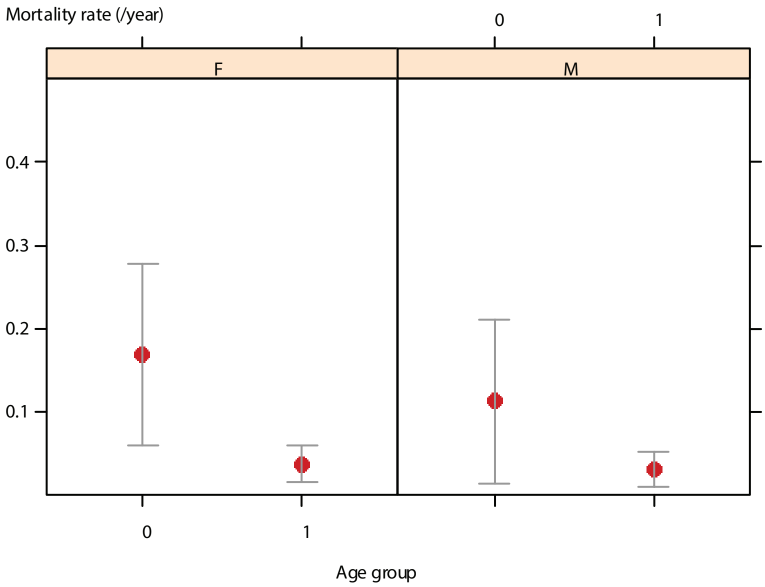
Parameter	Data source	Value
Annual abortion rate	12 month, all females ≥ 3 years of age1	0.03 (0.01)
	12 month, all females ≥ 4 years of age1	0.03 (0.01)
	Lifetime reproductive history of females2	0.03 (0.01)
Stillbirth rate	12 month	0.07 (0.02)
Prolificacy rate	12 month	1.00 (0.00)
Net prolificacy rate	12 month	0.93 (0.02)
Annual fecundity rate	12 month, all females ≥ 3 years of age	0.79 (0.06)
Annual net fecundity rate	12 month, all females ≥ 3 years of age	0.74 (0.06)

1. Average annual rate of abortion based on number of parturitions of all females ≥3 or 4 years during the last 12 months.
2. Average annual rate of abortion based on total number of parturitions of all females born in herd, and ≤ 9 years of age.

3.3 Natural mortality

The mortality rates are shown in Figure 8, and also given in Table 5 in section 3.4. The mortality rates were moderately high for females and males ≤ 1 year of age (at 0.17 and 0.11, respectively), but low for older animals (at 0.04 for females and 0.03 for males). The overall mortality rate was 0.05, meaning that for a herd with a constant size of 10 animals over the year, 0.5 natural deaths would be expected annually. This is similar to other results of cattle mortality in The Gambia (Agyemang et al. 1997), southern Mali (Ba et al. 2011) and sub-Saharan Africa (Otte and Chilonda 2002) which ranged from an overall mortality of 6–8% and a calf (≤ 1 year of age) mortality of 13–22%. It should be noted that the instantaneous hazard rates given here differs from the overall probability of a natural death (see appendix 1), which is frequently used as an indication of mortality in literature. The difference between these rates are greater the higher the rate. At the rates found for cattle mortality in this study there is little difference between the hazard rate and the probability.

Figure 8. *Annual mortality rates for natural death of cattle, for females (F) and males (M), with 95% confidence intervals indicated*



Age group 0 = animals ≤ 1 year of age, and age group 1 = animals > 1 year.

3.4 Offtake and intake

Offtake rates

Overall offtake rates, as well as offtake rates by individual events (i.e. slaughtering, sales/barter, loans /contracts, gifts/dowry, withdrawal/theft) are given in Table 5. Rates of natural death (mortality) are included in this table for comparison purposes. The overall rate of annual offtake was 0.14, meaning that for a herd with a constant size of 10 animals over the year, 1.4 exits would be expected annually. This is similar to the offtake observed by Ba et al. (2011) in mixed crop–livestock systems in southern Mali, who found an overall offtake rate of 0.11. The single most important offtake event was sale/barter, particular for males of > 1 year of age. The main reasons for sale of animals were 'ordinary' (27%) and 'emergency lack of feed' (73%). For animals ≤ 1 year the only offtake recorded was due to withdrawal/theft.

Table 5. Annual offtake rates (standard errors) for cattle, for different offtake events[1]

Sex	Age	Offtake events						Natural death
		Slaughter	Sales, barters	Loans, contracts	Gift, dowry	Withdrawal, theft	Overall	
Female	≤ 1 year	0	0	0	0	0.04 (0.03)	0.04 (0.03)	0.17 (0.06)
	> 1 year	0.02 (0.01)	0.06 (0.01)	0	0.02 (0.01)	0.01 (0.01)	0.12 (0.02)	0.04 (0.01)
Male	≤ 1 year	0	0	0	0	0	0	0.11 (0.05)
	> 1 year	0.01 (0.01)	0.15 (0.03)	0.01 (0.01)	0.02 (0.01	0.03 (0.01)	0.23 (0.03)	0.03 (0.01)
Overall		0.02 (0.01)	0.08 (0.01)	0.01 (0.01)	0.02 (0.01)	0.02 (0.01)	0.14 (0.02)	0.05 (0.01)

1. Effect of offtake rates not included see Lesnoff et al. (2010b).

Intake rates

The overall annual intake rate was 0.06, meaning that for a herd with a constant size of 10 animals over the year, 0.6 intake would be expected annually. Table 6 gives a breakdown by event (purchase/barters, loans/contracts, gifts/dowry/inheritance). The main intake event was purchase/barter of animals > 1 year of age. In comparison, Ba et al. (2011) found the overall intake rate to be slightly higher at 0.10, which was mainly due to a higher intake of females and males > 1 year of age.

Table 6. Annual intake rates (standard errors) for cattle, for different intake events

Sex	Age	Intake event			
		Purchases, barters	Loans, contracts	Gift, dowry, inheritance	Overall
Female	≤ 1 year	0	0	0	0
	> 1 year	0.06 (0.01)	0	0	0.07 (0.01)
Male	≤ 1 year	0	0	0	0
	> 1 year	0.06 (0.02)	0	0	0.06 (0.02)
Overall		0.05 (0.01)	0	0	0.06 (0.01)

Net offtake

Table 7 summarizes the annual offtake (excluding withdrawal/theft) and intake rates, combined for all events, by sex and age class. The overall net offtake rate was 0.07, meaning that for a herd with a constant size of 10 animals over the year, a net offtake of 0.7 animals is expected annually. The greatest net-offtake was for males > 1 year of age.

Table 7. Net offtake rates for cattle, as well as the underlying offtake and intake rates (standard errors)

	Female		Male		Total
	≤ 1 year of age	> 1 year of age	≤ 1 year of age	> 1 year of age	
Offtake	0	0.11 (0.02)	0	0.20 (0.03)	0.12 (0.01)
Intake	0	0.07 (0.02)	0	0.06 (0.02)	0.06 (0.01)
Net offtake	0	0.04	0	0.14	0.07

Note that offtake does not include withdrawal/theft

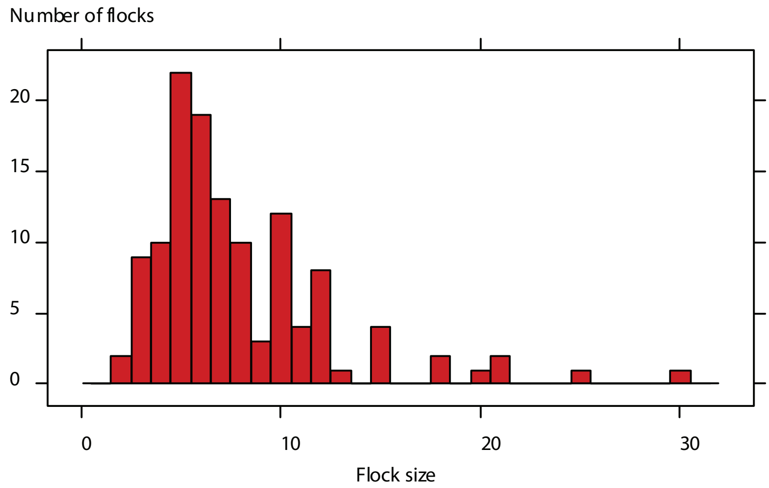
4 Sheep results

4.1 Flock sizes and structure

Flock size

The surveyed sheep flock sizes ranged from 2 to 30 animals. The mode (most frequent flock size) was 5 animals (Figure 9), with a mean flock size of 7.9 animals. Almost all of animals ≤ 1 year of age (98%) were born in the herd, whereas only 84% of females > 1 year of age and 89% of males >1 year of age were born in the flock. All sheep flocks were single household owned.

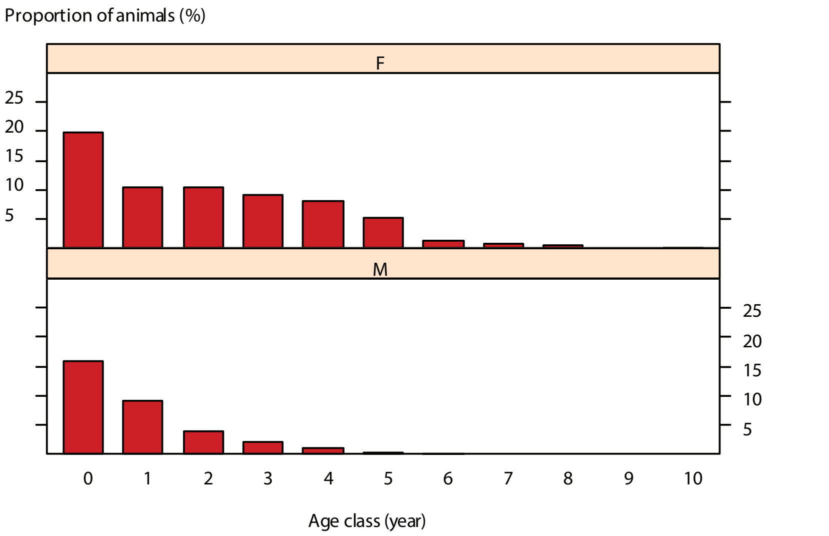
Figure 9. *Distribution of sheep flock size*



Age-by-sex structure

The age-by-sex structure is shown in Figure 10. The combined flocks comprised 20% females ≤ 1 year of age, 16% males ≤ 1 year of age, 47% females > 1 year of age, and 17% males > 1 year of age. Overall there were 67% females. The majority of females (95%) were ≤ 6 years of age, and the majority of males (98%) were ≤ 5 years of age. The drop in percentage of males with increasing age class can largely be attributed to sales.

Figure 10. *Age-by-sex structure in the surveyed sheep flocks for females (F) and males (M)*



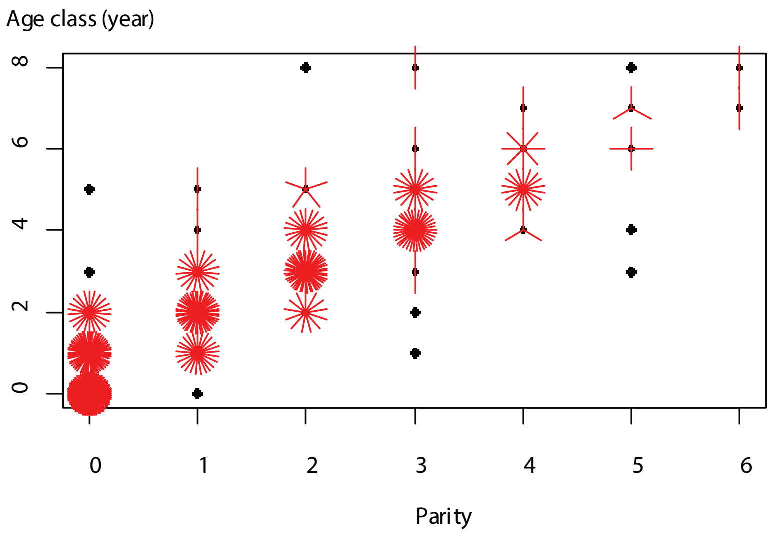
Age class 0 = animals of ≤ 1 year of age, age class 1 = animals > 1 year and ≤ 2 years of age etc.

4.2 Reproduction

Parity in relation to age-class

Figure 11 shows age class vs. parity for the full reproductive history data. The average age of first parturition cannot be determined from this data, but the earliest age at first parturition appears to be 1–2 years. Other studies of sheep in Senegal (Wilson 1991) and sub-Saharan Africa (Otte and Chilonda 2002) report an average age of first parturition at 1.3–1.4 years. Animals of second parity are mostly 3 years of age, and animals of third parity mostly 4 years of age. There were few animals of parity 4 and beyond.

Figure 11. *Parity in relation to age class for sheep (a sunflower plot where multiple points are shown as 'petals')*

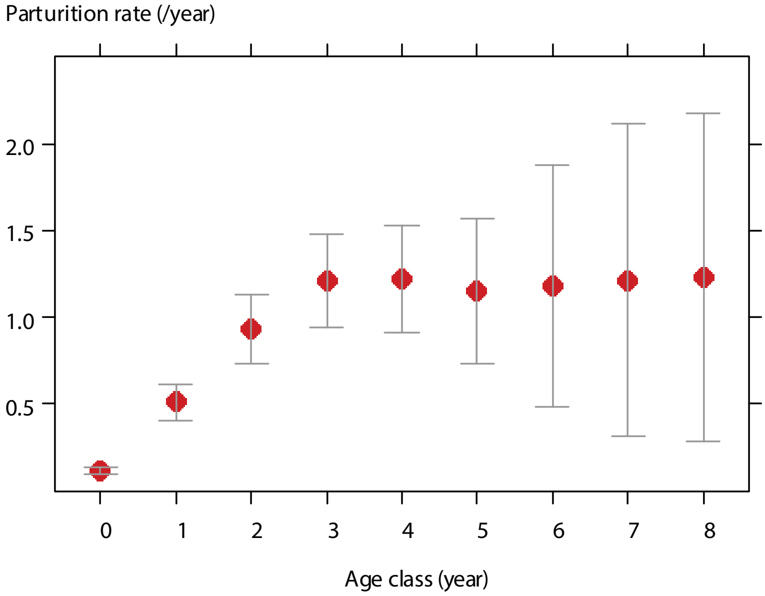


Age class 0 = animals of ≤ 1 year of age, age class 1 = animals > 1 year and ≤ 2 years of age etc. Sheep of age class > 8 were discarded due to the potential unreliability of this data.

Parturition rates

Figure 12 shows parturition rate by age class for the 12 month data. The main increase in the annual parturition rate is seen from 0 to 3 years of age, after which it stabilizes.

Figure 12. Annual parturition rates of female sheep, with 95% confidence intervals indicated



Age class 0 = animals of ≤ 1 year of age, age class 1 = animals > 1 year and ≤ 2 years of age etc. Sheep of age class > 8 were combined into age class 8.

Estimates of annual parturition rates, both for the 12 month data for females ≥ 1, 2, and 3 years of age and the complete reproductive history of the females, are presented in Table 8. The estimates using the 12 month data were sensitive to the minimum age chosen for reproductive females. The complete reproductive history gave the lowest estimate. This difference may be due to differences in year effect, or due to biases created from using a recall survey method. In comparison, the parturition rate was found to be 1.36–1.50 in Senegal (Wilson 1991).

Table 8. Various estimates of the annual parturition rates for female sheep

Data	Annual parturition rate (standard error)	Interval between parturitions, in days[3] (years)
12 month, all females ≥ 1 years of age[1]	0.96 (0.05)	380 (1.04)
12 month, all females ≥ 2 years of age[1]	1.12 (0.07)	326 (0.89)
12 month, all females ≥ 3 years of age[1]	1.20 (0.09)	304 (0.84)
Lifetime reproductive history of females[2]	0.65 (0.01)	561 (1.54)

1. Average annual rate of parturition based on number of parturitions of all females ≥1, 2 or 3 years during the last 12 months.
2. Average annual rate of parturition based on total number of parturitions of all females born in herd, and ≤ 8 years of age.
3. 365/parturition rate.

Other reproductive parameters

Estimates of other reproductive parameters (i.e. abortion, stillbirth, prolificacy and fecundity rates) are given in Table 9. Of note is that the abortion rate was low to moderate (at 0.04 to 0.08), the stillbirth rate moderate (at 0.09) and that the prolificacy rate was 1.31 due to some twin (and a few instances of triple) births.

Table 9. Estimates of abortion, stillbirth, prolificacy and fecundity rates of sheep (standard errors)

Parameter	Data source	Value
Annual abortion rate	12 month, all females ≥ 1 years of age[1]	0.04 (0.01)
	12 month, all females ≥ 2 years of age[1]	0.05 (0.01)
	12 month, all females ≥ 3 years of age[1]	0.06 (0.01)
	Lifetime reproductive history of females[2]	0.08 (0.01)
Stillbirth rate	12 month	0.09 (0.01)
Prolificacy rate	12 month	1.31 (0.03)
Net prolificacy rate	12 month	1.19 (0.03)
Annual fecundity rate	12 month, all females ≥ 2 years of age	1.47 (0.07)
Annual net fecundity rate	12 month, all females ≥ 2 years of age	1.33 (0.07)

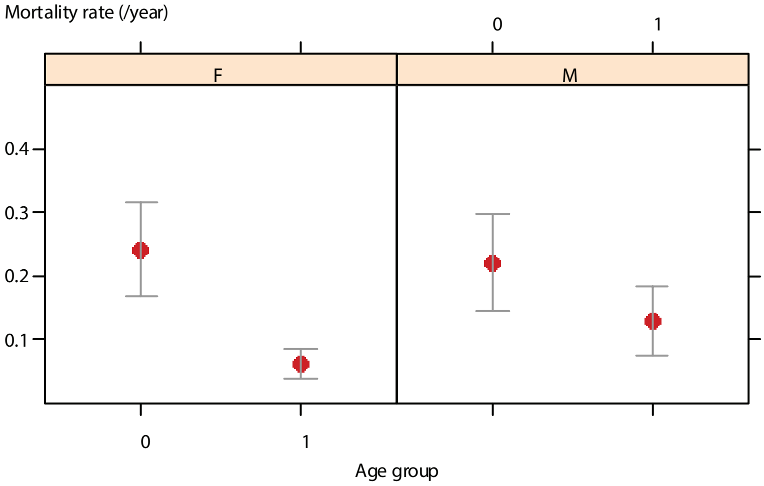
1. Average annual rate of abortion based on number of parturitions of all females ≥1,2 or 3 years during the last 12 months.

2. Average annual rate of abortion based on total number of parturitions of all females born in the flock, and ≤ 8 years of age.

4.3 Natural mortality

The mortality rates are shown in Figure 13, and also given in Table 10 in section 4.4. The mortality rate was high for females and males ≤ 1 year of age (0.24 and 0.22, respectively), moderately high for males > 1 year of age (0.13) and moderate for females > 1 year of age (0.06). Overall, the mortality rate was 0.13, meaning that for a flock with a constant size of 5 animals over the year, 0.65 deaths would be expected annually. In comparison, the annual mortality rates observed by Lesnoff (1999) in north Senegal was 0.10 for females and 0.15 for males, over all age classes. Recalculated to probabilities[1] the mortality rate of natural death was 0.21–0.22 for lambs and 0.06 for females > 1 year of age. These estimates are similar to the 26% lamb and 8% ewe mortality reported by Otte and Chilonda (2002) for sub-Saharan Africa.

Figure 13. *Annual mortality rates for natural death of sheep, for females (F) and males (M), with 95% confidence intervals*



Age group 0 = animals ≤ 1 year of age, and age group 1 = animals > 1 year.

4.4 Offtake and intake

Offtake rates

The overall offtake rates, as well as the offtake rates by individual events (slaughtering, sales/barter, loans/contracts, gifts/dowry, withdrawal/theft) are given in Table 10. Rates of natural death (mortality) are included in this table for comparison purposes. The overall rate of annual offtake was 0.20, meaning that for a flock with a constant size of 5

1. Effect of offtake rates not included see Lesnoff et al. (2010b).

animals over the year, 1.0 exits would be expected annually. The highest offtake rate was for natural death followed by sales. The main reasons for sale of animals were 'emergency lack of feed' (83%), with relative few animals sold for other reasons ('emergency disease' 8%, 'ordinary' 6%, and 'emergency traumatism' 3%).

Table 10. Annual offtake rates (standard errors) for sheep, for different offtake events

Sex	Age	Offtake event						Natural death
		Slaughter	Sales, barters	Loans, contracts	Gift, dowry	Withdrawal, theft	Overall	
Female	≤ 1 year	0.01 (0.01)	0.02 (0.01)	0	0	0.04 (0.02)	0.07 (0.02)	0.24 (0.04)
	> 1 year	0.03 (0.01)	0.08 (0.01)	0.01 (0.01)	0.01 (0.01)	0.02 (0.01)	0.15 (0.02)	0.06 (0.01)
Male	≤ 1 year	0	0.05 (0.02)	0	0.01 (0.01)	0.05 (0.02)	0.10 (0.03)	0.22 (0.04)
	> 1 year	0.16 (0.03)	0.36 (0.05)	0.02 (0.01)	0	0.03 (0.01)	0.58 (0.06)	0.13 (0.03)
Overall		0.04 (0.01)	0.11 (0.01)	0.01 (0.01)	0.01 (0.01)	0.03 (0.01)	0.20 (0.02)	0.13 (0.01)

Intake rates

The overall rate of annual intake was 0.07, meaning that for a flock with a constant size of 5 animals over the year, 0.15 intakes would be expected annually. Table 11 gives a breakdown of input rate by event (i.e. purchase/barters, loans/contracts, gifts/dowry/inheritance). The main reason for intake was through purchase/barter.

Table 11. Annual intake rates (standard errors) for sheep, for different intake events

Sex	Age	Intake event			
		Purchases, barters	Loans, contracts	Gift, dowry, inheritance	Overall
Female	≤ 1 year	0.01 (0.01)	0	0	0.01 (0.01)
	> 1 year	0.10 (0.02)	0	0.01 (0.01)	0.11 (0.02)
Male	≤ 1 year	0.01 (0.01)	0	0	0.01(0.01)
	> 1 year	0.04 (0.02)	0.01 (0.01)	0.01 (0.01)	0.06 (0.02)
Overall		0.06 (0.01)	0.003 (0.002)	0.004 (0.002)	0.07 (0.01)

Net offtake

Table 12 summarizes the overall annual offtake and intake rates by sex and age class, where offtake excludes withdrawal/theft. The highest rate of net offtake (at 0.55) was for males > 1 year of age: from Table 10 it can be observed that this is primarily through sales/barter. The total net offtake rate was 0.11, meaning that for a flock with a constant size of 5 animals over the year, a net offtake of 0.55 animal is expected annually.

Table 12. Net offtake rates for sheep, as well as the underlying offtake and intake rates (standard errors)

	Female		Male		Total
	≤ 1 year of age	> 1 year of age	≤ 1 year of age	> 1 year of age	
Offtake	0.03 (0.01)	0.13 (0.02)	0.06 (0.02)	0.55 (0.06)	0.18 (0.01)
Intake	0.01 (0.01)	0.11 (0.02)	0.01 (0.01)	0.06 (0.02)	0.07 (0.01)
Net offtake	0.01	0.02	0.05	0.49	0.11

Note that offtake does not include withdrawal/theft.

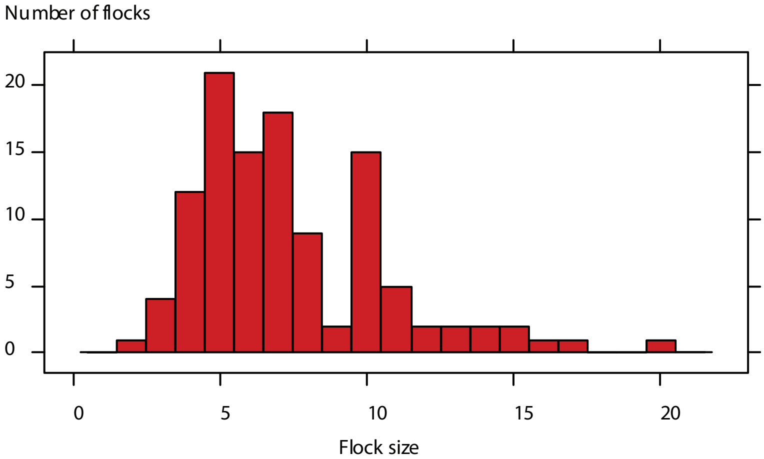
5 Goat results

5.1 Herd sizes and structure

Herd size

The surveyed goat herd sizes ranged from 2 to 20 animals, with a mode (most frequent herd size) of 5 animals (Figure 14) and a mean herd size of 7.5 animals. Almost all males and females ≤ 1 year of age were born in to the herd (98% and 97%, respectively), whilst 90% of males > 1 year of age and 76% of females > 1 year of age were born into the herd. All goat herds were single household owned.

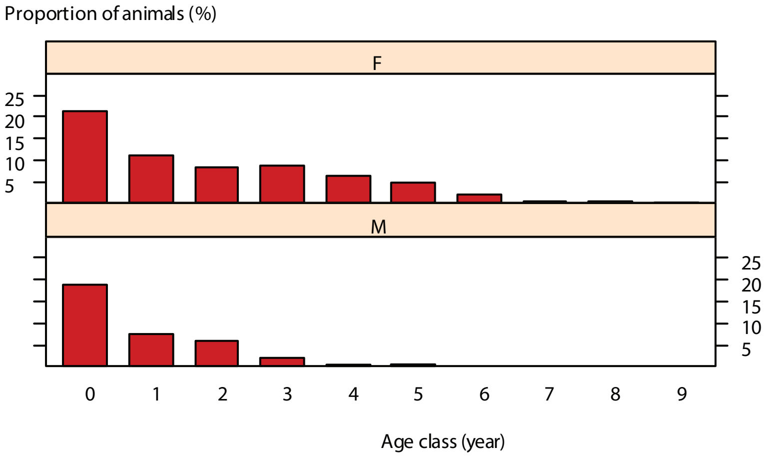
Figure 14. *Distribution of goat herd size*



Age-by-sex structure

The age-by-sex structure is shown in Figure 15. The combined flocks comprised 21% females ≤ 1 year of age, 19% males ≤ 1 year of age, 43% females > 1 year of age, and 17% males > 1 year of age. Overall there were 64% females. The majority of females (95%) were ≤ 6 years of age, and the majority of males (95%) were ≤ 4 years of age. The rapid decline in the percentage of males in early age classes is largely attributed to the high number of natural deaths of males 0 to 2 years old (age classes 0 and 1), and the high number of sales of males 1 to 3 years old (age classes 1 and 2).

Figure 15. *Age-by-sex structure in the surveyed goat herds for females (F) and males (M)*



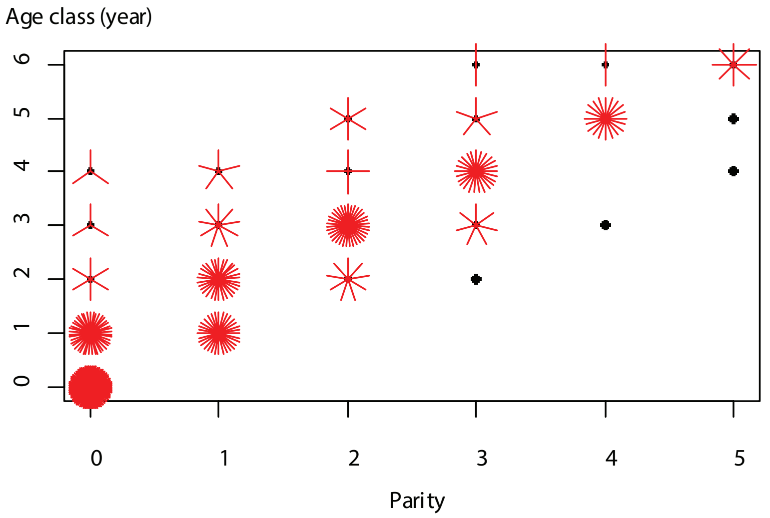
Age class 0 = animals of ≤ 1 year of age, age class 1 = animals > 1 year and ≤ 2 years of age etc.

5.2 Reproduction

Parity in relation to age-class

Figure 16 shows age class vs. parity for the full reproductive history data. The average age at first parturition cannot be determined from this study, but the earliest age at first parturition appears to be 1 to 2 years. Other studies gave an average age of first parturition of 1.0 year in Senegal (Wilson 1991) and 1.3 years in sub-Saharan Africa (Otte and Chilonda 2002). Animals of second parity are mostly 3 years of age, and animals of third parity mostly 4 years of age. There were few animals of parity 4 and beyond.

Figure 16. *Parity in relation to age class for goat (a sunflower plot where multiple points are shown as 'petals')*

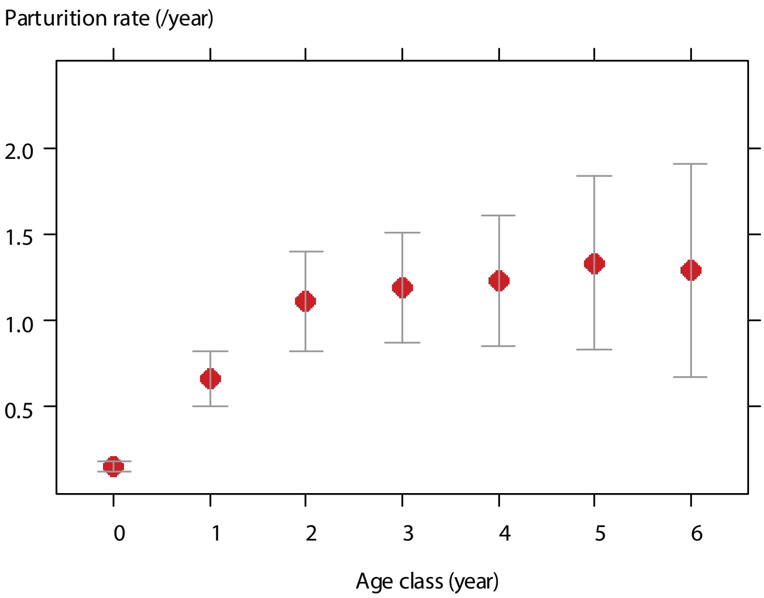


Age class 0 = animals of ≤ 1 year of age, age class 1 = animals > 1 year and ≤ 2 years of age etc. Age class > 6 were discarded due to the potential unreliability of this data.

Parturition rates

Figure 17 shows parturition rate by age class for the 12 month data. The main increase in the annual parturition rate is seen from 0 to 3 years of age, after which it stabilizes.

Figure 17. *Annual parturition rates of female goat, with 95% confidence intervals indicated*



Age class 0 = animals of ≤ 1 year of age, age class 1 = animals > 1 year and ≤ 2 years of age etc. Goat of age class > 6 were combined into age class 6.

Estimates of annual parturition rates, for both the 12 month data for females ≥ 1, 2, and 3 years of age respectively and for the complete reproductive history of the females, are presented in Table 13. The estimates using the 12 month data were sensitive to the minimum age chosen for reproductive. The complete reproductive history gave a much lower estimate. This difference may be due to differences in year effect or due to biases created from using a recall survey method. In comparison the parturition rate was observed to be 1.4–1.6 for WAD goats in Senegal (Wilson 1991).

Table 13. Various estimates of the annual parturition rates for female goat

Data	Annual parturition rate (standard error)	Interval between parturitions, in days (years)[3]
12 month, all females ≥ 1 years of age[1]	1.06 (0.07)	344 (0.94)
12 month, all females ≥ 2 years of age[1]	1.20 (0.09)	304 (0.83)
12 month, all females ≥ 3 years of age[1]	1.24 (0.11)	294 (0.81)
Lifetime reproductive history of females[2]	0.68 (0.02)	536 (1.47)

1. Based on number of parturitions of all females ≥1, 2 or 3 years during the last 12 months.
2. Based on total number of parturitions of all females born in herd, and ≤ 6 years of age.
3. 365/parturition rate.

Other reproductive parameters

Estimates of other reproductive parameters (i.e. abortion, stillbirth, prolificacy and fecundity rates) are given in Table 14. Of note is that the abortion rate was low to moderate (at 0.04 to 0.07), the stillbirth rate moderate (at 0.09) and that the prolificacy rate was 1.43 due to a number of twin (and a few instances of triple) births.

Table 14. Estimates of abortion, stillbirth, prolificacy and fecundity rates of goat (standard errors)

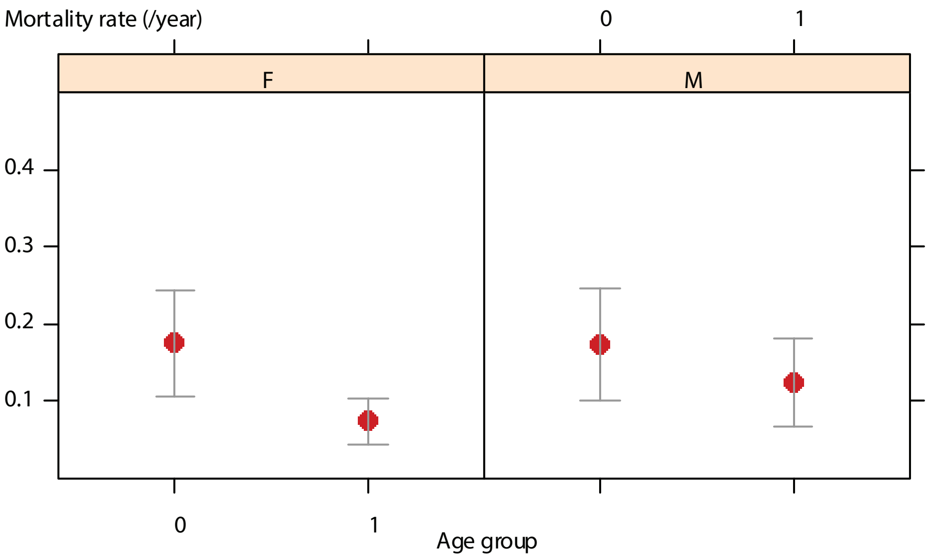
Parameter	Data source	Value
Annual abortion rate	12 month, all females ≥ 1 years of age[1]	0.04 (0.01)
	12 month, all females ≥ 2 years of age[1]	0.05 (0.01)
	12 month, all females ≥ 3 years of age[1]	0.07 (0.01)
	Lifetime reproductive history of females[2]	0.05 (0.01)
Stillbirth rate	12 month	0.09 (0.01)
Prolificacy rate	12 month	1.43 (0.03)
Net prolificacy rate	12 month	1.19 (0.03)
Annual fecundity rate	12 month, all females ≥ 2 years of age	1.72 (0.09)
Annual net fecundity rate	12 month, all females ≥ 2 years of age	1.43 (0.09)

1. Average annual rate of abortion based on number of parturitions of all females ≥1, 2 or 3 years during the last 12 months.
2. Average annual rate of abortion based on total number of parturitions of all females born in the flock, and ≤ 8 years of age.

5.3 Natural mortality

The mortality rates are shown in Figure 18, and Table 15 in section 5.4. The mortality rates were moderately high for females and males ≤ 1 year of age (0.18), moderately high for males > 1 year of age (0.13) and moderate females > 1 year of age (0.07). The overall mortality rate was 0.12, meaning that for a flock with a constant size of 5 animals over the year, 0.6 deaths would be expected annually. This is lower than the 24–28% kid mortality (corresponding to a hazard rate of 0.28 to 0.33) and 14–16% adult mortality (corresponding to a hazard rate of 0.15 to 0.18) found in other studies in Mali (Ba et al. 1996) and sub-Saharan Africa (Otte and Chilonda 2002).

Figure 18. *Annual mortality rates for natural death of goats, for females (F) and males (M), with 95% confidence intervals indicated*



Age group 0 = animals ≤ 1 year of age, and age group 1 = animals > 1 year.

5.4 Offtake and intake

Offtake rates

Overall offtake rates, as well as offtake rates by individual events (i.e. slaughtering, sales/barter, loans /contracts, gifts/dowry, withdrawal/theft) are given in Table 15. Rates of natural death (mortality) are included in this table for comparison purposes. The overall rate of annual offtake was 0.20, meaning that for a flock with a constant size of 5 animals over the year, 1.0 exits would be expected annually. The highest offtake rate was for sale/barter animals, followed by slaughter. The main reasons for sale of animals were 'ordinary' (71%) followed by emergency disease (29%). The main reasons for slaughter of animals were 'emergency lack of feed' (82%) followed by 'emergency disease' (18%). It is of note that the rate for sale is about that of the mortality rate.

Table 15. Annual offtake rates (standard errors) for goats, for different offtake events

Sex	Age	Offtake event						Natural death
		Slaughter	Sales, barters	Loans, contracts	Gift, dowry	Withdrawal, theft	Overall	
Female	≤ 1 year	0	0	0	0	0.04 (0.02)	0.04 (0.02)	0.18 (0.04)
	> 1 year	0.04 (0.01)	0.07 (0.02)	0	0.02 (0.01)	0.01 (0.01)	0.15 (0.02)	0.07 (0.02)
Male	≤ 1 year	0	0.03 (0.02)	0	0	0	0.03 (0.02)	0.18 (0.04)
	> 1 year	0.19 (0.04)	0.33 (0.05)	0	0.04 (0.02)	0.05 (0.02)	0.61 (0.06)	0.13 (0.03)
Overall		0.06 (0.01)	0.11 (0.01)	0	0.02 (0.01)	0.02 (0.01)	0.20 (0.02)	0.12 (0.01)

Intake rates

The overall rate of annual intake was 0.09, meaning that for a flock with a constant size of 5 animals over the year, 0.45 intakes would be expected annually. Table 16 gives a breakdown of input rate by event (i.e. purchase/barters, loans/contracts, gifts/dowry/inheritance). The major intake event was purchase/barter of animals.

Table 16. Annual intake rates (standard errors) for goats, for different intake events

Sex	Age	Intake event			Overall
		Purchases, barters	Loans, contracts	Gift, dowry, inheritance	
Female	≤ 1 year	0.04 (0.02)	0	0.02 (0.01)	0.06 (0.02)
	> 1 year	0.14 (0.02)	0	0.01 (0.01)	0.15 (0.02)
Male	≤ 1 year	0.02 (0.01)	0	0	0.02 (0.01)
	> 1 year	0.04 (0.02)	0.01 (0.01)	0.01 (0.01)	0.05 (0.02)
Overall		0.08 (0.01)	0	0.01 (0.01)	0.09 (0.02)

Net offtake

Table 17 summarizes the annual offtake (excluding withdrawal/theft) and intake rates, combined for all events, by sex and age class. The highest rate of net offtake (at 0.56) was for males > 1 year of age: from Table 15 it can be observed that this is primarily through sales/barter as well as slaughter. For females there was a net intake of animals (as observed from the negative net offtake). The overall net offtake rate was 0.09, meaning that for a flock with a constant size of 5 animals over the year, a net offtake of 0.45 animals is expected annually.

Table 17. Net offtake rates for goats, as well as the underlying offtake and intake rates (standard errors)

	Female		Male		Total
	≤ 1 year of age	> 1 year of age	≤ 1 year of age	> 1 year of age	
Offtake	0 (0)	0.14 (0.02)	0.03 (0.02)	0.56 (0.06)	0.18 (0.02)
Intake	0.06 (0.02)	0.15 (0.02)	0.02 (0.01)	0.05 (0.02)	0.09 (0.01)
Net offtake	–0.06	–0.01	0.02	0.51	0.09

Note that offtake does not include withdrawal/theft.

6 Discussion

The purposes of this survey were: i) to estimate demographic parameters for herds/flocks in the PROGEBE-Guinea project sites, which combined with other information sources, could be used for prioritizing project interventions; ii) compare demographic productive parameters between ERL and non-ERL; and iii) to be used as a baseline for evaluating impacts of project interventions. The survey was not designed to evaluate demographic productivity parameters over the long-term, which should be kept in mind when reading the discussion. For validation of the results and evaluation of demographic productivity parameters over the long-term, a long-term longitudinal survey is recommended.

The major results found and their implication for prioritizing future project interventions are discussed, as well as the suitability of using the data as a baseline for evaluating impact of project interventions. Due to the absence of non-ERL found within the surveyed sites, a comparative analysis of ERL and non-ERL demographic parameters was not possible. However, the implications of this finding on project priorities and future breeding strategies are discussed in brief.

6.1 Key demographic parameters

The most striking result is the moderately high to high annual mortality rates observed for animals ≤ 1 year of age (0.11 to 0.24, depending on species and sex). In addition the mortality rate of small ruminants > 1 year of age was also of concern (0.06 to 0.13). It is thus suggested that addressing these mortality rates should be one of PROGEBE's priority interventions. The reasons behind the observed mortality rates will have to be investigated further. However, in the short to medium term (next few to 20 years) the mortality rates are likely best addressed through changes to management practices, such as the increased use of dewormers particularly for small ruminants.

Another noteworthy result is the range in age at first parturition, which was typically from > 4 to ≤ 6 years for cattle, > 2 to ≤ 3 years for sheep, and > 1 to ≤ 3 years for goats. In comparison other studies (Wilson 1991; Otte and Chilonda 2002; Ba et al. 2011) give estimates of 4.0–4.2 years found for cattle and 1.0–1.4 found for small ruminants. Whilst not investigated here, it is reasonable to assume that this is primarily due to differences in management practices. In contrast, the intervals between parturition estimated here were similar to that reported previously. Interventions to decrease the age at first calving/lambing/kidding (e.g. feed supplementation) should also be considered as a potential PROGEBE intervention.

The abortion rate was found to be low to moderate, at 0.03 for cattle and 0.05 for the small ruminants. Stillbirth rates were higher at 0.07 for cattle and 0.09 for small ruminants. Abortion in sheep and goats in the humid tropics of West Africa have been found to mainly be associated with starvation and diseases (Oppong 1988). Improved management of feed resources and diseases (for all species) in order to decrease the abortion and stillbirth rate should therefore also be considered.

In the much longer term (20 to 50 years) it may be possible to reduce mortality and increase reproductive performance of the animals through a breeding program (as well as positively influence other traits of interest such as growth rate and milk production). Caution needs to be taken, however, for interventions targeting a shorter

parturition interval, as due to lactation anoestrous a shorter milking period resulting in the need to supplement young animals may result. Note that a long-term approach to any within-breed improvement program is essential, as within a typical breeding nucleus only about a 1 to 3% change in mean performance can be affected per annum (Falconer and Mackay-Longman 1996) and, should a tiered breeding structure be utilized, the average genetic merit of animals in the lower tiers will lag behind the average genetic merit of animals in the nucleus.

6.2 Findings on existing breeding strategies and their implications

All three ERL had animals not born within the herd/flock, with intake rates of 0.6 to 0.9 depending on species. There was a particularly high intake of female goats > 1 year of age (with an intake rate of 0.14). The use of 'outside' animals as breeding animals is important to keep the rate of inbreeding to an acceptable level (inbreeding is caused by the mating of relatives and typically results in reduced fitness and reproductive ability) and should therefore be encouraged.

Furthermore, it was found that adult males (> 4 years of age for cattle, and > 1 year of age for small ruminants) comprised 15–17% of the herds/flocks (depending on species), which suggests that controlled breeding is used across species. It is, however, uncertain whether the males remaining in the flock are genetically superior, or whether the genetically superior males are sold (as e.g. they can fetch higher market prices due to corresponding phenotypic superiority) leaving the inferior males as breeding animals.

In addition, it was found that the main exit event was sale/barter (0.08, 0.11 and 0.11 for cattle, sheep and goats, respectively), while slaughter of animals was limited for cattle (0.02) and higher, but still secondary to sale/barter, for sheep and goats (0.04 and 0.06, respectively). This indicates that domestic consumption is not a priority for cattle and a low priority for the small ruminants, and this should be taken into consideration when designing PROGEBE interventions.

The PROGEBE-Guinea household survey (ILRI 2011) further indicated that knowledge and use of breeding strategies is low. Capacity building programs on basic principles and practices of breeding, as well as management practices to reduce mortality and improve other key parameters, are thus recommended to improve awareness of traditional and alternate breeding and management practices on livestock performance.

The finding that all ruminant livestock within the surveyed sites were ERL indicates that the populations of ERL in the project intervention sites are currently not marginalized due to the introduction of non-ERL.

6.3 Considerations for use of survey data

The demographic parameters presented here should only be used as baseline parameters for PROGEBE with extreme care as they relate to a particular 12 month interval, which is subject to a particular set of environmental conditions. If a follow-up survey is performed in a year rated different to the baseline year it may be difficult to estimate the impact of project interventions. For example, if project interventions have had a positive impact on the demographic parameters reported here, but a follow-up survey is performed in an unusually poor year, the parameters will (artifactually) appear to have either stayed the same or become worse. Conversely, if project interventions have had no impact on the demographic parameters reported here, but a follow-up survey is performed in an unusually good year, the parameters will (artifactually) appear to have improved.

The demographic parameters estimated here, combined with other data (such as that from the household survey and livestock census), can also be used to model the expected impact of various interventions. For example, for a particular breeding strategy (e.g. with a given nucleus size, number of multiplier units etc.) it is possible to estimate

the percent genetic improvement of the commercial animals in say 10, 20, 30 etc. years. Ideally the per cent genetic improvement would then be translated to a more meaningful indicator such as value to households (e.g. increased income) or value to the livestock industry. Alternatively the model could be used to back-calculate the size of the breeding program required to give a pre-set level of genetic improvement (or improvement in an alternate indicator) in the commercial population within a certain time frame. It is strongly recommended that such an exercise be conducted in the near future to assist in the planning of PROGEBE breeding activities.

7 Conclusions and summary of main recommendations

The findings of this survey clearly indicate that N'Dama cattle, Djallonke sheep, and WAD goats are the prominent breeds in the PROGEBE-Gambia project areas and suggests that some level of controlled breeding seems to be applied in most herds/flocks, primarily through sire selection (although these may or may not be implemented with a specific breeding objective in mind). There seems to be considerable scope for improvement of the mortality rate, as well as particular reproductive parameters such as age at first parturition, through improved herd/flock management in the short term, and possibly breeding strategies in the long term.

Specifically, it can be recommended that PROGEBE consider/prioritize the following issues for future project activities or interventions:

- Interventions towards lowering the natural mortality rates should be prioritized. This should mainly be through changes in management practices in the short to medium-term, for example, by better disease control and improved feed. In the much longer term (20 to 50 years) it may be possible to reduce mortality by genetically improving disease resistance of the animals through a breeding program.

- Interventions to improve reproductive parameters should be prioritized, including age at first parturition. Again, this should mainly be through changes in management practices in the short-term, such as improved feeding, while in the longer term these parameters could potentially be improved through genetic improvement.

- Capacity building programs to improve awareness of traditional and alternate management and breeding practices and the effect these have on livestock production and productivity.

- A modelling study utilizing the demographic parameters estimated here, combined with other data from the household surveys, and literature to determine the expected impact of potential PROGEBE interventions (such as improved healthcare, feeding and/or animal genetic improvement) over different time horizons.

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Appendix 1 Illustrative example of instantaneous hazard rates in relation to this survey

Assume a 12 month retrospective survey, from which we will calculate annual instantaneous hazard rates (referred to as rates below for short). The herd/flock structure, and events happening during the 12 month survey period, are as follows:

Sex, age	Number of animals at the start of the 12 month period	Events (each uniformly distributed across the year)	Number of animals at the end of the 12 month period, i.e. at time of survey
Females ≤ 1 year	3	2 deaths birth of 2 females and 1 male offspring (from females > 1 year)	2 (the 2 females born)
Females > 1 year	6	One adult female purchased	8 (the 6 initial + the 1 remaining young female which is now > 1 year of age + the 1 purchased)
Males ≤ 1 year			1 (the 1 male born)
Males > 1 year	1		1
Total	10		12

The hazard rate (*h*) for a particularly category (sex and age class) is calculated as the number of events (*m*) divided by the time the animals have spent in that category (*T*): $h = m/T$. If all of the above data were available we would calculate *T* as the average of the number of animals in a particular category at the start and end of the 12 month period.

Examples:

- The overall mortality rate is = 2/11 = 0.18, as there were 2 mortalities across all age-sex classes and T = (10 + 12)/2 = 11. Thus for a herd with a constant size of 100 animals over the year, 18 deaths would be expected annually (as 0.18 * 100 = 18).

- The mortality rate for young females is 2/2.5 = 0.80, as there were 2 mortalities of young females, and T = (3 + 2)/2 = 2.5. Thus for a herd with a constant size of 20 young females over the year, 16 deaths of young females would be expected annually (as 0.80 * 20 = 16).

- The overall purchase rate is 1/11 = 0.09, as there was 1 purchase across all age-sex classes and T = (10 + 12)/2 = 11. Thus for a herd with a constant size of 50 animals over the year, 4.50 purchases would be expected annually (as 0.09 * 50 = 4.50).

- The parturition rate for females > 1 year of age is 3/7 = 0.43, as there were 3 births to adult females and T = (6 + 8)/2. Thus for a herd with a constant size of 10 adult females over the year, 4.3 parturitions would be expected annually (as 0.43 * 10 = 4.3)

In reality, however, the number of animals at the start of the 12 month period is not known (as the survey is retrospective and being conducted at the end of the 12 month period). This is thus approximated as 'the number of animals present at the time of the survey – entries over the 12 months + exits over the 12 months'. For the above example, over all sex-age classes, it is:

[12 animals present at time of survey] – [3 births + 1 purchase] + [2 deaths] = 10.

This concept is extended to individual age classes. The number of animals within a particular age class (*i*) at the start of the survey is approximated as 'the number of animals present at the time of survey in age class$_{i+1}$ – 0.5 * (net entries for age class$_i$) – 0.5 * (net entries for age class $_{i+1}$)'. The 0.5 is because we assume that animals enter/exit age classes uniformly throughout the year, thus on average each animal spends half a year in the herd.

Relationship between hazard rates and probabilities

It is important to note that hazard rates are not the same as probabilities. The equation relating hazard rates to probabilities is as follows:

$$p = 1 - \exp(-h * \Delta t),$$

where p is the probability, h the hazard rate, and Δ Δ t the length of the decomposition unit. For example, in this survey an annual instantaneous mortality rate of 0.5, would correspond to an annual probability of death of 0.39, as:

$$p = 1 - \exp(-0.5 * 1) = 0.39.$$

Thus 39% of animals (rather than 50%) would be expected to die within a year.

For more details in relation to this, including theoretical background, see Lesnoff et al. (2010b).

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