12mo

A retrospective method for estimating demographic parameters in tropical ruminant livestock population

Version 3.1

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Executive summary

This document, intended for educational use, is a handbook to be used by researchers, engineers and technicians of national services, development professionals or students dealing with demographic parameters (reproduction, mortality, etc.) of tropical ruminant livestock (cattle, small ruminants and camels). The handbook can be used in various fields such as animal science, genetics, epidemiology, or economy.

Demographic parameters are required for quantifying livestock dynamics and production and for evaluating, ex post or ex ante, impacts of human interventions or environmental risks. These parameters have to be estimated from data collected in the field. In developing countries, this data collection is the most difficult part of the work, due to the dispersion and mobility of herds and the lack of written records on herd demography by farmers. Three main field surveys approaches are used: individual animal monitoring, herd monitoring without individual animal identification, and cross-sectional retrospective surveys.

This handbook concerns the retrospective approach. Although it has been used for long, this approach is little standardized or documented. This limits the good use of the methods and generates important heterogeneities in the protocols used in the field. This also generates difficulties for comparison and interpretation of the different results presented in the published literatures. In this context, the aim of the handbook is to present one of the retrospective methods, referred as “12mo”, in greater detail and propose a formalisation thereof covering the protocol, the survey questionnaires, data entry and analysis

In 12mo, the enumerator’s role is to enumerate the animals in the herd at the time of the survey, and then record the demographic events (births, natural deaths, slaughtering, loans, purchases, etc.) that have occurred in the twelve months preceding the survey. 12mo provides essentially annual results. This method is well-suited to quantifying the demography and productivity of a livestock population at a given moment in time, and to assess the short-term impacts of projects or of unexpected events (drought, disease outbreak, etc.).

12mo focuses on livestock populations in traditional tropical farming systems that are non-intensive and where animal reproduction is subject to little or no control – for instance, when females are not separated from males during the year. It can be used on herds of small or medium size. It does not apply to industrial farms or ranches that handle several hundred animals.

It should be remembered that 12mo, as any retrospective survey, yields approximate results and that such a method cannot fully replace gold standard herd monitoring.

The materials used in the handbook (survey questionnaires, database and calculation routines) are available from the first author.

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Introduction

Demographic parameters such as annual reproductive or death rates are basic data for quantifying the dynamics and production of livestock populations and make *ex post* or *ex ante* assessments of the impact of human intervention (management practices, veterinary treatments, genetic improvements, etc.). They can be studied individually (Lancelot *et al.*, 1995; Lancelot *et al.*, 2002) or used jointly as input parameters in more general mathematical prediction models, in particular models simulating population dynamics (Tacher, 1975a; 1975b; Landais, 1986; Upton, 1989; Baptist, 1992; Itty, 1995; Lesnoff, 1999; 2000; Lesnoff *et al.*, 2001; Hary, 2004a; 2004b; Moulin *et al.*, 2004; Texeira and Paruelo, 2006).

Demographic parameters are estimated from data collected in the field. In developing countries, collecting data is the most difficult part of the work due to the dispersion and mobility of the herds and the fact that farmers do not keep written records about their herds. Three main survey approaches are used in practice (Landais and Sissokho, 1986; Lhoste *et al.*, 1993; Lesnoff *et al.*, 2007b):

- individual animal monitoring (Poivey *et al.*, 1981b; Faugère and Faugère, 1986; Landais and Faugère, 1986; Landais and Sissokho, 1986; CIRAD-IEMVT, 1990; ILCA, 1990; Planchenault, 1990; Faugère *et al.*, 1991; Lhoste *et al.*, 1993; de Leeuw *et al.*, 1995; van Klink *et al.*, 1996; Tillard *et al.*, 1997; Lancelot *et al.*, 1998; Juanès and Lancelot, 1999; Metz and Asfaw, 1999; Lesnoff *et al.*, 2007a);

- herd monitoring without individual animal identification (Berthet-Bondet and Bonnemaire, 1986; Landais and Sissokho, 1986; Huttner *et al.*, 2001; Madani *et al.*, 2002; Bebe *et al.*, 2003);

- retrospective surveys (SEDES, 1975; CIRAD-IEMVT, 1989; ILCA, 1990; Planchenault, 1991; Lhoste *et al.*, 1993).

The present handbook relates on the retrospective approach, which is based on farmers' interviews and their medium- or long-term recall of the herds' demography. Retrospective surveys are generally cross-sectional (one survey lasts roughly one month) but can be repeated over a period of several years. Various interviewing techniques are used to reconstruct the herd demography and the animals' history.

Retrospective approach is well suited for implementing quick diagnostics (Dumas, 1980; Peacock, 1983; CIRADIEMVT, 1988; Planchenault, 1992; Meyer *et al.*, 1997; Bebe *et al.*, 2003). Due to errors arising from farmers' recall (e.g. omission of animals or demographic events for taxes avoidance, cultural reasons or simple forgetfulness), results are more approximate than those provided by gold standard monitoring techniques. Nevertheless, retrospective surveys are less cumbersome and more suitable for surveying migrant herds. Furthermore, they can be rapidly implemented so as to quantify the impact of unpredictable events (drought, disease outbreaks, etc.) and can be used to cover larger areas. They are generally used to identify broad demographic characteristics during decision-making processes, or as exploratory methods to assist research institutions in identifying particular questions worth investigating (Lhoste *et al.*, 1993).

Retrospective surveys have long been used (the earliest document we found describing the retrospective approach goes back to 1975 although it was used prior to that; CIRAD-IEMVT, 1989) but oddly has been the subject of little standardization or documentation. This limits the proper usage of the methods and generates significant variability in the protocols implemented in the field, which in turn makes for difficulties in comparing and interpreting the different results published in the literature.

In this context, our aim is to present one of the retrospective methods in greater detail and propose a formalisation thereof covering the protocol, the survey questionnaires, data entry and analysis.

Among the retrospective methods already used in the past, we chose one that met the main objectives of demographic surveys, referred to as "12mo" in this handbook. Under this method, the enumerator's role is to enumerate the animals in the herd at the time of the survey, and then record the demographic events (births, natural deaths, slaughtering, loans, purchases, etc.) that have occurred in the twelve months preceding the survey. The method was designed and tested in collaboration with AGRHYMET and MRA Niger in the PAD research project "Improved livelihoods in the Sahel through the development and implementation of household level bio-economic decision support systems" coordinated by ICRISAT-Niamey, funded by DGCD-Belgium and located in Niger. One objective was to define a robust method that was simple enough to implement in the field as to be capable of being transferred to local structures (research institutes, technical services, NGOs, etc.). The method needed to be as readily applicable to both small and large ruminants and equally effective in estimating parameters relating to reproduction, mortality, offtake and intake of animals in livestock populations.

12mo focuses on livestock populations in traditional tropical farming systems that are non-intensive and where animal reproduction is subject to little or no control – for instance, when females are not separated from males during the year. It can be used on herds of small or medium size. It does not apply to industrial farms or ranches that handle several hundred animals.

12mo targets the estimation the population's state variables (herd sizes and sex-by-age structure) and demographic rates (Table 1). The demographic rates are those suggested and defined in Lesnoff *et al.* (2007b). The theoretical elements relating to definitions and calculations of demographic parameters for tropical livestock as used in this handbook have been described in Lesnoff *et al.* (2007b) and are not described here in detail. Some reminders are provided in the appendix but they are generally regarded as prerequisites.

12mo is complementary to the "progeny history method" (SEDES, 1975; CIRAD-IEMVT, 1989; Planchenault, 1991; Lhoste *et al.*, 1993; ILCA, 1990). With the latter method, the enumerator has to reconstruct both the complete reproductive career of a sub-sample of females present in the herd and the careers of those females' progeny. The progeny history method provides average results for the five or ten years preceding the survey, sometimes more. In contrast, 12mo provides annual results (the only retrospective calculations going back further than a year relate to the correlation between age of females and the numbers of abortions or parturitions they had in their reproductive life). 12mo is well-suited to quantifying the demography and productivity of a livestock population at a given moment in time, and to assess the short-term impacts of projects or of unexpected events like drought, disease outbreak, etc.

It should be remembered that 12mo, as any retrospective survey, yields approximate results and that such a method cannot fully replace gold standard herd monitoring (Lesnoff, 2008).

This is the third version of the handbook, and it is subject to additions and improvements deriving from complementary research work. This handbook should be considered as a work tool that can be adjusted depending on the goals and constraints of the surveys to be conducted. It is not a rigid framework capable of meeting the full range of study needs. For instance, the survey protocol may vary highly from one study to another and the survey questionnaires are adaptable. The handbook comprises six chapters. Chapter 1 describes the general protocol for a 12mo survey. Chapters 2 and 3 describe the survey questionnaires and a database interface for entering data collected in the field. Chapters 4, 5 and 6 go in to the detail of calculating the demographic parameters and provide a numerical example.

The materials used in the handbook (survey questionnaires, database and calculation routines) are available from the first author.

Table 1: *Demographic rates that can be estimated with the 12mo method.*

(a) Natural rates	
Abortion rate	Annual instantaneous hazard rate of abortion (average number of abortions per female present in the herd during all the year; an abortion is a gestation that has not reach its term)
Parturition rate	Annual instantaneous hazard rate of parturition (average number of parturition per female present in the herd during all the year)
Prolificacy rate	Average number of offspring (stillborn or born alive) per parturition
Mortinatality rate	Probability that an offspring is a stillborn (mortinatality is not included in the natural death rate, which only concerns animals born alive)
Mortality rate	Annual instantaneous hazard rate of natural death rate ("mortality" corresponds to all the deaths that has not been caused by slaughtering, referred as natural deaths in the handbook)
(b) 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.)

Chapter 1. Survey protocol

1. Introduction

The survey consists in interviewing the farmer, in the presence of the herd, and describing the characteristics of each animal as well as the demographic events that occurred in the last twelve months preceding the survey. The enumerator has to fill two survey questionnaires, i.e.:

- the 'Household' questionnaire, that describes household characteristics and farming practices (see below for the household definition);
- the 'Demography' questionnaire for each of the species studied in the herd.

For facilitating field work, the survey generally targets only one species per herd, even if the herd is composed of several species. To be surveyed, a herd must be of intermediate size – not too small to get a consistent sample of animals and not too large since the enumeration of the animals becomes too costly. The survey provides average results for such herds, assumed to be representative of the studied area for demography. If smaller or larger herds have to be involved in the study, other survey methods should be used.

Other points of the protocol may vary considerably depending on the study goals, the systems studied and the survey resources available. In this chapter we present only a few basic elements on which a 12mo survey is built.

2. Herd unit

Defining the "herd" unit is a fundamental step in any survey relating to livestock farming. This unit must be precisely and unambiguously defined prior to the survey, particularly when animal entries and exits are to be quantified and when these movements are used to calculate ratios. It is not easy to define the herd because animal groupings may vary over the year. Furthermore, this unit can be defined from several angles: herding, management, ownership, etc.

The basic unit for a 12mo survey is the "household herd". The household is defined as the following family unit: the head of household and all the people whom the latter must provide for on a daily basis (a concession, which is a social structure that is frequently encountered in West Africa, may comprise several households). A household herd comprises all the animals managed by the household at the time of the interview (i.e., directly in its charge). It includes animals entrusted to the household by people outside of that household (loaned animals or under contract). It does not include animals owned by the household but taken care of by other households.

3. Duration and schedule of the survey

The total duration of a 12mo survey should be approximately one month and must not exceed 45 days to ensure that the information collected from the various households applies to the same retrospective period and can be compared.

At household level, for any given species, the 12mo survey must be conducted with all the animals belonging to that species present. Seasonal transhumance periods should therefore be avoided and the survey should be carried out at the time when the herds are most likely to be assembled at the households' place of residence.

The survey should also preferably be anchored to a major calendar event so that the farmer can answer retrospective questions within a clear time frame. For instance, in Sahelian areas, the beginning or end of the rainy season are good points of reference.

4. Sampling size

Computing the size of samples required for a survey is a subject dealt with in many statistical textbooks. Theoretically, it is a matter of determining the size necessary to obtain estimates that have a given accuracy (this accuracy is quantified by the range of the confidence interval) or, in statistical tests that compare several groups, a significant result for a given risk of error.

In tropical livestock farming however the size of the sample is often determined by the human and financial resources available for the survey. We will deal only with this aspect.

In 12mo, a reasonable visiting schedule is some thirty to forty households per enumerator over the 30 to 45 days the survey lasts (one interview lasts from 2 to 4 hours, which allows the visit of one or two households per day). This number of herds is a compromise between field constraints (in particular the days the farmers are not available and the days spent by the enumerator travelling, contacts with local authorities, etc.) and the maximum duration of the survey. The total size of the survey is inferred from the total number of enumerators that can be called upon. Table 2 provides an example of how this is calculated.

The reliability of a 12mo survey is highly dependent on the quality of the field work done by the enumerators who often work under difficult conditions. Before the survey, it is important to provide extensive training that is both class-room based and, more importantly, practical and field-based. The quality of data collection during the survey period must also be monitored by field supervisors (for example, we recommend planning at least one field supervisor for 5 to 8 enumerators). These training and monitoring steps should never be neglected. Naturally, the more enumerators there are, the more difficult it is to implement these two stages.

Table 2: *Example of 12mo survey size computation. In this example, the enumerator is assumed to survey three villages and to conduct a demographic survey in n=10 households per village.*

Type of unit	Number of enumerators			
	1	5	10	20
Villages	3	15	30	60
Households	30	180	300	600

5. Experimental and sampling designs

Designing a demographic survey in a rural environment depends on the study objectives. Two main types of protocols can be implemented: experimental design, e.g. to assess impacts of interventions or differences between livestock systems, and sampling design, e.g., to quantify the average demographic performances of a livestock population. The handbook does not deal with the statistical aspects of these designs (readers are referred to specialized textbooks on this topic, for instance Searle, 1971; Dagnélie, 1981; Bergonzini, 1995; Cochran, 1999) and instead concentrates on a number of practical aspects.

Experimental designs consist of defining a (generally limited) set of factors of variation that will be the subject of the study. Then, either herds that match the various modalities of these factors must be randomly chosen, or, for instance in the case of testing an intervention (e.g., vaccination), intervention modalities (i.e. control versus vaccinated) must be randomly allocated to the herds included in the survey (this stage is referred to as randomisation). Experimental factors are diverse and depend directly on what is to be tested in the study (effects of household socio-economic characteristics, animal husbandry practices, external interventions, etc.).

Sampling designs consist in selecting randomly a set of herds within a “target population”. As with experimental designs, sampling designs are highly variable and numerous techniques are available (for instance, see Cochran, 1999).

When the target population for the survey is heterogeneous, it may be useful to stratify the population and conduct a survey within each stratum. In tropical livestock farming systems, these stratifications are often built up from crossing criteria such as agro-ecological zoning (for instance by separating mixed crop-livestock systems areas from pastoral areas) or from the type of livestock farming conducted by the household. As a rule, we recommend that the stratification criteria should have the following features:

- be as simple as possible and yield a limited number of strata so that significant results can be obtained for each stratum while maintaining a realistic sample size considering the human and financial means available;

- provide for the lowest degree of ambiguity possible as regards herd classification into the various strata. For instance, before the survey it is not always clear as to whether herds should be classified as being raised “extensively”, “semi-intensively” or “intensively” (in the field, stock-raising activities follow a continuous gradient of intensification where there is no clear cut-off point and where a broad set of factors is involved). With many stratification criteria, stratification can be performed afterwards but it is not always easy to use them to derive simple, unequivocal rules for classifying herds prior to the survey;

- if surveys are to be repeated over several years, they should be easy to reproduce and stable over time. It may be impossible to compare the results of surveys conducted several years apart if stratification criteria are not identical.

6. Household and herd selection

The selection of households and herds to be surveyed is implemented in two stages.

6.1. Stage n°1

The first stage consists in sampling the geographical areas (e.g. administrative districts, villages, hamlets, camps or, in pastoral areas, at rallying points, watering points) in which households will be surveyed.

This stage must conform to the experimental or sampling design previously set out by the survey supervisors. Because this design may vary considerably from one study to another, the first stage is not described in detail in this handbook.

6.2. Stage n°2

The second stage consists in selecting the households to be interviewed within the selected geographical areas. This is planned on the basis of rules relating to the species and to herd size.

6.2.1. Target species

12mo uses the concept of “target species”. The household is chosen based on a target species, whatever the other species eventually in charge by the household.

Consider the case of a study that covers cattle, goat and sheep populations in a given region. The assumption is that each enumerator working for the study is in charge of 30 households, distributed in three villages (he is required to interview ten households in each village). One rule that can be contemplated is that these ten households are chosen using the following constraint:

- 4 households with a target species of cattle;
- 3 households with a target species of goats;
- 3 households with a target species of sheep.

Two protocol options can thereafter be applied to the individual household:

- the first option (standard 12mo protocol) is that only the target species will be surveyed even if other species are present;

- the second option is to survey the target species and all the household's other species (providing they are covered by the study). In this option, while the final sample size in terms of the number of animals is increased (although the total number of households remains the same), the time needed to conduct the interview is prolonged making it more burdensome for the household.

6.2.2. Herd size

An additional rule is that a household should be surveyed only if the herd of the target species is neither too small (so as to ensure that the overall number of animals included in the sample is large enough) nor too large (which are impossible to enumerate in the field). For instance, the rule can be that the households considered are those whose herd of the target species ranges from 15 to 60 animals, including juveniles.

6.2.3. Method of household selection

Random selection of households that obey these rules can be done using a pre-established list of households. The list may be derived from existing data such as national census data or else from a preliminary survey in villages (an example is described in Lesnoff *et al.*, 2007d).

For all practical purposes however, the choice of households is often left to the discretion of the enumerator whose only obligation is to abide by the rules relating to target species and herd size set out by the survey supervisor. This approach corresponds to the "quotas method" often used in opinion poll protocols. Whenever this approach is used, the enumerators must avoid survey biases by making sure that they do not always interview the households located close to roads or households in one neighbourhood alone.

Chapter 2. Survey questionnaires

1. Introduction

As introduced in chapter 1, 12mo uses two questionnaires:

- a "Household" questionnaire describing household characteristics and farming practice;

- a "Demography" questionnaire composed of three sub-questionnaires:
  - Q1, current characteristics of the herd and female reproductive performance over the last twelve months;
  - Q2, entries in the herd over the last twelve months;
  - Q3, exits from the herd over the last twelve months.

In this chapter, we describe the household identification system in questionnaires (allowing linking up the various information collected in the household), some elements on how interviews are conducted with farmers and then the "Demography" questionnaire. The "Household" questionnaire varies considerably from one study to another - one may cover half a page while another will fill several pages depending on the range of data investigated and the level of detail sought. This is not described in this handbook.

The "Demography" questionnaire is available as a Microsoft ® Office Excel 2003 file comprising three sheets which are the Q1, Q2 and Q3 sub-questionnaires.

2. Identification of households in questionnaires

12mo uses a dual household identification. A first identification is performed in the field by enumerators. A second identification is performed by the survey supervisor in the processing centre.

Every household surveyed must be identified by means of two numbers that must appear on all "Household" and "Demography" questionnaires (sub-questionnaires Q1, Q2 and Q3) before data entry:

- NUMFARM;

- IDFARM.

The enumerators in the field allocate NUMFARM when they visit households. For instance, in the case where enumerators are expected to interview thirty households, NUMFARM goes from 1 to 30 for each enumerator.

The survey supervisor at the processing centre allocates IDFARM once the completed questionnaires have been collected. IDFARM is used to identify each household individually within the database. Two households must never have the same IDFARM in any one survey.

In the case of a stratified survey or when the data in a single survey are keyed in using several workstations, it may be useful to previously define IDFARM ranges allocated to each stratum or each workstation. For instance, if there are three strata and less than 300 households per stratum, a rule for IDFARM could be:

- ≤300 for stratum 1;
- 300< ≤600 for stratum 2;
- 600< ≤900 for stratum 3.

3. Guidance for interview in the field

3.1. Preparing the interview

Before starting the survey, it is recommended to inform all local authorities and livestock farming associations existing in the study areas. This will facilitate the acceptation of enumerators by farmers.

Enumerators should always introduce themselves to the head of the household and take time to explain the survey goals. It should be stressed that surveys are anonymous – the information sought consist in averages for a complete population, individual results are never published.

The household interview should be conducted with the head of household and the people most familiar with the demographic features of the herd (household head, women, herders, etc.). It is important to not implement the interview by grouping several household heads or persons external to the household (farmers would not feel free to answer to the questionnaires and collected information would be biased).

Enumerators should set the date and time for the interview in agreement with the household at a time when the respondents are available and the animals are all present (for instance early in the morning, the evening or the night).

The demographic survey must always be conducted with all the animals present. The enumerator has to check that young, lactating females or sick animals have not been separated from the rest of the herd. In such a case, the enumerator will have to continue with his interview until he reaches all the animals.

Prior to beginning the interview, enumerators should prepare their survey materials (questionnaires, pencils, etc.) and fill in already known data (location, date of survey, NUMFARM, etc.).

3.2. How to begin the interview

The enumerator should provide a brief explanation of how the survey is going to be conducted. For instance: sub-questionnaires Q1 (herd structure and female reproductive performance), Q2 (entries of animals to the herd) and Q3 (exits of animals from the herd) and then the "Household" questionnaire. It is advisable to process the latter last.

Enumerators must always emphasize that some of the information requested (births, entries and exits of animals) must relate only to the twelve months preceding the survey date. They must single out an event that will help farmers to establish and refer to a time frame. Enumerators must remind respondents of this twelve month constraint throughout the interview. The enumerators themselves must be fully familiar with the local calendar. A calendar designed to serve as an aid is appended to the questionnaires (Figure 1). It can be used to record the rainy season and the dates of major events in the year (e.g., the "Tabaski" feast).

If no entries or exits are declared for any one species, the enumerator should nevertheless fill in sub-questionnaires Q2 and Q3 by crossing them out and writing in "no event declared" so that the survey supervisor can check that no sub-questionnaires have been lost when it comes to consolidating them.

4. The "Demography" questionnaire

4.1. Head of sub-questionnaires Q1, Q2 et Q3

Enumerators must fill in the following fields:

- Enumerator's name;
- survey date;
- NUMFARM;
- species;
- household name;
- household localisation.

After the interview, the enumerator has to count the total number of animals enumerated in Q1. This helps the supervisor to check that Q1 sheets for a given household have not been lost.

Enumerators must not fill in the IDFARM field.

4.2. Sub-questionnaire Q1

The purpose of sub-questionnaire Q1 (Figure 2) is:

- to individually enumerate all the animals in the herd and describe their characteristics;
- for each female enumerated, to record additional data reflecting her reproductive performance over the last twelve months.

The characteristics that are collected during individual enumeration of the animals are as follows:

- breed (for crossed animals, one may only consider the dominance);
- sex (F. Female, M. Male);
- for males, an indicator specifying whether the male is castrated (1. Yes, 2. No);
- an indicator specifying whether the animal is owned by the household (1. Yes, 2. No);
- an indicator specifying whether the animal was born in the herd (1. Yes, 2. No);
- age of the animal at date of survey, in annual age class (number of full years lived by the animal; see section 4.5 of this chapter);
- for females:
  - total number of abortions that had the female since the beginning of its reproductive life (and not only since its eventual entry in the herd). For example, if the female has already got two abortions in its career but only one in the herd, the enumerator has to fill "2" (and not "1");
  - parity, i.e. the total number of parturitions that had the female since the beginning of its reproductive life (the principle is the same as for abortions). Current gestations must not be counted.

If the animal is a female, the enumerator has then to describe its reproduction over the last twelve months (without counting current gestations). Information to be collected is as follows:

- number of abortions in the last twelve months (0, 1 or 2);
- number of parturitions in the last twelve months (0, 1 or 2);
- for every parturition, the numbers of progeny born alive and those that were stillborn. The two columns named "1st parturition" and "2nd parturition" are distinguished because small ruminants can give birth twice a year. Farmers tend to forget to report the 2nd parturition, so enumerators must take special care in this respect and make a

point of clarifying this with the farmer. Otherwise, abortion and parturition rates will tend to be underestimated. It is also important to distinguish stillborn animals from those born alive that died the same day or even a few days later:

- a stillborn animal is one that was already dead at birth. Stillborn progeny are accounted for in mortinatality. They should be recorded in Q1 rather than Q3 which relates only to outcomes for animals born alive;
- an animal born alive that dies the first day, second day, etc. is not a stillborn. This is the case of death of an animal born alive that should be recorded as a natural death in Q3.

- an indicator specifying whether the female was milked in the last twelve months (1. Yes, 2. No);

Mandatory information that must be collected under Q1 is sex, birth status, age and reproduction. The remaining information is optional, some of which may be removed if it does not serve the purposes of the study. Moreover, users may include additional information on animal characteristics (e.g., veterinary treatment administered) in sub-questionnaire Q1. In such a case, he will have to add the corresponding variables in the database.

4.3. Sub-questionnaire Q2

The purpose of sub-questionnaire Q2 (Figure 3) is to enumerate and describe all herd entries over the twelve months preceding the survey, including entries of animals that were thereafter removed from the herd prior to the survey day. However, very short-lived entries-exits (for instance as a result of ploughing contracts lasting less than a month) should not be counted.

Q2 contains two tables:

- "Summary of entries in the last twelve months";
- "Details of entries". This table describes each entry listed in the summary table.

Enumerators must firstly fill the entire summary table (by recording the total numbers of entries per type) and secondly detail individually the recorded entries.

For each entry, the enumerator must record:

- breed (or dominance);
- sex (F. Female, M. Male);
- age of the animal at date of entry, in annual age class (number of full years lived by the animal; see section 4.5 of this chapter);

- entry type (1. Purchase or barter, 2. Arriving loan or contract, 3. Coming back loan or contract, 4. Gift, dowry, inheritance, etc.). If the farmer supplies an entry type that is not included on the list, enumerators must classify it in the most similar category.

As for Q1, if the user adds auxiliary information in Q2 (or Q3), he will have to add the corresponding variables in the database (chapter 3).

4.4. Sub-questionnaire Q3

The purpose of sub-questionnaire Q3 (Figure 4) is to enumerate and describe all herd exits over the twelve months preceding the survey, including exits of animals arrived into the herd in the twelve months (except very short-lived entries-removals, for instance as a result of ploughing contracts).

Q3 contains two tables:

- "Summary of exits in the last twelve months";
- "Details of exits". This table describes each exit listed in the summary table.

Enumerators must first fill the entire summary table (by recording the total numbers of exits per type) and secondly detail individually the recorded exits.

For each exit, the enumerator must record:

- breed (or dominance);
- sex (F. Female, M. Male);
- age of the animal at date of exit, in annual age class (number of full years lived by the animal; see section 4.5 of this chapter);
- exit type (1. Natural death, 2. Slaughtering, 3. Sale or barter, 4. Leaving for loan or contract, 5. Return of loan or contract, 6. Gift, dowry, etc., 7. Withdrawal, theft, etc.). If the farmer supplies an exit type that is not included on the list, enumerators must classify it in the most similar category.

4.5. Age in Q1, Q2 et Q3

The age is difficult to obtain but is essential. Ideally, enumerators should be able to inspect animals' teeth (Poivey *et al.*, 1981a; Landais and Bassewitz, 1982; ILCA, 1990; Lhoste *et al.*, 1993), although this remains a highly approximate technique. In practice, many breeds are not easy to approach or handle and in most cases enumerators will not have time to carry out such an inspection. As an alternative, enumerators must be fully cognizant with the local calendar and, with the help of the farmers (possibly using the calendar attached to the questionnaires to help the latter establish a time frame), they should approximate the birth date of the animal from which its age class can be inferred.

In 12mo (Q1, Q2 and Q3), age must be specified in number of full years lived by the animal:

- age 0 correspond to exact ages “0 to 12 months”;
- age 1 correspond to exact ages “> 12 to 24 months”;
- age 2 correspond to exact ages “> 24 to 36 months”;
- etc.

Classification of the animals into annual age classes is inevitably approximate since it is based on the farmer’s recall. Special care must be taken by the enumerator regarding juveniles and animals that are beginning to breed. For instance, it is important to distinguish correctly between:

- ages 0, 1 and 2 for small ruminants;
- ages 0, 1 and 2 and ages 3, 4 and 5 for large ruminants.

Errors in higher age groups have little impact on outcomes. In addition, during data analysis, animals are grouped in broader age classes than annual for astonishing the classification errors (chapter 6).

AGE	CALENDAR											
15	**1992 Jun**	1992 Jul	1992 Aug	1992 Sep	1992 Oct	1992 Nov	1992 Dec	1993 Jan	1993 Feb	1993 Mar	1993 Apr	1993 May
	rainy season											
14	**1993 Jun**	1993 Jul	1993 Aug	1993 Sep	1993 Oct	1993 Nov	1993 Dec	1994 Jan	1994 Feb	1994 Mar	1994 Apr	**1994 May**
	rainy season											
13	1994 Jun	1994 Jul	1994 Aug	1994 Sep	1994 Oct	1994 Nov	1994 Dec	1995 Jan	1995 Feb	1995 Mar	1995 Apr	**1995 May**
	rainy season											
12	1995 Jun	1995 Jul	1995 Aug	1995 Sep	1995 Oct	1995 Nov	1995 Dec	1996 Jan	1996 Feb	1996 Mar	**1996 Apr**	1996 May
	rainy season											
11	1996 Jun	1996 Jul	1996 Aug	1996 Sep	1996 Oct	1996 Nov	1996 Dec	1997 Jan	1997 Feb	1997 Mar	**1997 Apr**	1997 May
	rainy season											
10	1997 Jun	1997 Jul	1997 Aug	1997 Sep	1997 Oct	1997 Nov	1997 Dec	1998 Jan	1998 Feb	1998 Mar	**1998 Apr**	1998 May
	rainy season											
9	1998 Jun	1998 Jul	1998 Aug	1998 Sep	1998 Oct	1998 Nov	1998 Dec	1999 Jan	1999 Feb	**1999 Mar**	1999 Apr	1999 May
	rainy season											
8	1999 Jun	1999 Jul	1999 Aug	1999 Sep	1999 Oct	1999 Nov	1999 Dec	2000 Jan	2000 Feb	**2000 Mar**	2000 Apr	2000 May
	rainy season											
7	2000 Jun	2000 Jul	2000 Aug	2000 Sep	2000 Oct	2000 Nov	2000 Dec	2001 Jan	2001 Feb	**2001 Mar**	2001 Apr	2001 May
	rainy season											
6	2001 Jun	2001 Jul	2001 Aug	2001 Sep	2001 Oct	2001 Nov	2001 Dec	2002 Jan	**2002 Feb**	2002 Mar	2002 Apr	2002 May
	rainy season											
5	2002 Jun	2002 Jul	2002 Aug	2002 Sep	2002 Oct	2002 Nov	2002 Dec	2003 Jan	**2003 Feb**	2003 Mar	2003 Apr	2003 May
	rainy season											
4	2003 Jun	2003 Jul	2003 Aug	2003 Sep	2003 Oct	2003 Nov	2003 Dec	2004 Jan	**2004 Feb**	2004 Mar	2004 Apr	2004 May
	rainy season											
3	2004 Jun	2004 Jul	2004 Aug	2004 Sep	2004 Oct	2004 Nov	2004 Dec	**2005 Jan**	2005 Feb	2005 Mar	2005 Apr	2005 May
	rainy season											
2	2005 Jun	2005 Jul	2005 Aug	2005 Sep	2005 Oct	2005 Nov	2005 Dec	**2006 Jan**	2006 Feb	2006 Mar	2006 Apr	2006 May
	rainy season											
1	2006 Jun	2006 Jul	2006 Aug	2006 Sep	2006 Oct	2006 Nov	2006 Dec	**2007 Jan**	2007 Feb	2007 Mar	2007 Apr	2007 May
	rainy season											
0 (last twelve months)	2007 Jun	2007 Jul	2007 Aug	2007 Sep	2007 Oct	2007 Nov	**2007 Dec**	2008 Jan	2008 Feb	2008 Mar	2008 Apr	2008 May
	rainy season											

Figure 1: *Example of calendar to help enumerators establish a time frame and determine the age of animals on the survey date. This calendar was devised for the purposes of the survey conducted under the PAD project in Niger in June 2006.*

NAME DATA ENTRY OPERATOR: ______________________________ DATE DATA ENTRY: |___|___| /|___|___| / |___|___|

Q1. HERD STRUCTURE AND REPRODUCTION

IDFARM : |___|___|___|___|

NAME ENUMERATOR: ______________________________ DATE SURVEY: |___|___| /|___|___| / |___|___|

NUMFARM : |___|___|

REGION: ____________________________________

TOTAL NB. OF ANIMALS IN HERD : |__|__| (TO BE COUNTED FROM Q1)

SPECIES: ________________

DISTRICT: ____________________________________

NAME HOUSEHOLD: ______________________________

VILLAGE: ____________________________________

	CARACTERISTICS OF PRESENT ANIMALS								IF FEMALE: REPRODUCTION OVER THE LAST 12 MONTHS							
	BREED DOMINANCE	SEX F M	IF MALE CASTR. 1. YES 2. NO	OWNED 1. YES 2. NO	BORN IN HERD 1. YES 2. NO	AGE	IF FEMALE NB. TOT. ABORTIONS	NB. TOT. PARTURITIONS	NB. ABORTIONS	NB. PARTURITIONS	PARTURITION N°1 NB. STILLBORN	NB. BORN ALIVE	PARTURITION N°2 NB. STILLBORN	NB. BORN ALIVE	MILKED 1. YES 2. NO
1																
2																
3																
4																
5																
6																
7																
8																
9																
10																
11																
12																
13																
14																
15																
16																
17																
18																
19																
20																

Page: |___|/|___|

Figure 2: *Sub-questionnaire Q1 of the 12mo demographic survey.*

NAME DATA ENTRY OPERATOR: ________________________________ DATE DATA ENTRY: |___|___| /|___|___| / |___|___|

Q2. ENTRIES IN HERD

IDFARM : |___|___|___|___|	NAME ENUMERATOR: ______________________
NUMFARM : |___|___|	DATE SURVEY: |___|___| /|___|___| / |___|___|
SPECIES: _________________	REGION: ______________________________________
NAME HOUSEHOLD: ______________________	DISTRICT: ______________________________________
	VILLAGE: ______________________________________

SUMMARY OF ENTRIES OVER THE LAST 12 MONTHS

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

(CROSS THE QUESTIONNAIRE
IF NO ENTRY FOR THE SPECIES)

DETAIL OF ENTRIES

	BREED DOMINANCE	SEX F M	AGE AT DATE OF ENTRY	ENTRY TYPE **(c)**
1		|___|	|___|___|	|___|
2		|___|	|___|___|	|___|
3		|___|	|___|___|	|___|
4		|___|	|___|___|	|___|
5		|___|	|___|___|	|___|
6		|___|	|___|___|	|___|
7		|___|	|___|___|	|___|
8		|___|	|___|___|	|___|
9		|___|	|___|___|	|___|
10		|___|	|___|___|	|___|
11		|___|	|___|___|	|___|
12		|___|	|___|___|	|___|
13		|___|	|___|___|	|___|
14		|___|	|___|___|	|___|
15		|___|	|___|___|	|___|
16		|___|	|___|___|	|___|
17		|___|	|___|___|	|___|
18		|___|	|___|___|	|___|
19		|___|	|___|___|	|___|
20		|___|	|___|___|	|___|

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

Page: |___|/|___|

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

(c) See codes of "type of entry" in the summary table

Figure 3: *Sub-questionnaire Q2 of the 12mo demographic survey.*

NAME DATA ENTRY OPERATOR: ______________________________ DATE DATA ENTRY: |___|___| /|___|___| / |___|___|

Q3. EXITS FROM HERD

IDFARM : |___|___|___|___|___|	NAME ENUMERATOR: ______________________
NUMFARM : |___|___|	DATE SURVEY: |___|___| /|___|___| / |___|___|
SPECIES: _________________	REGION: _____________________________________
NAME HOUSEHOLD: ______________________	DISTRICT: _____________________________________
	VILLAGE: _____________________________________

SUMMARY OF EXITS OVER THE LAST 12 MONTHS

TYPE OF EXITS	TOTAL	(a)
1. NATURAL DEATH (ALL DEATH OTHER THAN SLAUGHTERING)	|___|___|	
2. SLAUGHTERING (ORDINARY + EMERGENCY)	|___|___|	
3. SALE, BARTER (LIVING ANIMALS)	|___|___|	
4. DEPARTURE IN LOAN/CONTRACT	|___|___|	(b)
5. SENDING BACK LOAN/CONTRACT	|___|___|	(b)
6. GIFT, DOWRY, etc.	|___|___|	
7. WITHDRAWAL, THEFT, etc.	|___|___|	

(CROSS THE QUESTIONNAIRE IF NO EXIT FOR THE SPECIES)

DETAIL OF EXITS

	BREED DOMINANCE	SEX F M	AGE AT DATE OF EXIT	EXIT TYPE **(c)**
1		|___|	|___|___|	|___|
2		|___|	|___|___|	|___|
3		|___|	|___|___|	|___|
4		|___|	|___|___|	|___|
5		|___|	|___|___|	|___|
6		|___|	|___|___|	|___|
7		|___|	|___|___|	|___|
8		|___|	|___|___|	|___|
9		|___|	|___|___|	|___|
10		|___|	|___|___|	|___|
11		|___|	|___|___|	|___|
12		|___|	|___|___|	|___|
13		|___|	|___|___|	|___|
14		|___|	|___|___|	|___|
15		|___|	|___|___|	|___|
16		|___|	|___|___|	|___|
17		|___|	|___|___|	|___|
18		|___|	|___|___|	|___|
19		|___|	|___|___|	|___|
20		|___|	|___|___|	|___|

(a) If other type of exit, select the closest within the proposed types Page: |___|/|___|

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

(c) See codes of "type of exit" in the summary table

Figure 4: *Sub-questionnaire Q3 of the 12mo demographic survey.*

Chapter 3. Data entry

1. Introduction

Data entry and management of information collected through a 12mo survey are fairly complex steps that require a database management system (DBMS). To facilitate this process, we have developed a database (12mo.mdb) that contains a data entry interface. The database uses Microsoft ® Office Access 2003 Microsoft.

No installation procedure is required for the 12mo database. The 12mo.mdb file has simply to be copied into the work directory. Double-clicking on the file has the effect of opening the database and the data input interface. By default, opening the 12mo.mdb base deactivates the Access standard display menu. To maintain all the functionalities of this menu, press down the SHIFT key when opening the 12mo.mdb base.

It essential to regularly save the database when keying in the data, for instance on a CD-ROM or USB storage device.

2. Data entry interface

The 12mo interface (Figure 5) is used for keying in information from sub-questionnaires Q1, Q2 and Q3.

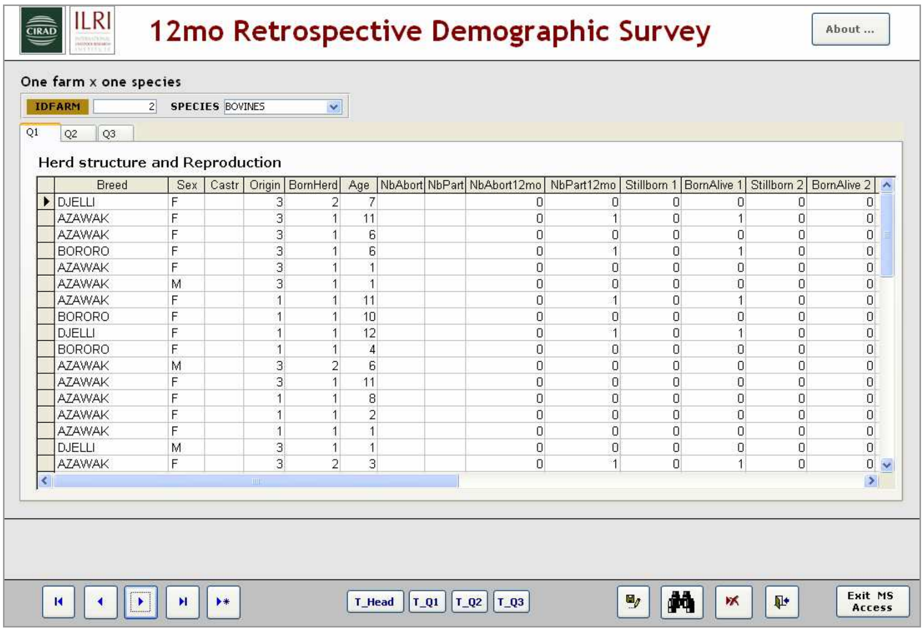
In a 12mo survey, the user has to build an additional database for keying in information from the questionnaire “Household”. Tables of this database depend on the questionnaire and we do not detail them. The only mandatory variable in the tables is “idfarm”.

3. Database structure

Database 12mo.mdb contains four tables whose structure and relationships are outlined in Figure 6: T_Head, T_Q1, T_Q2 and T_Q3.

The sole purpose of T_Head is to serve as a link between the other tables. T_Q1, T_Q2 and T_Q3 contain the information collected through questionnaires Q1, Q2 and Q3, respectively. In each of these three tables, variables can be freely added to enter auxiliary information not presented in the questionnaires described in this handbook.

The four tables are materially linked by a relation on variables “idfarm + species” (i.e., by crossing IDFARM and species).



Breed	Sex	Castr	Origin	BornHerd	Age	NbAbort	NbPart	NbAbort12mo	NbPart12mo	Stillborn 1	BornAlive 1	Stillborn 2	BornAlive 2
DJELLI	F		3	2	7			0	0	0	0	0	0
AZAWAK	F		3	1	11			0	1	0	1	0	0
AZAWAK	F		3	1	6			0	0	0	0	0	0
BORORO	F		3	1	6			0	1	0	1	0	0
AZAWAK	F		3	1	1			0	0	0	0	0	0
AZAWAK	M		3	1	1			0	0	0	0	0	0
AZAWAK	F		1	1	11			0	1	0	1	0	0
BORORO	F		1	1	10			0	0	0	0	0	0
DJELLI	F		1	1	12			0	1	0	1	0	0
BORORO	F		1	1	4			0	0	0	0	0	0
AZAWAK	M		3	2	6			0	0	0	0	0	0
AZAWAK	F		3	1	11			0	0	0	0	0	0
AZAWAK	F		1	1	8			0	0	0	0	0	0
AZAWAK	F		1	1	2			0	0	0	0	0	0
AZAWAK	F		1	1	1			0	0	0	0	0	0
DJELLI	M		3	1	1			0	0	0	0	0	0
AZAWAK	F		3	2	3			0	1	0	1	0	0

Figure 5: *Data entry interface for demographic data collected through a 12mo survey. Data are stored in the Microsoft ® Office Access 2003database "12mo.mdb".*

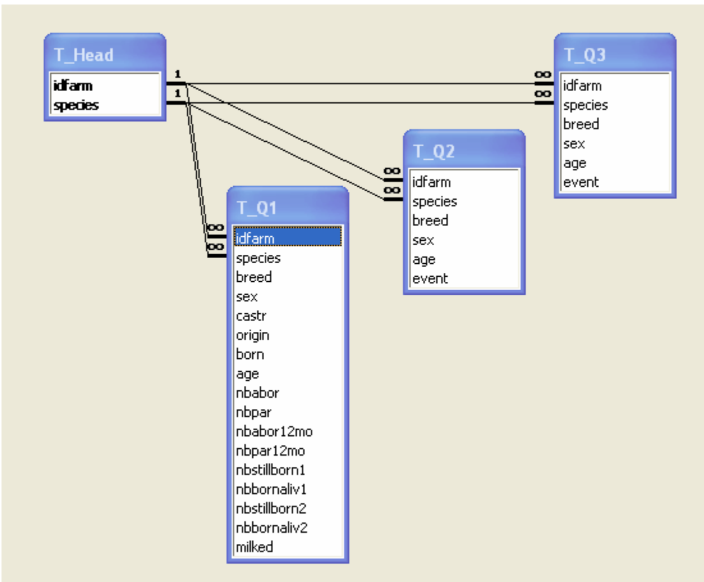


Figure 6: *Structure of the tables in the Microsoft ® Office Access 2003database "12mo.mdb" and relationships between the tables.*

Chapter 4. Computing demographic rates

1. Introduction

This chapter describes the calculations of the abortion, parturition, mortality, offtake and intake rates from 12mo data. Calculation of the other rates defined in Table 1 (prolificacy and mortinatality) present no particular difficulty and is not as such described in the handbook. Numerical examples are provided in Chapter 6.

Rates estimated in 12mo (except prolificacy and mortinatality) are instantaneous hazard rates, referred as "*h*" in the handbook (appendix 1). They are computed on an annual basis and are assumed to be constant throughout the year. This is an approximation because it is well known that demographic rates in tropical domestic livestock populations vary with the season (this approximation can generate a bias in the estimated rates; Lesnoff et al. 2007b).

2. Mortality, offtake and intake rates

Calculations are presented for mortality. The principle is the same for other exits and entries.

For a given category of animals (species, sex, age class, etc.), the mortality rate is calculated by:

$$h_{\text{death}} = m_{\text{death}} / T,$$

where m_{death} is the number of natural deaths that occurred in that category of animals in the twelve months preceding the survey (m_{death} is deduced from Q2) and T is the total time spent by the animals in this category and over this period. The main difficulty with retrospective methods lies in estimating T for each category of animals.

Under 12mo, T is estimated by an approximation of the mean number of animals (over the twelve months) in the age class (this approximation is obtained in exactly the same way as in the life table method in human demography; Chiang, 1984):

$$T_{\text{approx, i}} = \frac{n_{\text{t-1, i, approx}} + n_{\text{t, i}}}{2},$$

where $n_{\text{t, i}}$ represents the number of animals present in age class *i* at the date of survey and $n_{\text{t − 1, i, approx}}$ an estimate of the number of animals present in age class *i* twelve month before.

The calculation of $n_{\text{t − 1, i, approx}}$ is described in appendix 2. It differs from the method described in version 1 of this handbook (Lesnoff *et al.*, 2007c, Lesnoff, 2008b) and is less sensitive to herd size variations between time *t*-1 and time *t*.

3. Abortion and parturition rates

12mo offers two methods for calculating the parturition rate (the principle is the same for abortions). Both methods are based on the reproductive career of the females present at the date of the survey:

- the first method only considers the last twelve months;

- the second method considers all the reproductive life of the females; this method provides average rates over a period of several years prior to the survey, rather than just over the last twelve months.

In both methods, the estimated rate $h_{\text{parturition}}$ represents the average number of parturition per female and per year lived in the herd (see appendix 3).

Only surveying the females present at the date of the survey can generate an overestimation of the parturition rate. Farmers prefer to keep the best breeding females in the herds and cull the others (the latter have then statistically a lower chance to be observed during the surveys).

3.1.1. Parturition rate over the last twelve months

For age class *i*, the method uses the formula $h_{\text{parturition, i}} = m_{\text{parturition, i}} / T_{\text{F, i}}$.

$m_{\text{parturition, i}}$ corresponds to the number of parturitions of females present in age class *i* at the date of the survey (these parturition are recorded in the section "last twelve months" of Q1).

$T_{\text{F, i}}$ is estimated by the number of females present in age class *i* at the date of the survey (these females are recorded in Q1 and are assumed to have passed the full year in the herd):

$$T_{\text{approx, F, i}} = n_{\text{t, F, i}}.$$

3.1.2. Parturition rate over the reproductive life

The method (SEDES, 1975; Lhoste *et al.*, 1993) consists in fitting the age-and-parity data using linear regression:

$$y = \beta_0 + \beta_1 x,$$

where *y* is the age (year) of the females and *x* their parity. Only females with parity≥1 are considered in this regression analysis. The line's slope (coefficient β_1), which represents the number of additional parturitions for each unit increase in age, can be considered an estimation of the parturition rate.

Consider the example of a population of cattle in which the females are distributed by annual age class and parity as summarized in the following table (this is a contingency table;

for instance, there were 8 females in age class 4 and parity 1, i.e. whose exact age ranged from 48 to 60 months and which had only one parturition in their reproductive life):

```
         parity  0  1  2  3  4  5 Total
age
0               73  0  0  0  0  0    73
1               45  0  0  0  0  0    45
2               43  0  0  0  0  0    43
3               17  1  0  0  0  0    18
4               11  8  0  0  0  0    19
5                7 37  3  0  0  0    47
6                1 42 11  0  0  0    54
7                0 13 21  1  0  0    35
8                0  2 12  3  0  0    17
9                0  2  7 11  1  0    21
10               0  0  7  8  4  0    19
11               0  0  0 13  4  0    17
12               0  0  2  3  7  0    12
13               0  0  0  0  2  0     2
16               0  0  0  0  0  1     1
```

Once the females with parity≥1 are selected, the linear fit of the data in the table using the least squares methods yields the equation:

$$y = -0.79 + 0.36\, x,$$

and hence an estimated parturition rate of 0.36 year^{-1}.

The difficulty in this method is determining from what age onwards the estimated parturition rate applies. According to the previous table, parturitions began between age classes 4 and 5. It would therefore be reasonable to think that the estimated rate can be applied to females whose exact age is more than 4 years.

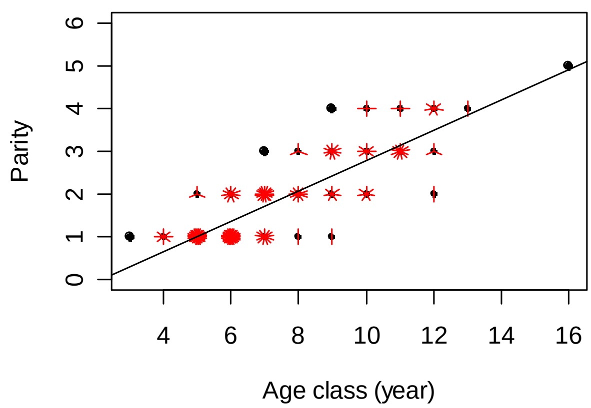


Figure 7: *Example of linear regression of female cattle parity on the basis of attained age. Multiple points are plotted as "sunflowers" with multiple leaves ("petals") such that points overplotting is visualized instead of invisible. With the R software (http://www.r-project.org/), this graph can be plotted using the sunflowerplot function.*

Chapter 5. Automated calculation routines

1. Introduction

As with data entry, calculating demographic parameters from 12mo data is fairly complex. To facilitate this task and data analysis, we have devised a set of automated functions that use the raw data stored in the 12mo.mdb base. These functions are confined to the demographic data (sub-questionnaires Q1, Q2 and Q3). These functions do not pertain to the data from the "Household" survey that must be analysed separately.

The 12mo functions were developed with the R free software (R Development Core Team, 2006) which can be downloaded freely from the web site http://www.r-project.org. The R software brings together sets of functions in "packages" that can be loaded when the software is used. The 12mo functions are gathered in the package "tdemog".

The R environment comprises commands and graphic outputs. In interactive use, commands are entered through a console and interpreted by the software. By convention, in this handbook:

```
this font depicts commands entered through the console
```

```
and this font depicts the result of the commands displayed on the console.
```

The R language enables objects of different types to be handled (vectors, matrices, tables, lists, functions, models, etc.) so as to produce results that can be displayed on the screen, sent to external files or internally stored in the form of objects. All these objects can be manipulated and edited.

This handbook does not provide the basic elements relating to the R language and its syntax. Readers who wish to more thoroughly explore the use of R should refer to the documentation supplied with the software that is automatically available once R has been installed, or to the documentation available at the R archives (http://cran.r-project.org/) or project (http://www.r-project.org/) sites.

2. Installing R and tdemog

To be able to implement the 12mo functions, users must first install R and package tdemog (appendix 4). Installation need only be performed once.

R and tdemog can be automatically and concomitantly installed by double-clicking on the executable file Rsetup_gead.exe developed by CIRAD (appendix 4). If this simple installation procedure is used, there is no need for the user to manually load package tdemog because it is loaded automatically every time R is opened.

3. Overall calculation procedure

12mo functions in package tdemog are listed in Table 3. These functions were those available at the time this handbook was drafted. Additional functions may be developed in future versions of 12mo.

The overall procedure used for calculating demographic parameters is as follows (Figure 8):

- tables in database 12mo.mdb are imported into R using function `import.tdemog` in package tdemog. This function imports the original tables from the database (T_Head, T_Q1, T_Q2 and T_Q3) and automatically generates two working tables:
  - `tabanim` for studying herd size, animals characteristics (sex, age, etc.) and reproductive performances;
  - `tabmov` for studying mortality, offtake and intake rates;

- working tables `tabanim` and `tabmov` can be manipulated (data selection and recoding) or supplemented with external data (such as the farmers type, if several types are being studied) ;

- these tables are then used as input data for the computation functions in package tdemog that generate the demographic parameter tables. The latter can be used as final results or subjected to statistical analysis using the basic functions in R.

Table 3: *List of 12mo functions in package tdemog for the R software (importation of data and demographic parameter calculation using data in sub-questionnaires Q1, Q2 and Q3).*

Function	Objective	Data used
`import.tdemog`	Data importation from database Microsoft ® Office Access 2003 12mo.mdb under the R software, and data preparation for calculations of the demographic parameters (the function creates tables `tabanim` and `tabmov`)	12mo.mdb
`stru`	Herd size and structure	`tabanim`
`abort`	Abortion rate	`tabanim`
`partur`	Parturition rate	`tabanim`
`prolif`	Prolificacy rate	`tabanim`
`mortinat`	Mortinatality rate	`tabanim`
`exit`	Exit rates (mortality, offatke)	`tabmov`
`entry`	Intake rates	`tabmov`

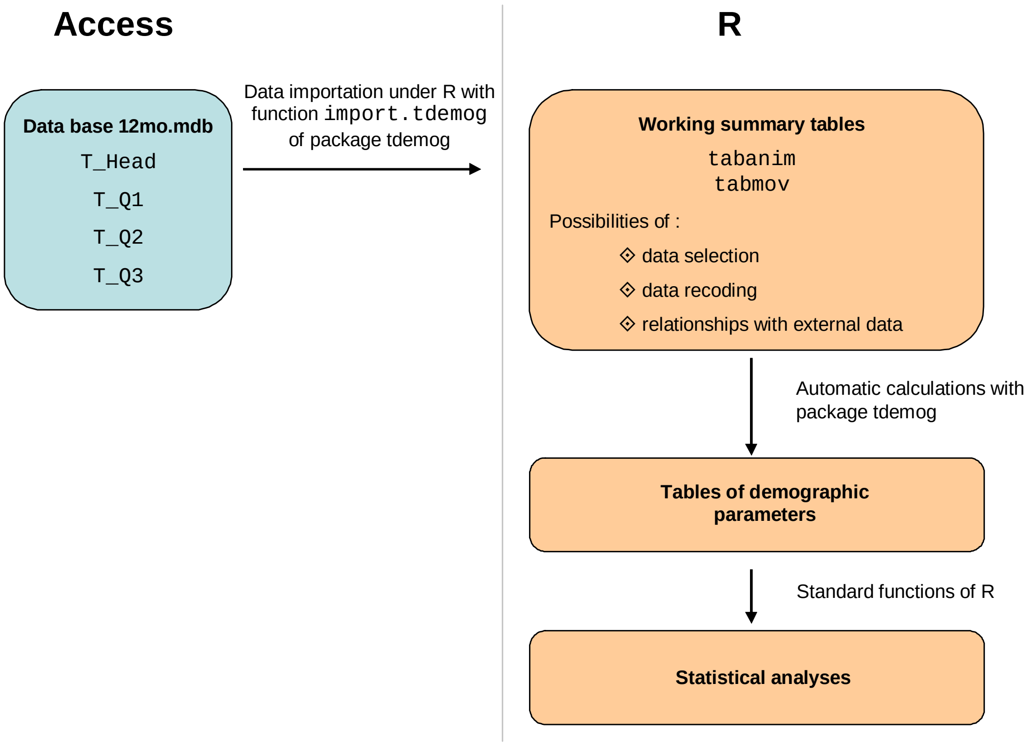


Figure 8: *Procedure for calculating demographic parameters in the 12mo method.*

4. Example of R script

We present an example of an R script (a script is a set of commands) using the tdemog package. The aim is to calculate cattle mortality using a 12mo.mdb database.

4.1. Importing data

Importing data from a 12mo.mdb base simply requires specifying the path and the name of the database in argument `db` of function `import.tdemog`.

The function imports the five original tables from the database and automatically generates the two working tables `tabanim` and `tabmov`.

In the example, we import the data from 12mo.mdb and store them in the object `my12mo` (function `attributes` in R allows the content of an object to be listed):

```
my12mo <- import.tdemog(db = "D:/Users/Data/12mo.mdb", typsurv = "12mo")
# List of tables in my12mo
attributes(my12mo)
$names
"tfarm"    "thead"    "tq1"    "tq2"    "tq3"    "tabanim"    "tabmov"
```

4.2. Calculations

Mortality rates are calculated from table `tabmov`. We extract `tabmov` from object `my12mo`, select the cattle data and then store the data in a table `mydata`:

```
mydata <- my12mo$tabmov
mydata <- mydata[mydata$species == "BOV", ]
```

Rates are then computed using the function `exit`. Variables defining the categories of animals for which rates are computed are specified in argument `formula`. This argument must be filled in for all the 12mo tdemog functions. Argument `event` specifies the type of exit – in this case natural death.

Below, we have calculated the overall (i.e., irrespective of age) mortality rates by sex:

```
exit(formula = ~ species + sex, data = mydata, event = "DEA")
$tab
  species sex trisk nbevent     h  se.h
1     BOV   F  1780      77 0.043 0.005
2     BOV   M   759      30 0.040 0.007
```

Rates are always expressed in years^{-1} and shown in column h (the column se.h is the standard errors of the estimates). For instance, in the table below, the estimated overall mortality rate for females was respectively h = 0.043 year^{-1}.

For calculating a parameter over all the animals (i.e., without any category), the user has to specify "~ 1" in `formula`, for instance:

```
exit(formula = ~ 1, data = mydata, event = "DEA")
$tab
  V1 trisk nbevent     h  se.h
1  1  2539     107 0.042 0.004
```

Rules on how to use the other functions and interpret the results are given in the numerical example provided in Chapter 6.

5. Functions `entry` and `exit`

Argument `event` in functions `entry` and `exit` determines the type of event considered in the entry and exit rates calculations.

For entries, possible codes for event are:

- `COM`: purchases, barters;
- `LO`: loans, contracts;
- `GIF`: gifts, dowry, inheritance, etc.;
- `INT`: `COM + LOA + GIF`.

For exits, possible codes for event are:

- `DEA`: natural deaths;
- `SLA`: slaughtering;
- `COM`: sales, barters;
- `LOA`: loans, contracts;
- `GIF`: gifts, dowry, etc.;
- `DIS`: withdrawals, thefts, etc.;
- `OFF`: `SLA + COM + LOA + GIF`.

Several types of entries or exits can be grouped using the R command "c" (this command is for building vectors). For instance, `event = OFF` in exit is equivalent to `event = c("SLA", "COM", "LOA", "GIF")`. Rates for "slaughtering + sales" are obtained by specifying `event = c("SLA", "COM")`:

```
exit(formula = ~ species + sex, data = mydata, event = c("SLA", "COM"))
$tab
  species sex trisk1 trisk2 nbevent    h1 se.h1    h2 se.h2
1     BOV   F   1780   1780     178 0.100 0.007 0.100 0.007
2     BOV   M    759    793     187 0.246 0.018 0.236 0.017
```

Chapter 6. Numerical example

1. Introduction

The demographic data used in this chapter were taken from the 12mo survey conducted in June 2006 for the purpose of the PAD Project in Niger. This survey was carried out by the Animal Resources Ministry of Niger and ILRI, and coordinated by the AGRHYMET Research Centre and ICRISAT in Niamey. The aim of the survey was to estimate the demographic performances of the cattle, goats and sheep populations in three study sites chosen for the project (Fakara, Gabi and Zermou) (Lesnoff *et al.*, 2007d).

Demographic data have been recorded in database 12mo_v3_pad_2006.mdb. The numerical example described here relates to the goats population. The example shows how to calculate each of the parameters listed in Table 1 and also serves as the opportunity to review the 12mo functions of the R package tdemog. Analysis of data recorded in the PAD "Household" questionnaire is not described in the handbook.

2. Data

The three study sites for PAD are located in the semi-arid area of the Niger, with a unimodal rainy season running from May to October. In Niamey, which is located at approximately the same latitude as the study sites, average rainfall was 575 mm (s.d. = 138) between 1921 and 1990 (Turner and Hierniaux, 2002).

A team of nine pre-selected and trained enumerators (three per site) conducted the 12mo survey. Enumerators were each expected to visit three villages that were previously assigned to them.

For each of the villages, enumerators had to pseudo-randomly choose six households in the village enclosure and four households in camps located in the village outskirts (by "wandering" from dwelling to dwelling and following the rules pertaining to size and target species described in Chapter 1). For each household, the enumerator had to fill the questionnaire "Demography" and then the questionnaire "Household". All the household's species (among cattle, goats and sheep) were surveyed. The size of the samples of households and of surveyed animals is provided in Table 4.

Table 4: *Size of samples of households and of animals surveyed for the purposes of the 12mo survey conducted in June 2006 under the PAD Project in Niger (source: Lesnoff et al., 2007d).*

Site	Sample size				
	Villages	Households	Animals		
			Cattle	Goats	Sheep
Fakara	9	90	954	794	597
Gabi	9	90	718	931	732
Zermou	9	90	901	1214	768

3. Calculating the demographic parameters

In this section, average demographic parameters over the three study sites are estimated for goats.

3.1. Preparing the data

We import data under R with function `import.tdemog` and store them in the object `my12mo`:

```
my12mo <- import.tdemog(db = "D:/Users/Data/ 12mo_ v3_PAD_2006.mdb", typsurv =
"12mo")
```

We extract tables `tabanim` and `tabmov` from object `my12mo`:

```
tabanim <- my12mo$tabanim
tabmov <- my12mo$tabmov
```

We select the data relating to goats and we store them in new tables `tabanim` and `tabmov` (which erases the previous ones), which are our two working tables:

```
tabanim <- tabanim[tabanim$species == "CAP", ]
tabmov <- tabmov[tabmov$species == "CAP", ]
```

3.2. Herd number and size

To calculate the numbers of herds surveyed and the size of the herds, we use function `stru` and we specify variable `idfarm` (IDFARM identifier) in argument `formula`. We also specify variable `species` so that the species appears in the results, although this is not strictly necessary here because `tabanim` contains data that relate only to goats.

We store the result in object `res`:

```
res <- stru(formula = ~ species + idfarm, data = tabanim)
```

Object `res` contains a table `tab` where variable `n` is the number of animals per category, i.e. in this case, by herd:

```
res$tab
    species idfarm  n  freq
1       CAP      3  7 0.002
2       CAP      4  7 0.002
3       CAP      5  6 0.002
4       CAP      6  9 0.003
5       CAP      7  5 0.002
6       CAP      8 21 0.007
etc.
```

We compute the number of herds (for goats) surveyed with function `nrow` in R:

```
nrow(res$tab)
[1] 241
```

A total of 241 herds were surveyed. We summary variable `n` using function `summary` in R:

```
summary(res$tab$n)
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
    1.0     6.0    10.0    12.2    15.0    56.0
```

The size of herds varied from 1 to 56 goats, the average being 12.2 goats. We use function `histogram` of R to plot the distribution of variable `n` (providing package lattice in R has been activated) (Figure 9):

```
histogram(
    x = ~ n,
    n = 30,
    xlab = "Number of herds",
    ylab = "Herd size",
    data = res$tab
    )
```

(In the script above, `n = 30` determines the approximate number of classes sought in the histogram; users may alter its value to achieve broader or narrower herd size categories).

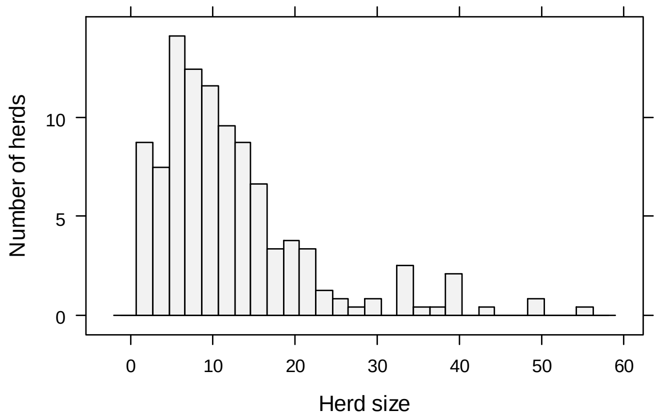


Figure 9: *Distribution of goats herd sizes (numbers of animals) in the example (12mo survey under the PAD Project in Niger in June 2006).*

3.3. Herd structure

Like for the herd size, we use function `stru` and table `tabanim` to calculate distribution by sex and age.

3.3.1. Sex structure

We specify variable `sex` in argument `formula`:

```
stru(formula = ~ species + sex, data = tabanim)
$tab
  species sex n  freq
1     CAP   F   2304 0.784
2     CAP   M    635 0.216
```

The population of goats was composed of 78% of females and 22% of males.

3.3.2. Sex-by-age structure

We add variable `age` from table `tabanim` in argument `formula` so as to get the distribution by annual age class. We store the results in object `res` so as to be plotted as a graph:

```
res <- stru(formula = ~ species + sex + age, data = tabanim)
res
$tab
   species sex     age      n  freq
1       CAP   F      0    724 0.246
2       CAP   F      1    323 0.110
3       CAP   F      2    304 0.103
4       CAP   F      3    329 0.112
5       CAP   F      4    267 0.091
6       CAP   F      5    166 0.056
7       CAP   F      6     95 0.032
8       CAP   F      7     65 0.022
9       CAP   F      8     17 0.006
10      CAP   F      9      4 0.001
11      CAP   F     10      8 0.003
12      CAP   F     12      2 0.001
13      CAP   M      0    540 0.184
14      CAP   M      1     59 0.020
15      CAP   M      2     31 0.011
16      CAP   M      3      3 0.001
17      CAP   M      4      1 0.000
18      CAP   M      6      1 0.000
```

Variable `freq` in table `tab` reflects relative frequencies (`tab$freq` always sums to 1). Females and males with exact age ≤1 year (age class 0) accounted for respectively 25 and 18% of the goats. The maximum exact age was 13 years (age class 12) for females and 7 years (age class 6) for males. Only five males had an exact age >3 years.

We use function `barchart` of R to plot this sex-by-age distribution (providing package lattice in R has been activated) (Figure 10):

```
barchart(
    x = 100 * freq ~ age | sex,
    layout = c(1, 2),
    horizontal = FALSE, as.table = TRUE,
    ylim = c(0, 30),
    xlab = "Age class (year)",
    ylab = "Proportion of animals (%)",
    data = res$tab
    )
```

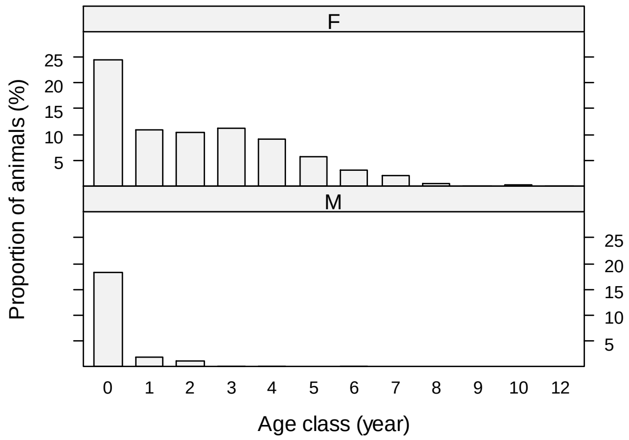


Figure 10: *Sex-by-age distribution of the goat population in the example (PAD project 12mo survey in Niger in June 2006). Age class 0 comprises animals whose exact age ranges from 0 to 1 year(0 to 12 months), age class 1 comprises animals whose exact age ranges from >1 to 2 years (>12 to 24 months), etc.*

In addition, we recommend calculating the same distribution considering only the animals born in the surveyed herds, that households are assumed to be better acquainted with. If this is significantly different from the distribution as computed for all the animals, there may be a reliability issue in relation to age data collected through the survey.

In our example, the two distributions are very similar:

```
stru(formula = ~ species + sex + age, data = tabanim[tabanim$born == 1, ])
$tab
   species sex     age       n  freq
1       CAP    F     0     656 0.257
2       CAP    F     1     260 0.102
3       CAP    F     2     244 0.096
4       CAP    F     3     261 0.102
5       CAP    F     4     223 0.087
6       CAP    F     5     141 0.055
7       CAP    F     6      82 0.032
8       CAP    F     7      52 0.020
9       CAP    F     8      15 0.006
10      CAP    F     9       2 0.001
11      CAP    F    10       8 0.003
12      CAP    F    12       1 0.000
13      CAP    M     0     519 0.203
14      CAP    M     1      53 0.021
15      CAP    M     2      29 0.011
16      CAP    M     3       3 0.001
17      CAP    M     4       1 0.000
18      CAP    M     6       1 0.000
```

3.4. Mortality, offtake and intake rates

For these rates, we recommend to group the age classes. This attenuates the age classification errors.

In the example, we calculate rates by sex for two age groups: "0" represents exact ages ranging from 0 to 1 year (0 to 12 months) and "1^+" the exact ages >1 year (>12 months).

3.4.1. Mortality

We generate a variable `agegroup` for these groups 0 an 1^+ using function `ifelse` of R:

```
tabmov$agegroup <- ifelse(tabmov$age == 0, 0, 1)
```

We use function `exit` and table `tabmov`. We calculate rates by sex and age group. We store the results in object `res`:

```
res <- exit(formula = ~ species + sex + agegroup, data = tabmov, event = "DEA")
res
$tab
  species sex agegroup   trisk nbevent     h  se.h
1     CAP   F        0  596.75     148 0.248 0.020
2     CAP   F        1 1556.25     122 0.078 0.007
3     CAP   M        0  410.75     111 0.270 0.026
4     CAP   M        1   99.50       4 0.040 0.020
```

The estimated mortality rates for females and males in age group 0 were 0.248 and 0.270 $years^{-1}$. Those for age group 1^+ were 0.078 and 0.040 $years^{-1}$. To pursue the analysis further would require to statistically test the differences found between these estimates, for instance between males and females (for examples of tests under R, see Lesnoff *et al.*, 2007a, b).

We use function `dotplot` of R to plot the mortality rates by age group (providing that package lattice in R has been activated) (Figure 11):

```
dotplot(
    x = 100 * h ~ agegroup,
    groups = sex, auto.key = TRUE,
    xlab = "Age group",
    ylab = expression(paste("Mortality rate (year "^-1, ")")),
    data = res$tab
    )
```

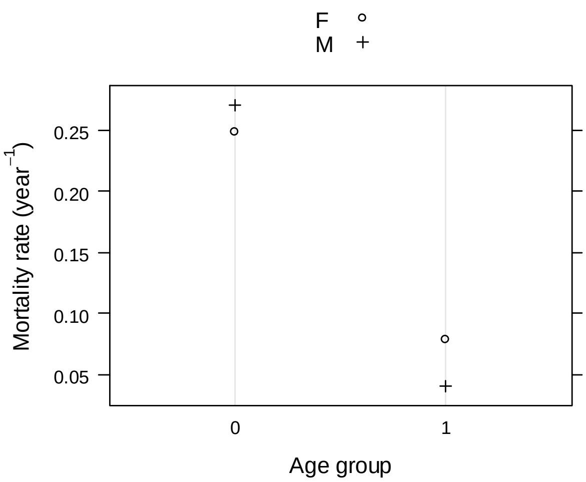


Figure 11: *Mortality rates for age groups 0 (0 to 12 months) and 1⁺ (> 12 months) of the goat population in the example (PAD 12mo survey in Niger, June 2006).*

3.4.2. Offtake

Offtake rates are calculated in the same way as mortality rates, but with a different code in argument `event`.

Overall offtake rates are obtained as follows:

```
exit(formula = ~ species + sex + agegroup, data = tabmov, event = "OFF")
$tab
  species sex agegroup   trisk nbevent     h  se.h
1     CAP   F        0  596.75     161 0.270 0.021
2     CAP   F        1 1556.25     229 0.147 0.010
3     CAP   M        0  410.75     293 0.713 0.042
4     CAP   M        1   99.50     104 1.045 0.102
```

It is characteristic of small ruminants that offtake rates for males are much higher than those for females. For instance in age group 1^+, estimated offtake rates were 1.045 $years^{-1}$ for males and 0.147 $years^{-1}$ for females.

These rates can be broken down by type of offtake. For instance, to obtain slaughtering rates, code `SLA` should be specified in argument `event`:

```
exit(formula = ~ species + sex + agegroup, data = tabmov, event = "SLA")
$tab
  species sex agegroup   trisk nbevent     h  se.h
1     CAP   F        0  596.75      14 0.023 0.006
2     CAP   F        1 1556.25      30 0.019 0.004
3     CAP   M        0  410.75      60 0.146 0.019
4     CAP   M        1   99.50      47 0.472 0.069
```

3.4.3. Intake

Function `entry` is used just like `exit`. For instance, we calculate overall intake rates using:

```
entry(formula = ~ species + sex + agegroup, data = tabmov, event = "INT")
$tab
  species sex agegroup   trisk nbevent     h  se.h
1     CAP   F        0  596.75      95 0.159 0.016
2     CAP   F        1 1556.25      74 0.048 0.006
3     CAP   M        0  410.75      25 0.061 0.012
4     CAP   M        1   99.50      16 0.161 0.040
```

To estimate "net offtake rates" (= offtake - intake), estimates derived from `entry` can be subtracted from those derived from `exit`. For instance:

```
hoff <- exit(formula = ~ species + sex + agegroup, data = tabmov, event = "OFF")$tab
hint <- entry(formula = ~ species + sex + agegroup, data = tabmov, event = "INT")$tab
data.frame(
    agegroup = c(0, 1, 0, 1),
    sex = c("F","F", "M", "M"),
    hoff = hoff$h,
    hint = hint$h,
    hoff.net = hoff$h - hint$h
    )
  agegroup sex  hoff  hint hoff.net
1        0   F 0.270 0.159    0.111
2        1   F 0.147 0.048    0.099
3        0   M 0.713 0.061    0.652
4        1   M 1.045 0.161    0.884
```

The same result can also be obtained directly using function `exit` (only when `event = "OFF"`) by using argument `net`:

```
exit(formula = ~ species + sex + agegroup, data = tabmov, event = "OFF", net =
TRUE)
$tab
  species sex agegroup   trisk nbevent     h  se.h
1     CAP   F        0  596.75      66 0.111 0.014
2     CAP   F        1 1556.25     155 0.100 0.008
3     CAP   M        0  410.75     268 0.652 0.040
4     CAP   M        1   99.50      88 0.884 0.094
```

3.5. Reproduction

Abortions have not been recorded in the PAD survey. We only describe calculations of parturition, prolificacy and mortinatality rates. In addition, parity of females has not been recorded, and we do not present the regression method for calculating parturition rates.

3.5.1. Parturition rate

For parturitions, we recommend to consider only one age group, referred as "reproductive females" in this handbook.

In small ruminants, earliest parturitions occur towards age of nine months, but most occur after 12 months. Here, we examine only parturition rates for females >12 months.

We use function `partur` and table `tabanim`. We select females in age classes >=1 (this is an approximation for representing females >12 months; appendix 3):

```
partur(formula = ~ species, data = tabanim[tabanim$age >= 1, ])
$tab
  species trisk nbevent     h  se.h
1     CAP  1580    1289 0.816 0.021
```

The estimated parturition rate was 0.816 years^{-1}. This means that a female that was present in the population all year round delivered 0.816 times on average. The corresponding average interval between parturitions, which can be estimated by the reciprocal of the parturition rate, is 365/0.816 = 447 days.

3.5.2. Prolificacy rate

We use function `prolif` and table `tabanim`. Function `prolif` generates table `tab` (containing variable `nbborn` of numbers of progeny, whether born alive or stillborns, for the various individual parturitions) and table `tab.summ` summarizing variable `nbborn`:

```
prolif(formula = ~ species, data = tabanim)
$tab
     species nbborn
1        CAP      2
2        CAP      1
3        CAP      2
4        CAP      1
5        CAP      2
etc.

$tab.summ
  species    n  mean se.mean
1     CAP 1300 1.207   0.012
```

The average prolificacy rate was 1.207 kids per parturition.

3.5.3. Mortinatality

We use function `mortinat` and table `tabanim`:

```
mortinat(formula = ~ species, data = tabanim)
$tab
  species nbborn nbstillborn     p  se.p
1     CAP   1569          70 0.045 0.005
```

Mortinatality rate was 4.5%. A "net prolificacy" (mean number of progeny born alive per parturition) can be computed as follows:

(1 - mortinatality rate) x prolificacy rate = (1 - 0.045) * 1.207 = 1.153.

This result can be obtained directly by using argument `net` in `prolif`:

```
prolif(formula = ~ species, data = tabanim, net = TRUE)$tab.summ
  species    n  mean se.mean
1     CAP 1300 1.153   0.013
```

3.6. Summary of the demographic baseline

A total 241 goats herds – mean size 12.2 animals – were surveyed (min = 1.0; max = 56.0; 75 % of these herds had a mean size <15.0 animals). Females accounted for 78 % of herds and juveniles (females and males ≤12 months) for 43 %. Exact age of did not exceed 13 years in females and 7 years in males (among males, exact age >3 years represented less than 1%).

The other parameters are shown in Table 5.

Table 5: *Summary of mortality, offtake, intake, parturition and prolificacy rates computed in the example(PAD 12mo survey in Niger, June 2006).*

Parameter	Sex	Exact age	
		0 to 12 months	>12 months
Mortality rate [(a)]	F	0.25	0.08
	M	0.27	0.04
Offtake rate	F	0.27	0.15
	M	0.71	1.05
Intake rate	F	0.16	0.05
	M	0.06	0.16
Parturition rate	F	–	0.82
Prolificacy rate	F	–	1.21
Mortinatality rate	F	–	0.05

(a) Probabilities of intrinsic mortality (i.e., natural deaths that would have occurred without offtake) can be computed by $p_{death,\,c} = 1 - \exp(-h_{death})$ (appendix 1). For instance, among females "0 to 12 months" and ">12 months", $p_{death,\,c} = 1 - \exp(-0.25) = 0.22$ and $p_{death,\,c} = 1 - \exp(-0.08) = 0.08$.

Appendix

1. Probabilities an instantaneous hazard rates in demography

A number of basic concepts relating to rates in demography are presented below. Calculation of rates relating to tropical domestic populations is discussed in Lesnoff (2000) and Lesnoff et al. (2007b). Readers are also referred to the many publications on survival analysis methods (e.g. Anderson and Burnham, 1976; Kalbfleisch and Prentice, 1980; Chiang, 1984; Cox et Oakes, 1984; Lee, 1992; Collett, 2003b).

In the area of demography, the rate of occurrence of an event may represent two distinct mathematical parameters: a probability and an instantaneous hazard rate, which in this handbook are notated respectively p and h. This can give rise to ambiguities when the definition of rates and the method for calculating them are not described in detail.

Several terms have been used for h – hazard function, instantaneous hazard rate or intensity of risk. The below description of these parameters derives largely from Collet (2003b), taking the example of mortality. The instantaneous hazard rate for mortality $h_{\text{death}}(t)$ is the risk of natural death per unit of time, at time t: the quantity $h_{\text{death}}(t)dt$ is the expected proportion of surviving animals at time t that will die within the small interval (t, $t + dt$). For a more formal definition, consider 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 $P(t \leq T < t+ dt \mid T \geq t)$, 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:

$$h_{\text{death}}(t) = lim_{dt \to 0} \frac{P(t \leq T < t + dtT \geq t)}{dt}.$$

In the area of livestock-raising, the instantaneous offtake rate $h_{\text{offtake}}(t)$, is defined in the same way as $h_{\text{death}}(t)$. The total instantaneous hazard rate of removal is $h_{\text{total}}(t) = h_{\text{death}}(t) + h_{\text{offtake}}(t)$.

Some of the properties of probabilities and instantaneous hazard rates are described below.

A probability ranges from 0 to 1 and has no unit, whereas an instantaneous hazard rate can be greater than 1 and is expressed in unit time^{-1}.

Under some circumstances, the two parameters are connected by functional relationships (in which case p can be estimated on the basis of h and vice-versa). For instance, if one assumes that the only cause of removal is natural death and that the instantaneous hazard rate h_{death} is constant for the period (t, $t + \Delta t$), the probability of natural death p_{death} during that period can be calculated using the formula (Kalbfleisch and Prentice, 1980; Cox et Oakes, 1984; Lee, 1992):

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

Hence, an instantaneous hazard rate for death of 0.50 year^{-1} (= 0.0417 month^{-1}) is associated with an annual probability of dying of 0.39 (with no offtake), which means that 39%, not 50%, of the 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, 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" to the daily natural death risk, which here is $h_{death}/365$, in the population). It can be computed as follows (Anderson and Burnham, 1976; Chiang, 1984):

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

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

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 the animals will die in average over the year and, in the second case, only 33%.

When data are grouped by category of animal and by period, the probability of occurrence p and the instantaneous hazard rate h can be estimated respectively by:

$$p = m / n \qquad \text{and} \qquad h = m / T,$$

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.

Statistical methods for analysing parameters p and h, and more generally for count data, are numerous and have been widely described. One of the more common methods is the generalized linear models, such as logistic regression for probabilities and log-linear regression for instantaneous hazard rates (Laird and Olivier, 1981; Larson, 1984; Aitkin et al., 1989; McCullagh and Nelder, 1989; Agresti, 1990; Collett, 2003a). Concerning these statistical aspects, readers may refer to the articles and publications cited.

2. Annual mean number of animals by age class

We describe the method used for calculating the mean number m of animals by annual age class over the last twelve months (chapter 4) used to approximate the time of presence T in the calculation of mortality, offtake and intake rates.

For a given category of animals (species, breed, sex, etc.), the data available from the survey for each age class i are:

- $n_{t,\ i}$: the number of animals present on the survey date in age class *i*;
- $m_{entry,\ i}$: the number of entries into age class *i* in the last twelve months;
- $m_{exit,\ i}$: the number of exits into age class *i* in the last twelve months.

The principle for calculating the numbers of animals present at time *t* - 1 year, i.e. twelve months prior to the survey date, is as follows (the example is illustrated in Figure 12). Entries and exits are assumed to be uniformly distributed over time and within the age class. The number of animals present in age class *i* -1 at time *t* -1 is then estimated by the approximation:

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

This approximation is made for each age class and the mean number of animals for each age class *i* is then calculated by $(n_{t\ -1,\ approx,\ i} + n_{t,i})/2$.

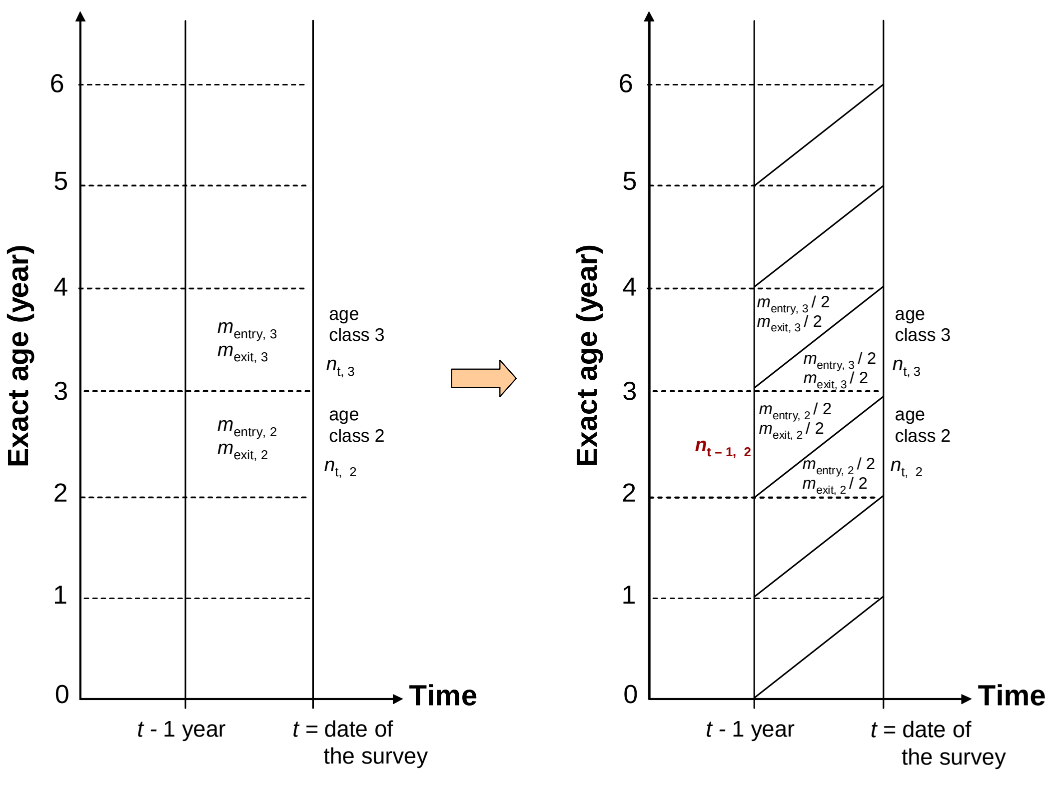


Figure 12: *Method for computing the mean number m (over the last twelve months) of animals by annual age class (chapter 4) used in formula h = m / T for mortality, offtake and intake rates. For instance, the number of animals present in age class 2 twelve months before the survey is estimated by* $n_{t\ -\ 1,\ approx,\ 2} = n_{t,\ 3} - (m_{entry,\ 2} - m_{exit,\ 2}) / 2 - (m_{entry,\ 3} - m_{exit,\ 3}) / 2.$

3. Abortions and parturitions in sub-questionnaire Q1

In a graph that plots "age as a function of time", referred to as a Lexis diagram (e.g., Pressat, 1983), the previous twelve months of the females present in an annual age class at the time of the survey can be plotted by a parallelogram (or, in the case of age class 0, a triangle) (Figure 13). These parallelograms are referred as "vertical demographic decomposition units" in Lesnoff *et al.* (2007b). The same name is used in this handbook. Decomposition units have indexes from 0 to *L*, *L* being the maximum age (in years) encountered in the survey.

Vertical decomposition unit *j* reflects the history over the previous twelve months of a female of age class *j* (i.e., one with an exact age ranging from *j* to *j* + 1 years) on the survey date (Figure 13). In contrast with entries and exits recorded in Q2 and Q3, parturitions (or abortions) recorded in Q1 belong to vertical unit *j*, and not exactly to the square corresponding to the "females having an exact age between *j* and *j* + 1 between time *t* and time t + *1*".

In 12mo, this problem is neglected when calculating parturition rates with formula $h = m_{parturition} / T$ for the age group "reproductive females". For instance, if the reproductive females are defined by the females of exact age >4 years (48 months) between time *t* - 1 and time *t*, this age group is assimilated to vertical units >=4 (while the inferior triangle of the vertical unit 4 should not be counted).

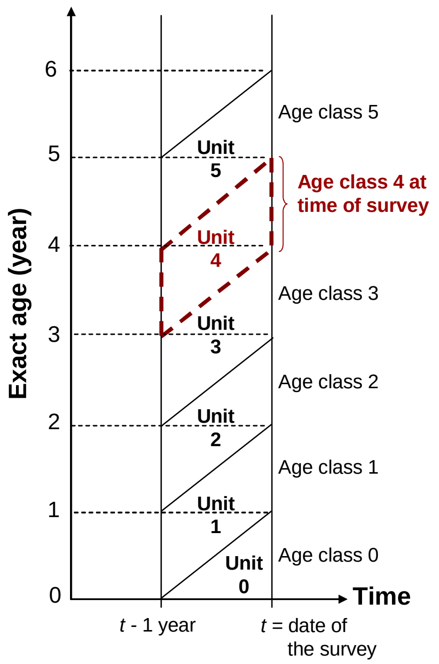


Figure 13: *Vertical demographic decomposition units used for calculating the abortion and parturition rates in 12mo. Unit j reflects the reproductive career over the previous twelve months of a female in age group j (exact age ranging from j to j + 1 years) on the survey date (as an example, unit 4 is bounded by dotted lines).*

4. Installing R and package tdemog

We describe two installation procedures – one is automatic and recommended for beginners in R, and the other is manual.

4.1. Automatic installation

The executable file Rsetup_gead.exe was developed by CIRAD. It contains the R software, the package tdemog, the package RODBC (http://cran.at.r-project.org/) for importing data in the Access ©, Excel ©, etc. formats together, and other R packages that are not specific to this handbook.

Double-clicking on the Rsetup_gead.exe executable file automatically installs the R software and the packages mentioned above in the directory C:\Program Files\R\R-x.x.x, where x.x.x is the version number for the R software installed by Rsetup_gead.exe (for instance R-2.6.2 is version 2.6.2 of the software).

If this installation procedure is used, package tdemog is loaded (i.e., activated) automatically every time the R software is opened – there is no need for the user to load the package manually, see section below.

Caution: Rsetup_gead.exe is updated on a regular basis. However updates are not always concomitant with the release of a new version of the R software. The R software installed by Rsetup_gead.exe may not be the most recent version available at the official site for the software (http://www.r-project.org/).

4.2. Advanced Installation

As an alternative to Rsetup_gead.exe, more advanced users can manually install the R software components.

The installation file for the basic R software can be downloaded directly from the CRAN page of the R project site - http://www.r-project.org/ (CRAN is the acronym for Comprehensive R Archive Network). In addition to the basic software, a minimal requirement is to install the packages RODBC and tdemog – RODBC can be downloaded from the CRAN page.

Packages can be installed once R is open using the scroll-down menu "Package" located at the top of the "R Console" window.

When advanced installation is performed, package tdemog must be loaded manually every time the R software is activated. If the package has been installed, it can be loaded using the "Package" scroll-menu in the "R Console" window or through function `library` of R (for instance, the command **`library(tdemog)`** loads the package tdemog).

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