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A Simple Retrospective Demographic Survey Tool Adapted To Traditional Livestock Systems: Application to Cattle Herds In Sahelian Zone In Niger

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Abstract
This study reports a simple retrospective demographic survey tool based on 12 month surveys, covering the period of the last twelve months preceding the survey. The methodology offers a complete chain, from the field protocol to the calculation of demographic parameters. In Niger, the interest in the broad sense of the application of this method remains unknown or is taken into account to a lesser extent. In addition, the dispersion and mobility of herds pose specific problems for the collection of demographic data. Local structures in the livestock sector are constantly facing difficulties in estimating the effects of interventions and shocks on the herds. The lack of a tool for bioeconomic decision-making has to date becomes a major concern the impetus for a sustainable agrarian system.. The present study shows the interest of the 12 MO method as an alternative to fill these gaps. Demographic data from 1,412 cattle from fifty herds were analyzed. The annuals rates parturition, abortion and stillbirth of cows, calculated to study the reproductive performance of herds, have varied according to the age and breed of the animals studied. Also, physiological phenomena involving certain age-related demographic rates have been highlighted. The analysis of the rates according to the breeds, established for animals having evolved in the same space-time, will allow opening in an objective way the debate on the comparison of the zootechnical performances of the local breeds. Balance sheet of natural rates has generated a productivity rate whose improvement is favored to the size and breeding females of the herds. A relatively high exploitation rate has also been observed, which invites further reflection on the demographic factors determining of average sustainable exploitable potential of herds. Demographic projections and the use of the Lexis diagram are emerging perspectives for assessing this potential while correcting bias rates of memory and reporting, associated with 12 MO method.

Keywords: *Demographic rate; Survey tool; Extensive system; Cattle; Niger*

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I. Introduction

In Niger, livestock plays an important role in the national economy and contributes 11% to national Gross Domestic Product (GDP) and 24% to agricultural GDP (SDDEL, 2013; Aboubacar, 2017). Despite, it dependence on environmental and climatic conditions which affect the dynamics of pastoral systems (Aboubacar, 2017), livestock farming also contributes more than 15% to household budget by ensuring the satisfaction of food needs by up to 25% (SDDEL , 2013).

Despite the growing role of livestock in Niger, the demographic characteristics of villagers' livestock have been little studied. Traditional farming systems pose specific problems for collecting demographic data (Lesnoff, 2011). Collecting this data is the most difficult and demanding part of the work, due to the dispersal and mobility of herds and the fact that breeders do not keep written records on their herds (Lesnof, 2013). The lack of a bioeconomic decision-making tool has become, to date, a major challenge for the impetus of a sustainable agrarian system, as shown by several studies such as that of Ba (2011), Yoann (2012) and Lesnoff (2013).

In this context, one of the objectives of this work was to assess the demographic rates of cattle herds in the extensive farming systems of the rural commune of Sassoumbroum, in the Zinder region (Niger). The choice of the study area is justified by the diversity of cattle breeds in the farming systems put in place and the

observation of the beginnings of a dynamic of integration of agro-pastoral practices (Rhissa, 2010). The regional cattle population in the study area (Zinder region) is significantly larger than that of other regions of the country. The breeding is carried out in the rural commune of Sassoumbroum in a semi intensive mode around the villages and the fields of cultures, and in a limited extensive mode because those which practiced it, tended to reconvert into sedentary.

Among the main survey methods commonly developed and used (Lesnoff et *al.*, 2007), the retrospective method called 12MO is well suited to the specific problems mentioned above. The 12MO tool was used in several African countries to carry out a preliminary diagnosis on the productivity of endemic West African livestock (Lesnoff, 2011).

In Niger, if it is admitted that the method is known as a valuable tool for zootechnical investigation, it is less obvious that it is used in the field by local structures. There are, in fact, very few publications on data collected by this method. The use of the methodology in the works remains timid since the preliminary surveys conducted in 2006 by ILRI / ICRISAT to study the variability of demographic rates according to a west-east gradient and in 2007 by the Ministry of Animal Resources conducted on the whole country as part of the General Census of Agriculture and Livestock. The most recent studies on demographic characteristics using the 12 MO method date back to 2008, in the administrative region of Tahoua as part of a European support project for technical services (Lesnoff, 2011). The method nevertheless provides standard tools for estimating a large panel of annual demographic rates, while remaining sufficiently simple and easily achievable.

The present study shows the interest of the 12 MO method as an alternative to fill these gaps. The study then insisted, because it was little known, on the productivity of herds by using synthetic demographic rates (Lesnoff, 2011) more complete than many of the indicators proposed in the literature to quantify this productivity.

II. Material And Methods

2.1 Study area

The Rural Municipality of Sassoumbroum is located in the southwest of the Zinder Region with an area of 322.43 km2 and limited to the South by the Federal Republic of Nigeria (Fig. 1). The soil cover is dominated by tropical ferruginous soils with little or no leaching, low fertility and hydro-morphic shallow soils. The region's annual rainfall, estimated in 2015, was 450.4 mm for 41 days of precipitation (INS, 2016). It is located in the North Sudanese Central phytogeographical compartment with vegetation consisting of (Saadou, 1990):

- Low dry forest on the plateaus;
- Gallery forest on the banks of watercourses;
- Savannah on sandy terraces, dunes and dry valleys.

Rain-fed agriculture is the main activity of the population of Sassoumbroum and some irrigated crops were grown along the valleys during the dry season. Livestock farming, the second activity after agriculture, it is carried out in an intensive and extensive way. Semi-intensive livestock farming involves small ruminants and some draft oxen which is carried out by sedentary people around villages and crop fields. Extensive livestock farming generally concerns cattle, sheep and goats, and practiced by Fulani nomads who tend to convert to sedentary.

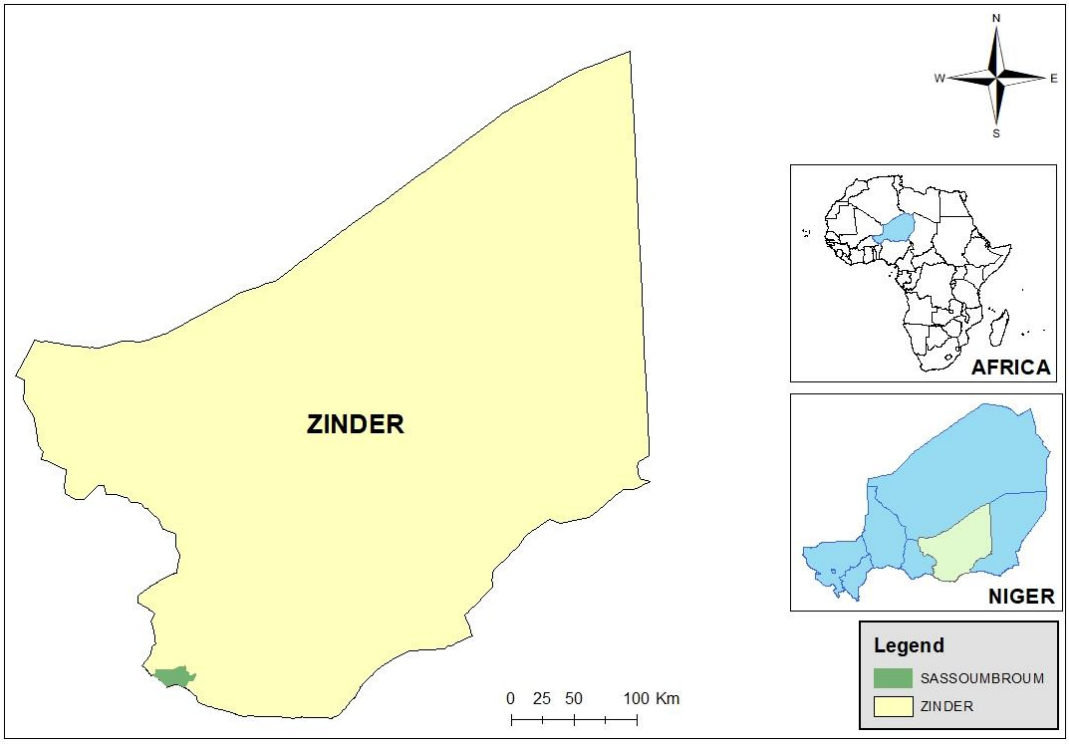

Fig. 1 Geographical location of the rural commune of Sassoumbroum (edit by authors)

2.2. Methodology

The methodology used was based on retrospective surveys 12 MO, as described by Lesnoff et *al.* (2007), and used in several studies on the zootechnical parameters of domestic ruminant herds in Sahelian countries (Lesnoff *et al.,* 2009 ; Ba, 2011 ; Assani *et al.,* 2016 ; Toko et *al*., 2016 ; Azalou et *al*., 2017, Zampaligre et al., 2019). The 12 MO method regenerate herd demography based on the memory and declarations of the breeders in the period of the last twelve months preceding the survey (Lesnoff et *al*., 2007). On the field, the method consists to make an inventory of the animals present in the herd at the time of the survey, estimate their age and all demographic events (birth, mortality, exploitation and importation), by sex and age class, occurring in the herd during the last twelve months.

The survey was conducted in the rural municipality of Sassoumbroum in June 2019 and therefore covers the 12 months preceding this period. Additional data on herd management was also collected from farmers for a detailed analysis of the livestock farming systems in place. For that, an inventory of the most relevant livestock farming practices was necessary. The questionary developed for this purpose included socio-professional status of respondents, herd food management, prophylaxis, milking practices and herd exploitation.

Herds suitable for standards 12 MO survey (Lesnoff, 2013) were first identified at the level of the breeders of the Municipality. These corresponded to functional herds able to renew itself by births and whose size varied between 9 to 54 heads (including juveniles) with at least five breeding females and belonging to only one household. The 12MO demographic questionnaire was administered to the farmer in the presence of all the animals in the herd. This 12 month method (12MO) offers a complete chain, from field protocol to calculation of demographic parameters

2.3. Calculation of demographic rates

The demographic parameters used in this study were instant risk rates. Each rate was estimated as the number of the demographic event occurring in the past 12 months, divided by the total time "at risk" (Lesnoff, 2008). The annual rates of calving or abortion of cows (HC and HA respectively) and the stillbirth rate (HM) were calculated first for the sample, then for each age group and for each breed by the formula as:

- $\mathrm{HCi} = \mathrm{C}/(\mathrm{N\ Cows})$
- $\mathrm{HAi} = \mathrm{A}/(\mathrm{N\ Cows})\mathrm{A}$
- $\mathrm{HMi} = \mathrm{M}/\mathrm{P}$

Where C = number of births, A = number of abortions, M = number of stillbirths and i represents the age class or breed index (this index is eliminated from the formula when the calculation is performed for all herds). These rates have been calculated to study the reproductive performance of herds. The exploitation (slaughtering, sale, donation, etc.) and import (purchase, donation, inheritance, etc.) rates were calculated to study the behavior of

breeders regards herds' management. Exploitation and import demographic rates were estimated by the ratio between the number of demographic events observed in the follow-up year (12 months preceding the survey) and the average size of the herd. In order to assess the hypothesis of a link between herd size and demographic parameters, four herd size classes were defined in relation to the number of cows kept on average over the year. For each sex, breed, age class and herd class, the annual mortality, exploitation (slaughtering, sales and loan) and import (purchase and loan return) rates were calculated respectively by:

- Death rate: $\mathrm{h\,dea,i} = \frac{\mathrm{Di}}{\mathrm{N}}$
- Export rate: $\mathrm{h\,off,i} = \frac{\mathrm{Ei}}{\mathrm{N}}$
- Import rate: $\mathrm{h\,int,i} = \mathrm{Ii}/(\mathrm{N})$

Where D = Number of natural deaths, E = Number of export, I = Number of import, N = Average herd size and i represents the index of sex, race, age class and herd class, which is eliminated from the formula when the calculation is performed on the whole herd. Subsequently, several synthetic annual rates were calculated for the predefined herd classes. The synthetic rates were easily calculated, for each class of herd, empirically by directly aggregating the entries and exits of animals occurring during the last 12 months preceding the survey period (Lesnoff et *al*., 2009):

- The empirical productivity rate : $\mathrm{P\,emp\,i} = ((\mathrm{B\,i} - \mathrm{D\,i}))/(\mathrm{N\,i})$
- the net operating rate :$\mathrm{h\,net\,E,i} = \mathrm{hoff,i} - \mathrm{h\,I,i}$
- The gross growth rate: $\mathrm{G\,emp} = \mathrm{Pemp\,i} - \mathrm{hnet\,off\,i}$

B being the number of products born alive, i represent the herd class index, which is eliminated from the formula when the calculation is carried out on the whole herd.

2.4. Statistical analysis

The 12 MO method includes a standardized field protocol, survey questionnaires, an Ms Access database and computer routines for estimating demographic parameters. These routines have been grouped together as an R package called "t12mo" (Lesnoff et *al*., 2007). Thus, the data collected were registrated into the Access 12 MO database and saved under the software R.3.3.2 (R Core Team, 2013). The different parameters were then calculated from the t12mo package. The functions of the t12mo package are listed in Table 1. Four (4) work tables were used in the calculation of demographic rates. They were used as input data to the t12mo calculation functions. These functions directly generate the tables of demographic parameters. Then used as input data for regression analyzes of demographic rates using the basic R packages and functions ("tdisplay", "ggplot2", " e1071 "," plot "," panel.smooth ", etc.).

Table 1 Main functions of the R t12mo package used for calculating demographic rates (Lesnoff et *al*., 2007)

Function	**Objective**	**Data used**
disp	Display the contents of each variable of the tables present in database 12mo.accdb (this function is used for data checking).	12mo.accdb
check	Check the contents of the tables present in database 12mo.accdb (this function is used for data checking).	12mo.accdb
import12mo	Import data from the database 12mo.accdb under R and prepare the data for calculations of the demographic parameters (the function creates the working tables tabanim, tabpar, tabmov and tabamr)	12mo.accdb
stru	Herd size and sex-and-age structure	Tabanim
abort	Abortion rate	tabpar
partur	Parturition rate	tabpar
prolif	Prolificacy rate	Tabanim
Stillb	Stillbirth rate	tabanim
Exit	Exit rates (mortality and off take)	tabmov
Entry	Intake rates	tabmov
typexit	Number of exits per type	tabmov
typentry	Number of entries per type	tabmov
syntmov	Synthesis of exit (mortality and off take) and entry (intake) rates	tabmov
prod	Overall demographic indicators (annual growth and production rates)	tabprod

III. Results

3.1. Farming systems characteristics

The breeders interviewed in the rural commune of Sassoumbroum Fulani ethnic group (100% of the respondents), agro-pastoralists who practiced agriculture (98% of respondents) as their main activity and livestock as a secondary activity. The analysis of livestock farming practices showed that animals feed was mainly based on mobility in the form of transhumance in the rainy season (38 and 52% of respondents respectively for transhumance with low amplitude and large amplitude) and nomadism during the dry season (78% of respondents). According to all respondents, the animals were regularly vaccinated once during the dry season, for some epizootics.

The result shows that the main constraints of the livestock development were food deficit (90%) and pathological (86%), rangelands reduction (20%), limited available space for livestock activities (38%), difficulties of passage lanes access (32%) and a limited zoo-technical performance (34%).

The survey also, showed that 30% of respondents used animal supplementation as an alternative way to alleviate feed deficit mainly in the dry season. However, the supplementation was used for specific animals like young weaned and Bulls respectively 6 and 3 %.

During milking cows, the breeders were taking to account the needs of self-consumption, the marketable needs and those of the veal (Table 2). 74% of breeders' weren't emptying all four udders during milking. The milk quantity voluntarily made available to the calf was varied, according to respondents, from an eighth to Half of the total daily production per cow. The main use of milk was sales with or without processing (90%) and self-consumption (10%). Problems with poor sales were only reported by 16% of breeders.

Table 2 Breeding practices of the agro-pastoralists in the commune of Sassoumbroum

Practice	**Modalities**	**Numbers**	**Percentage**	**% cumulative**
Milk milking	At empty	13	26	26
	At More than half	33	66	46
	At Half	4	8	100
Main use	Self-consumption	5	10	10
	Direct sale	44	88	98
	Sale after transformation	1	2	100
Secondary use	Self-consumption	45	90	90
	Direct sale	5	10	100

3.1. Herd demographic structure

The size of the herds studied was varied from 9 to 54 heads with an average of 28.4 ± 9.10 heads and a mode (the most frequent herd size) of 28 animals (Fig. 2a). All animals in the same herd belonged to a single household. The Djelli zebu race, dominating the race structure of the herds, was varied between 3 and 20 heads with an average of 9.4 ± 3.7 heads per herd(Fig. 2b).The other breeds, composing the herds were Bororo (between 1 to 17 heads with an average of 6.9 ± 3.0 per flock), the Gudali (varied from 2 to 16 heads with an average of 6.6 ± 2.9 per flock) and the Azawak race (between 2 to 13 heads with an average of 5.5 ± 2.7 per herd).The first three breeds were present in all households surveyed, while Azawak was present only in 47 households of the 50 studied. The presence of a few Arabian breed (numbers varied from 1 to 4 animals in three households) and Kuri (varied from 1 to 3 animals in 7 households) were also observed in the herds (Fig. 2b).

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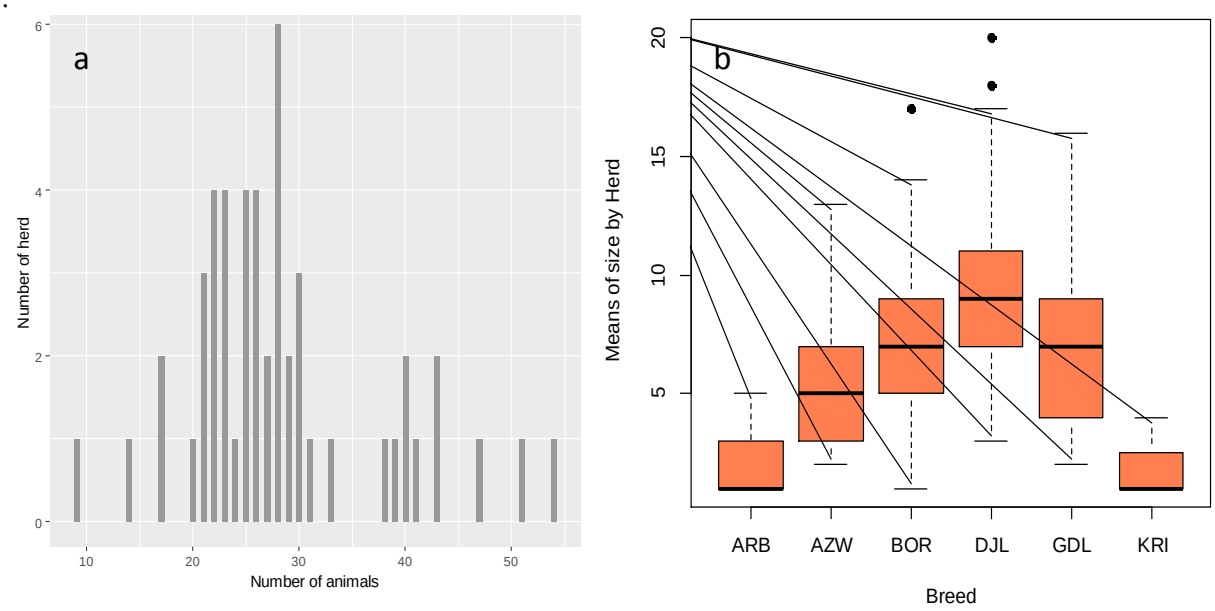

Legend: ARB: Arabian race; AZW: Bororo race; DJL: Djelli race; GDL: Gudali race; KRI: Kuri race

Fig. 2 Demographic structure of herds: distribution of herds by size (a) and average number of breeds by herd (b)

A total of 1.412 cattle divided into 972 females (68.5%) and 446 males (31.5%) composed the herds studied. The age pyramid drawn up from the sample studied presented an evolutionary, sawtooth structure with a wide base (Fig. 3a). Indeed, young animals less than a year old and sub-adults (1 to 4 years old) represented 18.2 and 23% of the total population, respectively (Fig. 3b). females dominated in the herds and were present until the age of 15 years whereas, bulls were completely eliminated from the age of 13 years (Fig. 3). The age pyramid also indicates for both sexes an reduction of individuals in age classes from to 2-3 years, 5-6 and 12-13 year age class (Fig. 3). The age pyramid shows that the recovery time after each fall was 2, 4 and 3 years, respectively.

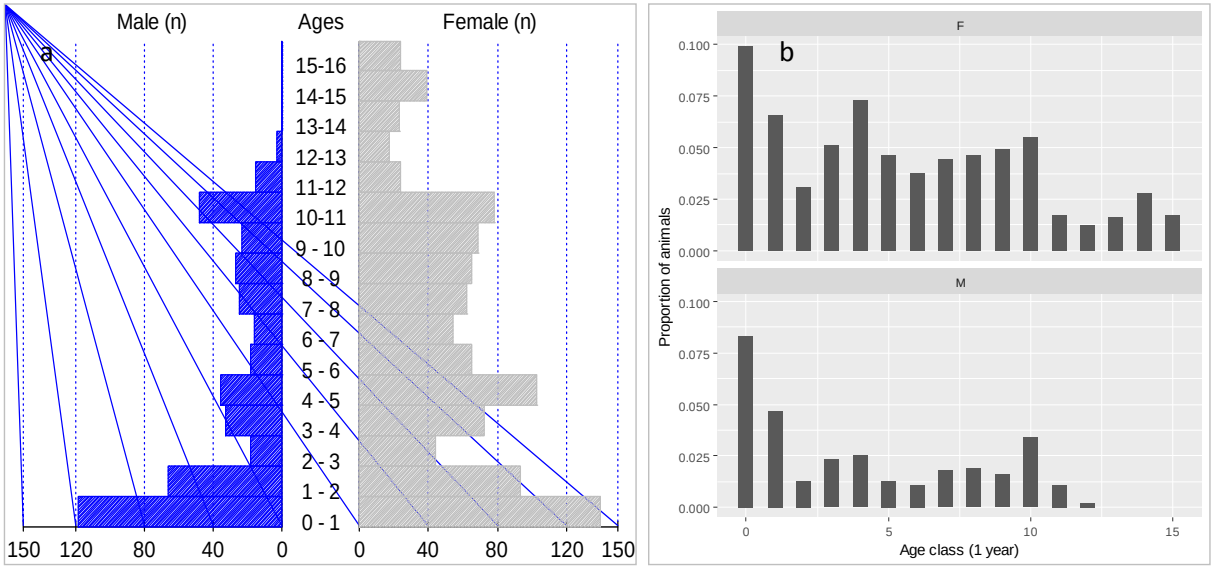

Fig. 3 Herd age pyramid (a) and animals proportion by age class

3.1. Herd reproduction performance

The first parturition was observed at 4 years old with an average rate of 0.19 ± 0.02 / year corresponding to the lowest rate (Fig. 4a). The average calving rate for females' age class from 4 years to more (all females with a reproductive age) was 0.50 ± 0.02 / year. The average was increased progressively and reaches 0.69 ± 0.08 / year for females of 9 years age class. The calving rate then dropped to an average value of

0.59 ± 0.13 / year at 12 years from which, it was observed with an average of 0.60 / year up to 15 years (Fig. 4a). A slight variation in this rate was observed according to race (Fig. 4b), the average values were 0.46 ± 0.05 / year for Azawak race, 0.47 ± 0.04 / year for Bororo race and were slightly higher with Djelli (0.51 ± 0.04 / year) and Gudali (0.51 ± 0.04 / year) races.

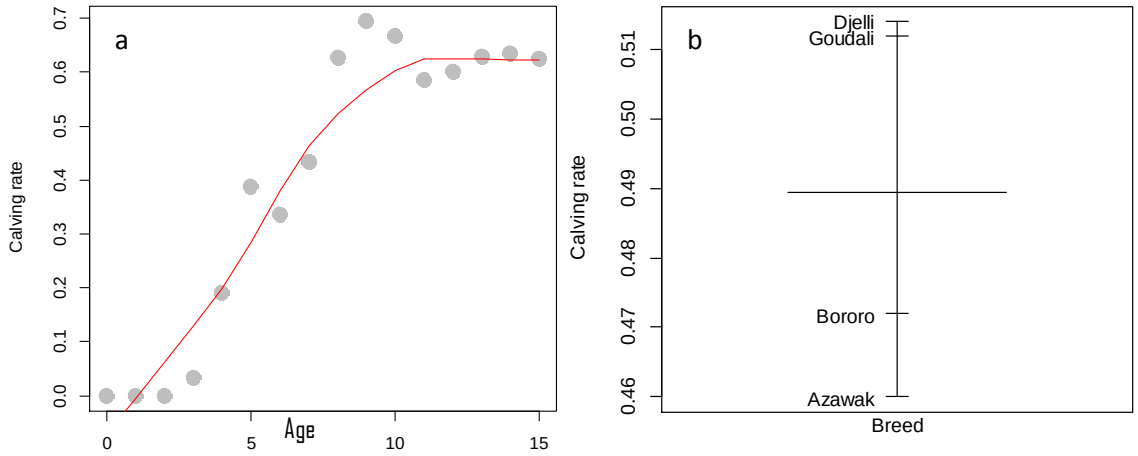

Fig. 4 Variation in parturition rate by age class (a) and race (b)

Linear regression adjustment of age prediction from the parity of breeding females (age class ≥ 4 years) resulted in two equations (Fig. 5):

•Age = 0.41 * parity (without intercept) or

•Age = 0.45 * parity - 1.68 (with intercept).

The p-value associated with these two models was <2.2e-16, which means a better description of the relationship between age and parity better than a null model. The values of t and their p-values (<2.2e-16) indicate that the regression coefficients of these two equations were significantly different from zero. The parity variable therefore had a significant influence on animal's age. The adjusted R2 was 0.94 and 0.89 respectively for the two models, so the equation age = 0.41 * parity explains a greater proportion of variation than the model with intercept.

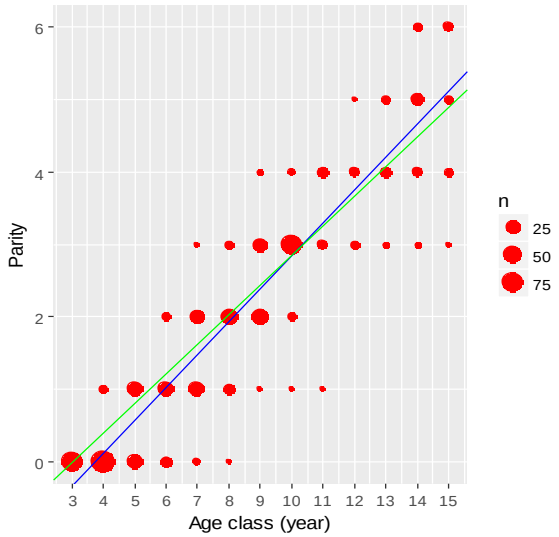

Fig. 5 Linear regressions of age × parity for bovine females according to two models: with and without "intercept"

The average abortion rate for all females of reproductive age was 0.037 ± 0.002 / year. This rate was lowest for females of 4 year age class (0.012 ± 0.001 / year). Above 4 years, abortions seem to be more frequent with young and elderly females (Fig. 6a). Indeed, the rate was reached 0.060 ± 0.008 / year at 6 years old, was decreased with cows of 8 years (0.030 ± 0.004 / year), then was increased for 13 years old (0.065 ± 0.012 / year). Important variation in abortion rate was observed between races (Fig. 6b). Abortions were more frequent for Azawak race (0.036 ± 0.003 / year) than that for Djelli race (0.027 ± 0.002 / year). The lowest rates were observed for Gudali (0.020 ± 0.001 / year) and Bororo (0.021 ± 0.002 / year) races.

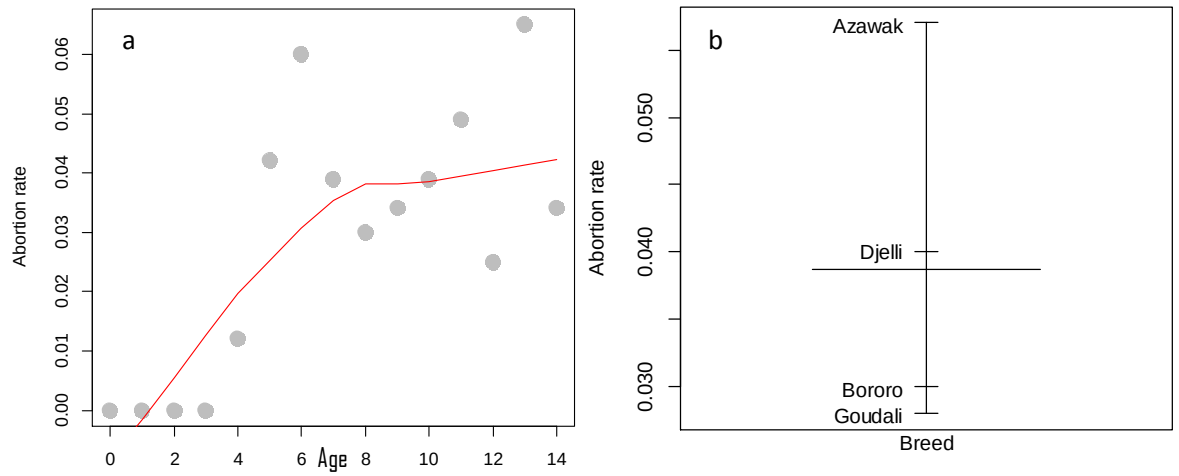

Fig. 6 Variation in the instant abortion rate by age class (a) and race (b)

Likewise, stillbirths were more common in young females and in the oldest class (Fig. 7a). The mean stillbirth rate (0.077 ± 0.016 / year) was associated with a prolific rate of 0.923 ± 0.016 / year. As stillbirth varied by age, the rate was very high for young of 4-year-old females (0.167 ± 0.152 / year), decreased and reaches 0 at 11-12 years old, then increased sawtooth with 13 years (0.071 ± 0.069 / year). Variations by race (Fig. 7b) indicate that stillbirths were relatively more frequent with Azawak race (0.098 ± 0.046 / year), than with Djelli (0.096 ± 0.029 / year) and Gudali (0.096 ± 0.029 / year) races. The lowest rate was observed with Bororo race (0.048 ± 0.027 / year).

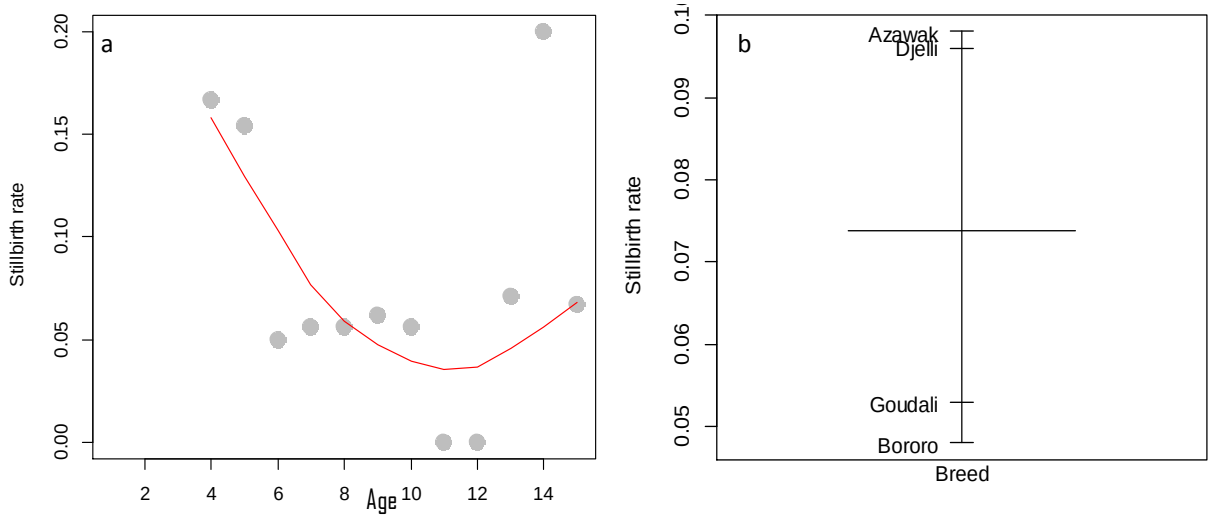

Fig. 7 Variation in the instant stillbirth rate by age class (a) and race (b)

3.1. Demographic rates

The management of the animals studied were characterized in the farming systems by a high rate of exploitation (sale, slaughter and entrust), the instantaneous average rate of natural death being very low (Table 3). Animal's exploitation was relatively higher with males than females. The values of demographic rates also indicate that the Djelli breed was more exploited compared to Azawak and Bororo. The data also indicate an excess of mortality of this breed in the last 12 months preceding the survey. The means age group (1 to 4 years old) was more concerned with the exploitation, but the rate of natural death was higher among juveniles (less than one year old). None outings were not observed for the two Arab and Kuri breeds race in the past 12 months. Apart from births, the main entry for animals was purchasing, with some returns of loan animals. The purchase involved all breeds, despite a significant inflow was observed in the past 12 months, by purchasing the Arab and Kuri breeds. All of these entries particularly affect the means age class and males.

Table 3 Instantaneous rate (in Year-1) of animals leaving and entering during the last 12 months preceding the survey

Variables	Modalities	Average exit rates (%)					Average entry rates (%)		
		Natural death	Slaughter	Sale	ready	Total	buy	Loan return	Total
Overall average		1.6±0.3	1.1±0.3	4.7±0.6	1.0±0.3	8.5±0.8	3.8±0.5	3.8±0.5	7.6±0 .2
Sexes	Female	1.3±0.4	1.3±0.4	4.0±0.7	1.4±0.4	8.1±0.9	2.9±0.6	0.8±0 .3	3.7±0 .6
	Male	2.3±0.8	0.8±0.4	6.4±1.3	0.0±0.0	9.5±1.6	5.9±1.2	0.3±0.3	6.1±1 .3
Breeds	Arabian	19±19	0.0±0.0	0.0±0.0	0.0±0.0	19±19	57.1±33	0.0±0.0	57.1±33
	Azawak	1.3±0.7	0.9±0 .6	3.9±1 .3	0.4±0.4	6.4±1.7	4.7±1.4	0.4±0 .4	5.1±1 .5
	Bororo	0.9±0.5	0.3±0 .3	4.1±1 .1	1.9±0.8	7.2±1.5	4.4±1.2	0.6±0 .4	5.0±1.3
	Djelli	2.5±0.8	1.6±0 .6	6.2±1 .2	0.9±0.5	11.2±1.6	2.1±0.8	0.7±0 .4	2.7±0.8
	Gudali	1.0±0.6	1.6±0 .7	4.3±1.2	0.7±0.5	7.6±1.6	3.0±1.0	0.7±0 .5	3.6±1.1
	Kuri	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	40±20	0.0±0.0	40±20
Age classes	Juvenile	8.9±2.0	0.0±0 .0	0.0±0 .0	0.0±0 .0	8.9±2.0	0.0±0.0	0.0±0 .0	0.0±0 .0
	Sub-adult	0.1±0.1	0.3±0 .3	3.4±1.0	1.6±0.7	5.3±1.3	4.1±1.1	0.0±0 .0	4.1±1 .1
	Adult	0.3±0.2	1.8±0 .5	6.6±0 .9	1.0±0.4	9.6±1.1	4.8±0.8	1.0±0 .4	5.8±0 .9

Natural growth, estimated raw growth and observed growth were increased with herd size (Table 4). In contrast, the highest net exploitation rate was observed for holdings with a medium-sized herd (25-29 heads). This rate was lower in the case of small herds (9-24 heads)

Table 4 Annual synthetic productivity and exploitation rates for herds

Growth and exploitation	Herd 9-24 heads	Herd 25-29 heads	Herd 30-54 heads	Sample 9-54 heads
Number of farms	19	18	13	50
Average herd size	20.20	27.30	39.70	28.40
Average number of cows	12.23	15.82	23.00	14.04
Natural growth (/ year)	0.185	0.196	0.210	0.200
Net exploitation (/ year)	0.009	0.028	0.017	0.024
Estimated gross growth (/ year)	0.176	0.168	0.193	0.176
Gross observed growth (/ year)	0.162	0.164	0.168	0.1636

IV. Discussion

4.1 Characteristics of farming systems

In the commune of Sassoumbroum, livestock farming, the second most active activity in agriculture, faces food (90%) and pathological (86%) constraints. The dominance of agriculture in household farming systems, coupled with livestock farming practices based on herd mobility and a significant part of the self-consumption of animal products (milk, table 2) reflects the characteristics of typical agro-pastoral systems described in West Africa (Barton et *al*., 2001). In these agro-pastoral farming systems, socioeconomic differentiation is marked by livestock ownership (Belli et *al*., 2008), but the presence of large ruminants and self-sufficiency in animal traction are scare (Dixon et *al*., 2001). The predominance of cattle livestock in the study area (Zinder region) compared to those in other regions of the country (Rhissa, 2010), could well explain the relatively large size of the cattle herd (28.4 ± 9.10 heads). Besides, livestock is the only way to place a surplus of income when accessible bank is lacking (Faye and Alary, 2001). Contrarily to the specific constraints of the pastoral systems in sub-Saharan countries as described by Faye and Alary (2001), Tielkes et *al*. (2001), the main use of milk was the sale after processing or not (90%) and self-consumption (10%). This suggests a strong involvement of households in market systems and the significant participation of livestock in food security for the families. Cattle milk production is better valued by breeders (Guichard, 2004). After these economic considerations, livestock, whether mainly dairy or butchery, contributes significantly to food security for the families, by providing them various consumed products (Guichard, 2004).

4.2 Herd structure

4.2.1 Age pyramid

The age pyramid reflects the herds past (Lhoste et *al*., 1993). It provides information on its function, significant past events and its general dynamic. The age pyramid of the sampled population (Figure 3a) had an irregular slope with a narrow base, which reflected an unstable demographic regime and low reproductive fertility. Similar shape pyramids was described by Azalou et *al*. (2019) for the transhumant herds. Every three years reduction in individuals of both sexes on average constitutes a sign of a significant episode (Lhoste et *al*., 1993). In the study area, structural constraints of a food and pathological nature, mentioned by breeders (90 and 86% of breeders respectively), could well explain episodes of excess mortality leading, therefore, to a marked reduction in certain slices of age in the pyramid. The replenishment period after each fall (3 years on average) is an important parameter to reflect the resilience of livestock systems in the face of environmental constraints (Lesnoff et *al*., 2012). Demographic resilience is a key parameter for the sustainability of livestock populations regularly disturbed by demographic shocks, especially for cattle which are more vulnerable to food shortage than small ruminants (Lesnoff et *al*., 2012). The dominance of females in the herds shows a strategy reflecting the aim of perpetuating the herd and sustainable management. The profile of the pyramid also shows a low exploitation of the males. The maintenance of a significant proportion of young males and even of bulls is a sign of significant livestock-farming integration which is in line with the structure of a herd with a dairy-dairy and meat-producing function (Lhoste et *al*., 1993). Moreover, in Sahelian agro-pastoral farming systems in Niger, 84% of gross farm income comes from livestock, more than a third of which is for the sale of cow's milk and one third for the sale of meat from cattle (Guichard, 2004).

4.2.2 Structure in race

Breeders choose the race to be bred based on their production objectives and the adaptation of these races to the climatic conditions (Toko et *al*., 2016). In Niger, whatever the farming system considered, there are four main races of zebu and one taurine race for milk production (Marichatou et *al*., 2005). The Djelli race clearly dominated the herds surveyed (on average 9.4 heads per herd, figure 2b) although it is generally known to be bred on the borders of the Niger river and its islands (Rhissa, 2010). Also, it constitutes a minority breed (almost 7%) of the cattle races bred in Niger. It is a traditional race of the Fulani, mainly bred for its meat. The Djelli cow is poor dairy with 400 to 450 liters per lactation (Rhissa, 2010). This amount is just enough to feed the calf to justify its predominance in the studied farming systems. Indeed, the breeding of the race is not of primary economic character. Improving the profitability of the system is therefore not a necessity and the only-one selection made is based on natural selection. In addition, it is a race which is so well adapted to its hostile environment of the Sahel, which could well motivate breeders for its choice in their herds.

The second race that dominated the herds surveyed is the Bororo race (on average 6.9 per herd, figure 2b). This race represents about 18% of the national livestock population and takes its name from one of the Fulani tribes of Niger (Ayantunde et *al*., 2007). Bororo is a big animal whose carcass yield varied between 40 to 50% (Rhissa, 2010) and milk production between 1.5 to 4 liters per day for a maximum period of 6 months of lactation (Duteurtre and Corniaux, 2013). All of these productive performances could explain its abundance in the herds in the study area.

The Gudali race, zebu with short horns from East and Central Africa is much encountered in the study area (on average 6.6 heads per herd). It is renowned not only for its meat (50 to 52% yield (MRA, 2004)) and its milk quality up to 7 - 8 liters of milk per day), but also for its resistance to harsh conditions environmental. Gudali race is the best fattening race for farmers (Toko et *al*., 2016).

The Azawak, the most important cattle race in Niger, has a multitude zootechnical qualities (Achard and Chanono, 1997; Duteurtre and Corniaux, 2013) which would explain its choice in the surveyed farms (This race is present in 46 herds with an average of 5.5 heads per household). It is calm and well adapted to food and climatic conditions. Its carcass yield at slaughter ranged from 48 to 52%. It represents the most dairy race of the sub-region with a milk production ranging from 800 to 1000 kg for a period of 270 to 300 days of lactation (Aboubacar, 2017).

At the end, the study reveals the presence, in the herds, of some heads of Arabian and Kuri races. As for the Kuri, its cradle is made up of the islands and polders of Lake Chad (Adamou et *al*. 2018a). It is one of the oldest cattle populations in Africa which is on the verge of extinction due to the degradation of its original biotope (Adamou et *al*., 2018a). According to the authors, average milk production varies from 3 to 6 kg for a lactation duration that varies widely between 180 and 314 days (Zeuh et *al*., 2014; Adamou et *al*., 2018a). In Niger, Kuri farming was mainly practiced by the Buduma and Kanuri, but the involvement of other ethnic groups in this farming, like that observed in this study, is increasingly observed (Adamou et *al*., 2018b).

4.3 Reproductive demography rate

Comparing the demographic rates calculated in this study with those reported by other authors (Ba, 2011; Lesnoff, 2015 ; Zampaligre et *al*., 2019) requires making the assumption that the probability of the demographic events studied is constant for each animal species, because these animals are reared in farming systems contrasted with very different agro-climatic conditions and farming behavior. Compared to other studies as those of Toko et *a*l. (2016) and Azalou et *al*. (2017), as the tools used to calculate the rates over the last 12 months are very different, the comparison of demographic rates must be considered with caution.

Demographic reproduction rates generally vary by breed. Inter-race variations of 61.1 to 70.3% for parturition rate and from 3.93 to 9.3% for abortion rate were reported from stations after individual monitoring of animals over several years (Alkoiret et *al*., 2010). In this study, there was little cross-race variations of instantaneous birth (0.46-0.51) and abortion (0.021 - 0.036) rates (figure 4b and figure 6b respectively), which may reflect the adaptation of these local races to stressed environments. The average instantaneous birth rate (0.50 ± 0.02) is in the 46-53% range reported for cattle herds in West Africa (Lesnoff et *al*., 2006; Ba et *al*., 2011). However, depending on the type of transhumant farming system, variations in different forms (0.71 to 0.91) were observed in a wetter equatorial climate (Azalou et *al*., 2017). Such variations confirm our hypothesis of a multi-factorial origin linked to the environmental conditions of breeding.

The 12MO survey method is ad hoc without taking account of inter-annual variations of herd performance (Lesnoff, 2015). At station, the fluctuations from 73.3 to 86.4 % of the fertility rate were observed over a period of 6 years of individual monitoring of cattle herds under the same type of Sahelian climate (Achard and Chanono, 1997). The adjustment coefficients of the linear regressions on the age and parity data collected for the females present in the herds of the study area ($Coef_1$ = 0.41 and $Coef_2$=0.45 Of which $Coef_1$ is the most adjusted, figure 5) are average estimates of the average parturition rate over a retrospective period of several years (Lesnoff, 2011). The first estimate (0.50 / year discussed above) is only relative to the last twelve months before the survey, this last estimate of the multi-year average could, to a certain extent, replace the establishment of long follow-ups to take into account for the inter-annual variability in the birth rate (Lesnoff, 2011). A comparison of the two calving rate estimators (that of the last twelve months (0.50 / year) and that of the inter-annual variability (Coef1 = 0.41 / year) highlights a very marked increase in female fertility compared to the multi-year average.

The average instantaneous juvenile mortality rate (8.9, table 3) is in the range of 10-16% as reported by Lesnoff et *al*. (2006) in Niger. It is consistent with the 8.5% juvenile mortality rate reported after individual monitoring of Azawak cattle in the station (Achard and Chanono, 1997). Also, the estimated mortality rates for the age groups were low for juveniles and sub-adults, but very high for adults compared to those reported by Ba (2011). The most cited causes of death in young people (Achard and Chanono, 1997) were digestive pathologies (enteritis, diarrhea, coccidiosis, and milky indigestion), various diseases (rickettsiosis, septicemia, pneumonia) and accidents (Inanition, malformations, tetanus).

An increasing trend followed by a plateau in the probability of parturition with age was highlighted (figure 4a). This finding, in agreement with those of cattle herds in sub-Saharan Africa (Lesnoff, 2011), can be very useful in informing the age from which an economic reform of cows is necessary. Likewise, the stillbirth regression model described the age of the mother as an important factor having a detrimental effect on the survival of the juvenile at birth. Indeed, numerous authors (Brickell et *al*. 2009; Bleul, 2011) identify primiparous females (therefore, the least elderly) as more at risk of stillbirth. Between each gestation, there is a

significant reduction in this risk until the third gestation (Brickell et *al*., 2009). The physiological explanation of this effect relies on feto-maternal disproportion (Mee et *al.*, 2008), that is more frequent in primiparas than in multiparas on.

4.4. Demographic rates of viability-mortality and exploitation

The concern of the place, the role and the contributions of livestock within agro-pastoral systems in the Sahelian zone and in Niger are well known thanks to Guichard (2004). In such systems, the animal is multifunctional because it plays many socio-economic roles. The rates of exit and entrance of animals represent some indicators of choice to analyze the practices of herds' exploitation by the stockbreeders, but also to describe an important part of these functions. The high values of these rates (table 3) show that the economic interest of livestock and its contribution to the formation of household income remain crucial to the surveyed breeders. This interest manifests itself through the revenue from the sale of animals and their products (milk, meat ...). Indeed, monetary need is the main reason for the sale of animals to meet family expenses (Ba, 2011).

The balance of natural rates (parturition and mortality) generated a productivity rate of 0.20 /year (table 4). This finding is in line with the estimate of 0.22 animal / year reported by Lesnoff (2015) in Niger. One of the objectives of calculating this balance was to study the sensitivity of productivity to variations in herd size. Unfortunately, the empirical calculation of the productivity rate has the advantage of being simple, but constitutes a black box that does not allow sensitivity analyzes (Lesnoff, 2011). Thus, the empirically productivity rate calculated for herd classes varied from 0.18 to 0.210 in favor of increasing the size of herds and breeding females. Therefore, improving productivity of herds in the commune of Sassoumbroum requires improved reproduction and an increase in the proportion of breeding females in the herds. Indeed, the proportion of females in the population and the calving rate are among the factors that contribute more to the variance in productivity (Lesnoff, 2015). Variations of the same form were reported by Ba (2011) with a productivity rate changing with the size of the herds, from 0.10 / year in herds of 1 to 5 breeding cows to 0.13 / year when the number of breeding females is greater than 25.

Besides, studies of pastoral systems in East Africa have shown a link between demographic parameters and herd size (e.g. mortalities are higher in large herds than in small ones) (Sieff, 1999). Other studies have also shown that animal sales occur differently depending on the herd size. Poor herders, with few animals, are more likely to sell animals (Ba, 2011). These examples illustrate the need to study the sensitivity of productivity to certain demographic rates, as well as the margins of possible variations of this productivity (Ba et *al*., 2009; Ba et *al*., 11).

V. Conclusion

The analysis of farming practices reveals very extensive agro-pastoral systems in the commune of Sassoumbroum. A flock-dairy function of the herds, an unstable demographic regime and low reproductive fertility highlighted by the analysis of the age pyramid of the studied herds, perfectly reflect the extensive nature of these systems.

The demographic rates of cattle herds estimated in this study trough the 12MO method, are in agreement with those observed in similar Sahelian agro-pastoral systems. The analysis of these rates following the races established for animals evolving in the same space-time, will allow at least, opening the debate on a more objective comparison of the zootechnical performances of the local races of the Sahelian breeding systems. Also, physiological phenomena involving certain demographic rates related to age have been highlighted, which shows other practical advantages of using this methodology in the service of Zootechnics. The use of the Lexis diagram and its breakdown into shorter cells (monthly herd monitoring for one year) will allow standardized results to be obtained taking into account the time spent by the animals on the farm while correcting the bias rate of memory and reporting bias.

Analysis of the balance of natural rates, showed a link between the increase in empirical productivity and the improvement of reproduction and the proportion of breeding females in herds. Moreover, the relatively higher exploitation rate than those generally accepted for Sahelian farming systems observed invites towards deeper reflection of the demographic factors determining in the sensitivity of herd productivity. The demographic projections performing based on demographic rates fixed as hypotheses, would be better suitable to assess with accuracy, the average exploitable potential of the herds beyond which the sustainability of the cattle farming systems of this area would be compromised.

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