

# Comparison of some zootechnical performances of local and Red Maradi goats reared under smallholder production systems in the Sudanian zone of Benin

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## ABSTRACT

The aim of this research was to compare the zootechnical performances of indigenous and Maradi goats reared under village conditions in the Sudanian zone of Benin. A questionnaire survey was carried out between August and October 2019, using the 12MO, a retrospective method for estimating demographic parameters in tropical ruminant livestock population and the progeny history method. Information related to farmers' socioeconomic characteristics, goat herd management practices and demographic parameters, and milk productivity from 198 does including 66 West African Dwarf (WADG), 68 Red Maradi (RMG) and 64 West African long-legged (WLLG) goats were collected in 80 smallholder farms. Pearson Chi-square and Kruskal-Wallis W tests were performed respectively on the categorical and continuous variables. The average herd size was about  $16.7 \pm 9.0$ ;  $5.8 \pm 3.1$  and  $15.4 \pm 7.4$  heads respectively for WADG, RMG and WLLG. Bucks were absent in several herds where kids ( $47.9 \pm 12.8\%$ ) and does ( $46.6 \pm 12.8\%$ ) predominated. Prolificacy rates at first and second parturition varied significantly ( $P \leq 0.05$ ) among goat types and were respectively  $165.2 \pm 59.5\%$  and  $195.1 \pm 66.9\%$  for WADG;  $160.3 \pm 55.0\%$  and  $196.0 \pm 53.9\%$  for RMG;  $134.4 \pm 54.1\%$  and  $154.6 \pm 51.0\%$  for WLLG. Parturition rates were higher ( $P \leq 0.05$ ) in WADG ( $159.1 \pm 49.5\%$ ) than in RMG ( $138.2 \pm 49.0\%$ ) and WLLG ( $132.8 \pm 47.3\%$ ). Likewise, productive rates were higher ( $P \leq 0.05$ ) in WADG ( $277.3 \pm 142.3\%$ ) than in RMG and WLLG ( $204.4 \pm 125.1\%$  and  $168.8 \pm 102.2\%$  respectively). Milking was only performed on RMG and the amount of milk collected per milking ranged between 0.6 and 1 liter per doe. Enhancing goat herds' productivity could be achieved through improved general herd management practices.

## 1. Introduction

Rearing goats has become very popular among rural people (Akpa, Alphonsus, Dalha & Garba, 2010) due to its multifunctionality (Missohou, Nahimana, Ayssiwede & Sembene, 2016). Indeed, goats fulfill important roles in the livelihoods of rural communities (Akpa et al., 2010; Food & Agriculture Organization [FAO], 2015; Missohou et al., 2016). These roles range from socio-cultural functions, food security, resilience to shocks, and income generation (Bakary et al., 2019; Boogaard & Moyo, 2015; Mdladla, Dzomba & Muchadeyi, 2017).

The goat population of West Africa, estimated in 2019 to be about 177,937,000 heads of live animals (Food and Agriculture Organization Statistics [FAOStat], 2020), is made of indigenous breeds adapted to local environmental conditions (Missohou et al., 2016). The goat population of Benin, estimated to be about 2.0 million head in 2019

(FAOStat, 2020), is kept in various traditional production systems. Two main goat types are encountered, the West African Dwarf goat (WADG) and the Long Legged Sahelian goat (WLLG), and kept in small herds.

While very little is known about their reproductive and productive performances under village conditions, many initiatives aiming at improving their productivity by introducing new breeds in several rural areas of Benin have been supported by both national and international institutions. This is the case of the introduction in 2005 of the French Alpine goat breed in the south of Benin by the Non-Governmental Organization named « *Elevage sans Frontières* ». This goat breed is known for its good milk performance ( $577.2 \pm 3.7$  kg milk in  $264.5 \pm 0.6$  lactating days in its environment of origin Mioč et al., (2008) and produced about  $93.2 \pm 26.0$  kg milk in 73 lactating days in improved production systems of Benin Vissoh, Gbangboche & Padonou, (2015). More recently, the World Bank funded project PPAAO/WAAPP (Projet de

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*Productivité Agricole en Afrique de l'Ouest/West Africa Agricultural Productivity Project*) has introduced the Red Maradi goat in the northern departments of the country. This goat breed is known for its good milk performance, skin quality and high litter size (Union Africaine-Bureau Interfricain des Ressources Animales [UA-BIRA], 2016). The ultimate aim of these projects was to improve the wellbeing of its beneficiaries through improved goat productivity. But how does the Red Maradi goat perform in its new environment in Benin? The study aimed to compare some reproductive and demographic parameters of Red Maradi goat (RMG), West African Dwarf goat (WADG) and West Long Legged Sahelian goat (WLLG) reared in the prevailing traditional production systems of Northern Benin.

## 2. Material and methods

### 2.1. Study area

The study was carried out from August to October 2019 in the Alibori department in the Sudanian zone of North Benin Fig. 1. Five municipalities (Segbana, Kandi, Gogounou, Banikoara and Malanville) out of the six in the department were included in this study because they were the main target of the PPAAO's Maradi goat distribution project. The climate in the Sudanian zone is typically dry tropical with one single rainy season. The rainfall decreases along the gradient South-North from the 1 150 mm/year to 900 mm/year (Adomou, 2005). The humidity index is less than 2. The soil is tropical ferruginous (Sinsin & Kampmann, 2010). The vegetation is largely dominated by savannas with continuous grassy groundcover (*Andropogonae*) followed by dense dry forests of *Anogeissus leiocarpa* and *Tamarindus*, light forests of *Isobertinia tomentosa* and *Isobertinia doka* and wooded savannas of *Daniellia oliveri* (Adomou, 2005).

### 2.2. Sampling and data collection

The list of farmers beneficiaries of the PPAAO Red Maradi goat distribution project was obtained from the PPAAO project coordination team. Using a stratified sampling approach, beneficiaries and non-beneficiaries farmers of the Red Maradi goat were selected. Non-beneficiaries farmers gathered farmers keeping WADG (28) and WLLG (18). A total of eighty goat farmers, 34 beneficiaries and 46 non-beneficiaries of the Red Maradi goat, were thus selected and interviewed using a structured questionnaire designed according to the 12MO method developed for estimating livestock demographic parameters in tropical smallholder farming systems over a period of 12 months before the survey (Lesnoff, 2011, 2014). This questionnaire included information on the general farmers' household characteristics, their goat herd structure, their breeding practices, all entries and exits that occurred in the last 12 months. Furthermore, the progeny survey method (Iles, 1994) was used to recall information on the reproductive carrier of a total of 198 does, of which 66 from the WADG, 68 RMG and 64 WLLG, randomly selected in the respective flock types. This information included the numbers of kidding and abortion, the litter size, numbers of stillborn and born alive per parturition. The questionnaire was pretested on a sample of 10 farmers before its administration.

### 2.3. Data analysis

Herd demographic and productive parameters were calculated using formulas developed by Lhoste (2001) and Lesnoff (2011) and summarized in Table 1.

All statistical analyses were performed using IBM® SPSS® Statistics 23 (IBM Corp. Release 2015). Cross-tabulations were performed and the value of the associated Pearson Chi-square statistic used to establish the relationships between categorical variables. The means and standard

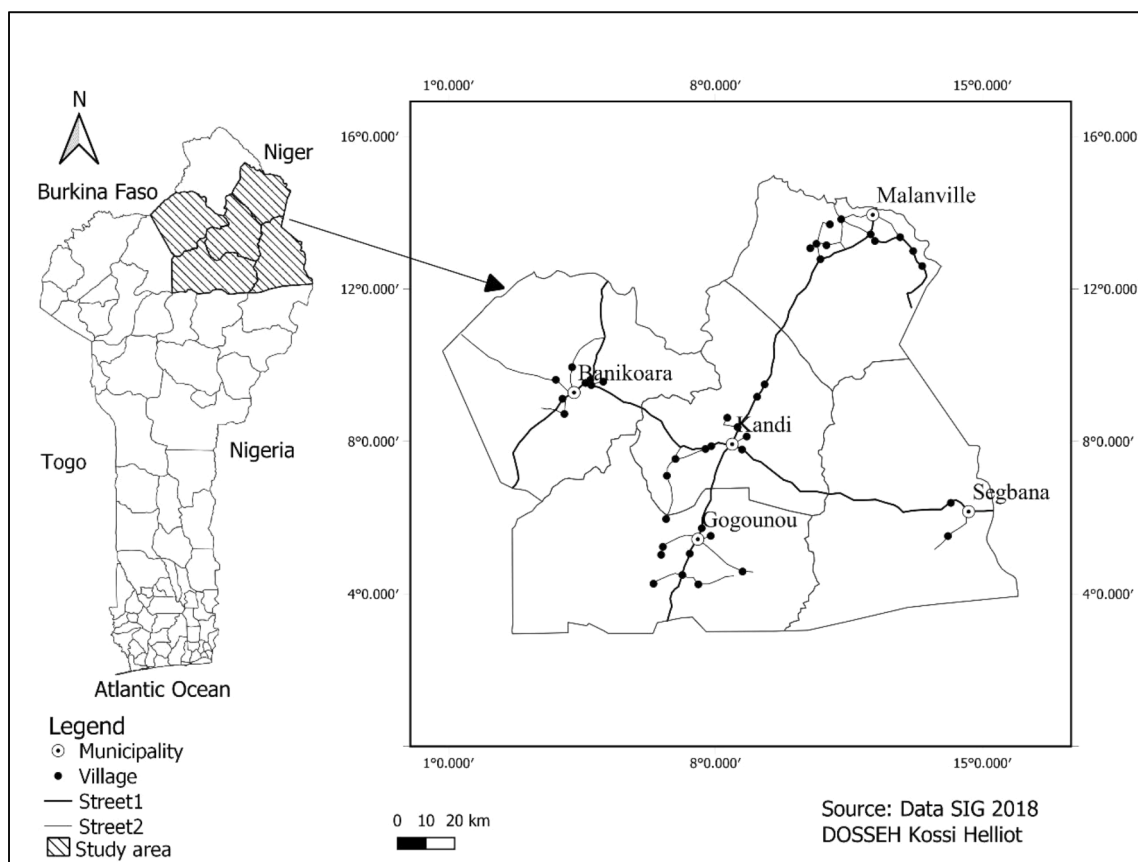


Fig. 1. Map of the department of Alibori showing the studies municipalities.

**Table 1**  
Demographic parameters of small ruminants.

Demographic parameters <sup>a</sup>	Formula
<b>Reproductive parameters</b>	
Abortion rate (%)	Number of abortion*100 / Breeding females
Parturition rate (%)	Number of parturition*100/Breeding females
Fecundity rate (%)	Offspring alive born*100/ Breeding females
Prolificacy rate (%)	Number of offspring *100/Kidding females
<b>Mortality parameters</b>	
Mortality rate (%)	Total number of deaths*100/ Mean number of herds
Stillborn rate (%)	Number of stillborn*100/ offspring
<b>Numeric offtake parameters</b>	
Offtake rate (γ) in% of herd	Number of offtake*100/ Mean number of herds
Gross herd growth rate (φ)	(Final number – Initial number)*100/ Mean number of herds
Net herd growth rate (Ψ)	φ – (Immigration*100/ Mean number of herds)
Numeric yield	γ + Ψ

<sup>a</sup>Demographic parameters is consisted of reproductive parameters, mortality parameters and numeric offtake parameters (Lesnoff, 2011; Lhoste, 2001).

deviations of continuous variables were calculated and differences among goat types explored using the non-parametric W test of Kruskal-Wallis. The significance level considered was 5% with a confidence interval of 95%.

### 3. Results

#### 3.1. General household characteristics and breeding practices

The socioeconomic characteristics of the surveyed goat farmers are

**Table 2**  
Characteristics of households beneficiaries and non-beneficiaries of Maradi goat in the north of Benin (% of respondents).

Variables	Total (n = 80)	Beneficiaries (n = 34)	Non-Beneficiaries (n = 46)	χ <sup>2</sup>	P-value
Gender				8.203	0.004
Female	55.0	73.5 <sup>a</sup>	41.3 <sup>b</sup>		
Male	45.0	26.5 <sup>a</sup>	58.7 <sup>b</sup>		
Educational level				0.205	0.903
None	80.0	82.4	78.3		
Primary	10.0	8.8	10.9		
Secondary and further	10.0	8.8	10.8		
Marital status				4.426	0.035
Married	92.5	85.3 <sup>a</sup>	97.8 <sup>b</sup>		
Widow	7.5	14.7 <sup>a</sup>	2.2 <sup>b</sup>		
Main occupation				7.204	0.066
Crop cultivation	32.5	26.5	37.0		
Livestock farming	38.8	35.3	41.3		
Processing/trading	25.0	38.2	15.2		
Others	3.8	0.0	6.5		
Religion				2.835	0.242
Christianism	1.2	2.9	0.0		
Islam	96.2	97.1	95.7		
Animism	2.5	0.0	4.3		
Ethnicity				3.766	0.288
Bariba and related	31.2	23.5	37.0		
Dendi and related	18.8	26.5	13.0		
Fulani and related	48.8	50.0	47.8		
Others	1.2	0.0	2.2		

<sup>a, b</sup> Within a row, values with different superscript letters are significantly different at  $P \leq 0.05$  level (Chi-square test).

presented in Table 2. More than half of the goat farmers were women (55.0%) with significant differences between beneficiaries and non-beneficiaries of Red Maradi goat. Their average age was  $44.3 \pm 10.8$  years and did not vary significantly between beneficiaries and non-beneficiaries of Maradi goat. Their main occupation was crop farming (32.5%), livestock keeping (38.8%), petty trade or traditional healing (28.8%). They belonged to the Fulani (48.8%), Bariba (31.3%) and Dendi (18.8%) ethnic groups.

The average goat herd size was  $11.8 \pm 8.3$  and was significantly ( $P < 0.001$ ) greater for non-beneficiaries of Maradi goat. The herds were dominated by does ( $46.6 \pm 12.8\%$ ) and kids ( $47.9 \pm 12.8\%$ ). Table 3 shows the herd structure per type of herd. About 50.0% of farmers practiced crossbreeding between RMG and indigenous breeds (WADG and/or WLLG).

About two-third (71.2%) of the goat herds were scavenging throughout the year, 17.5% were brought to grazing and 11.3% kept and fed in enclosures. Regarding health care, only 36.2% of respondents reported that they prevent their animals from the pest of small ruminants (known as *Peste des Petits Ruminants*) through vaccination; 98.8% treat against external parasites and 58.8% against internal parasites using Ivermectin (Alfamec) and Albendazole, respectively. The main source of feeding was natural pasture complemented sometimes with salt, crop residues and by-product of grain (Maize, Millet, Sorghum) processing.

#### 3.2. Animal demographic parameters

##### 3.2.1. Reproductive parameters

The reproductive parameters of the goat herds are reported in Table 4. The kidding intervals ranged between  $6.8 \pm 1.5$  and  $9.6 \pm 1.7$  months for WADG,  $8.3 \pm 1.8$  and  $10.1 \pm 1.5$  months for RMG, and  $7.5 \pm 2.0$  and  $9 \pm 1.4$  months for WLLG. In contrast to the recorded abortion rates, the calculated rates of prolificacy at the first and second kidding over the past 12 months, as well as the parturition and fecundity rates varied significantly ( $P \leq 0.05$ ) among goat breeds (Table 4).

##### 3.2.2. Mortality parameters

Mortality rates varied significantly ( $P \leq 0.05$ ) between goat breeds and were higher in RMG. But, irrespective of goat breed, there was no significant difference between male and female goats. Likewise, they were higher in young females (age classes between 0 and 12 months) than in adults aged of more than 24 months (Fig. 2, 3a, 3b, 4c and 4d).

The overall stillbirth rate was 15%. But, it varied significantly ( $P \leq 0.05$ ) between goat breeds (6% in WADG, 9% in WLLG and 28% in RMG) and in function of birth ranks, being lower at first parturition in all goat breeds.

**Table 3**  
Average goat herd sizes (mean and SD) and herd structure (% of herd size) in the Alibori department in north of Benin.

	Total (n = 80)	Type of herds Beneficiaries (n = 34)	Non-Beneficiaries (n = 46)	P-value
Herd size (n)	$11.8 \pm 8.3$	$5.8 \pm 3.1^a$	$16.2 \pm 8.3^b$	0.000
Herd Structure (%)				
Reproductive male	$5.5 \pm 6.9$	$3.8 \pm 5.5$	$6.6 \pm 7.7$	0.163
Reproductive female	$46.6 \pm 12.8$	$43.6 \pm 7.0$	$48.8 \pm 15.5$	0.058
Kids	$47.9 \pm 12.8$	$52.5 \pm 7.8^a$	$44.6 \pm 14.7^b$	0.000

<sup>a, b</sup> Within a row, values with different superscript letters are significantly different at  $P \leq 0.001$  level.

**Table 4**  
Reproductive performances of Red Maradi goat and indigenous does over the 12 months before the survey in the Alibori department in north Benin.

Parameters (%)	Total (n <sup>c</sup> = 198)	Goat breeds			P-value
		WADG (n = 66)	RMG (n = 68)	WLLG (n = 64)	
<b>Reproduction</b>					
Prolificacy rates (P1)	153.5 ± 57.6	165.2 ± 59.5 <sup>a</sup>	160.3 ± 55.0 <sup>a</sup>	134.4 ± 54.1 <sup>b</sup>	0.002
Prolificacy rates (P2)	185.2 ± 61.7	195.1 ± 66.9 <sup>a</sup>	196.0 ± 53.9 <sup>a</sup>	154.6 ± 51.0 <sup>b</sup>	0.023
Parturition rates	143.4 ± 49.7	159.1 ± 49.5 <sup>a</sup>	138.2 ± 49.0 <sup>b</sup>	132.8 ± 47.3 <sup>b</sup>	0.006
Fecundity rates	217.2 ± 131.8	277.3 ± 142.3 <sup>a</sup>	204.4 ± 125.1 <sup>b</sup>	168.8 ± 102.2 <sup>b</sup>	0.000
Abortion rate	11.2 ± 31.5	6.6 ± 24.1	16.2 ± 37.3	9.7 ± 29.0	0.154

<sup>c</sup> Overall number of reproductive females.

P1: First parturition and P2: Second parturition.

<sup>a,b</sup> Within a row, values with different superscript letters are significantly different at  $P \leq 0.001$  level.

WADG = West African Dwarf Goat; RMG = Red Mardi Goat; WLLG = West African Long-legged Goat.

### 3.2.3. Numeric offtake parameters

Numeric offtake rate, gross herd growth rate and net growth rate are presented in Table 5. All these parameters were significantly higher in RMG than for other breeds. Negative values were recorded for WLLG herd growth rates. Sales counted for 71.4%; 64.7% and 66.7% of exits respectively in WADG, RMG and WLLG herds. Further exit forms included gifts, use as dowry payment, and slaughtering during festivals (religious and others).

### 3.3. Milk production and skin

Doe milking was only practiced in 44.4% of RMG herds. The frequency of milking varied among practitioners' farmers. The percentages of goat farmers that performed milking once, twice or three times a day were respectively 62.6%; 31.1% and 6.3%. Milking lasted at most 2 weeks after parturition. The amount of milk collected per milking ranged between 0.6 and 1 liter per doe. It must be pointed out that the

remaining RMG farmers (55.6%) that did not practice milking reported that most of the does in their goat herd had developed mammary inflammations.

Except it uses as praying mat by a very insignificant proportion of farmers, goat skin was generally not valued.

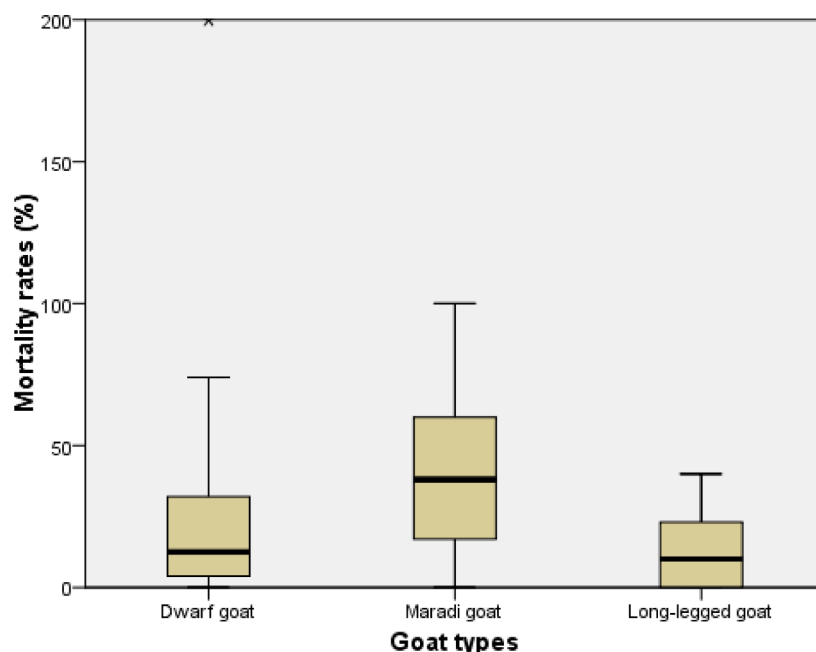
## 4. Discussion

### 4.1. Socioeconomic characteristics of goat farmers

The socioeconomic characteristics of goat farmers did not vary significantly between beneficiaries and non-beneficiaries of Red Maradi goat, but could have affected the management of herds. Generally, there were more women (55.0%) than men (45.0%) among all goat farmers interviewed. This result contrasts with those reported elsewhere (Fikru & Gebeyew, 2015; Mataveia, Garrine, Pondja, Hassen & Visser, 2018). However, these authors convened that goat breeding activities are shared among household's members. The high involvement of women in our study could be explained either by the high commitment of men in other activities than goat breeding in the study area such as activities related to crop cultivation and trade or more importantly by a selection bias. Indeed, the RMG beneficiaries' farmers interviewed in the present study were not randomly selected. This non-random selection combined with the fact that the PPAO/WAAPP program, like many development programs (Guèye, 2009), targeted women by promoting their role in agro-production systems certainly explains their higher representation among interviewed RMG beneficiaries, at the expense of men.

Most of the surveyed goat farmers were illiterate (lack of writing and reading abilities). This high illiteracy rate among rural livestock farmers could be considered as a hindrance for the improvement of livestock productivity (Alkoiret, Awohouedji, Akossou & Bosma, 2009; Youssao et al., 2013) as it negatively impacts on the adoption of innovations (Byaruhanga, Oluka & Olinga, 2015).

The small size ( $11.8 \pm 8.1$  head) of surveyed goat herds, which seems to agree with those previously reported by some authors (Dossa, Wollny & Gaulty, 2007; Ketema, 2007; Sunder, Kundu, Kundu, Sujatha & De, 2018), shows that goat rearing was not the main economic activity in these households. The low proportion of breeding males in the herds surveyed is mainly due to early sales to prevent them from theft, as recurrent cases of theft was reported by goat farmers as one of the main



**Fig. 2.** Mortality rates (%) of Red Maradi goat herds and indigenous goat herds over the 12 months before the survey at Alibori department in north of Benin.

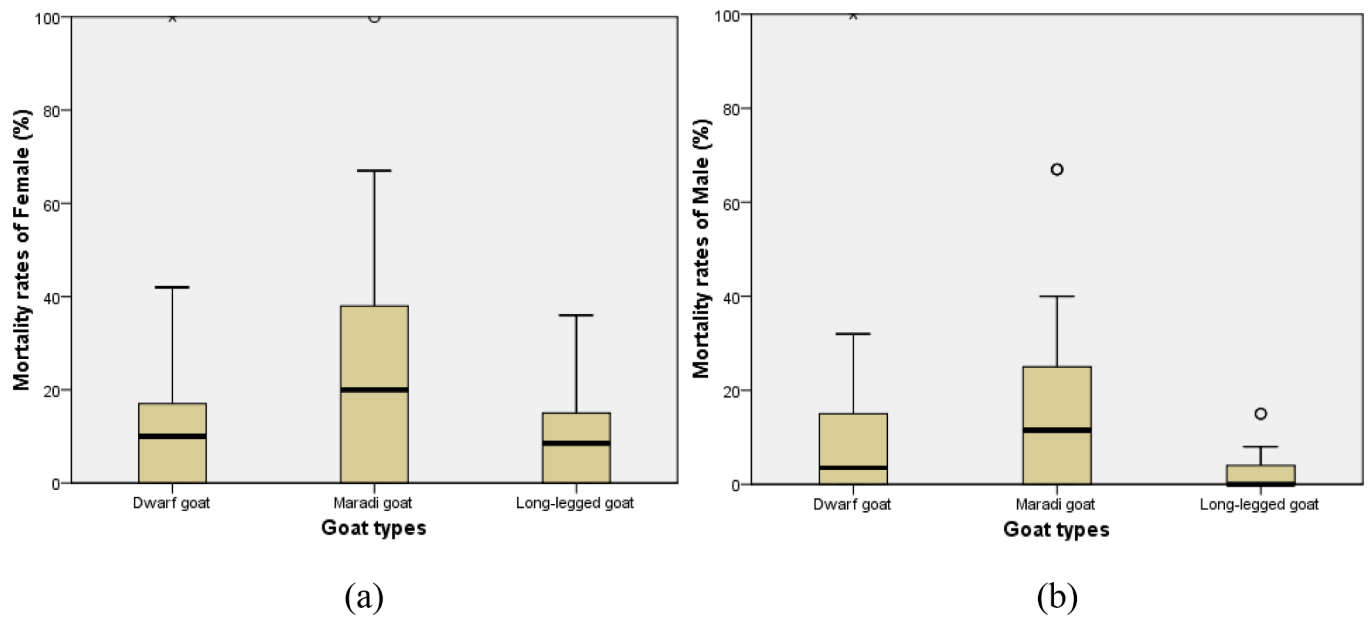


Fig. 3. Mortality rates (%) disaggregated by sex. (a) female. (b) male of Red Maradi goat herds and indigenous goat herds at Alibori department in north of Benin.

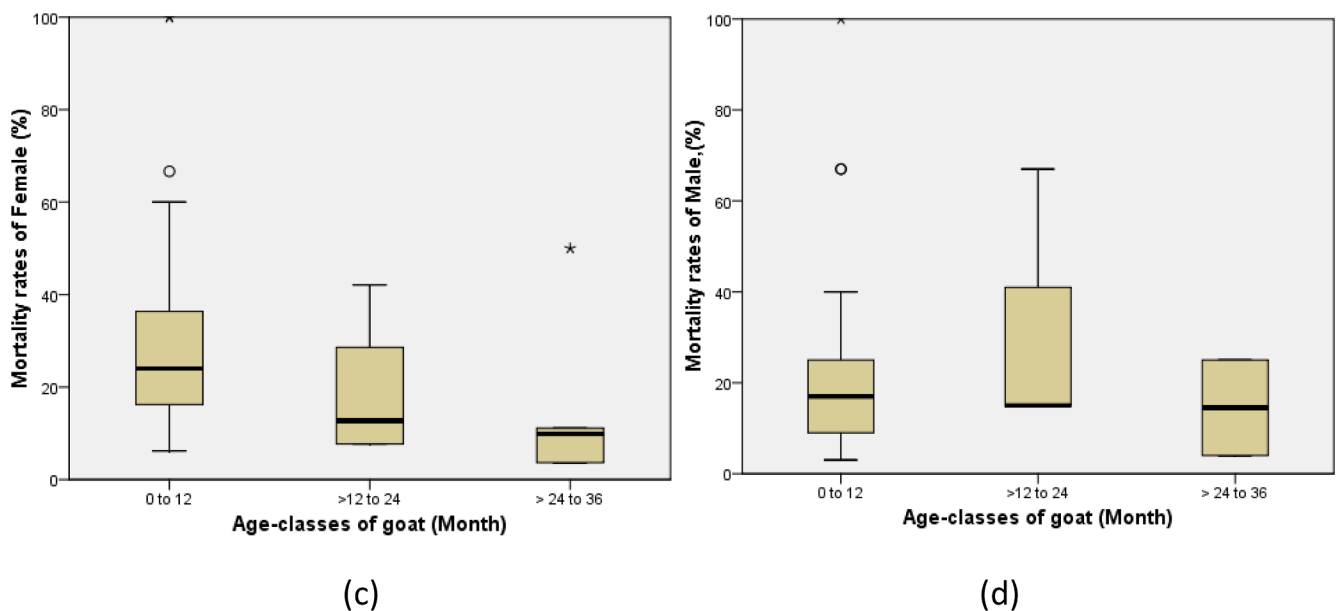


Fig. 4. Mortality rates (%) by sex and age-classes of Red Maradi goat herds and indigenous goat herds at the department of Alibori in north of Benin. (c) female. (d) male.

constraints they face. Yet, this has a negative impact on herd productivity as it delays mating of does.

#### 4.2. Animal demographic parameters

Demographic parameters determine the productivity of herds. The kidding interval obtained in the present study is shorter for the WADG than for WLLG and RMG. However, the values obtained in this study for the WADG are higher than those previously reported by Idrissou et al. (2017) for the same goat breed. In general, the relatively long kidding intervals, regardless of breeds, are likely related to the lack of breeding males in the herds and the practice of goat tethering during the cropping season, the later generally leading to inadequate nutrition in the absence of supplementary feeding (Boogaard, Hendrickx & Swaans, 2012; Mataveia et al., 2018). While the difference observed in favor of the WADG

may be probably due to differences in farmers' management practices (Odubote et al., 1996), it could also be linked to environmental conditions. The RMG, in its original environmental conditions in Maradi (Niger) has an average kidding interval of 386 days (Marichatou, Mamane, Banoin & Baril, 2002; Moussa, 2011), which is relatively longer than the interval recorded in the current study.

The abortion rates recorded for the different goat breeds did not vary significantly, but were lower than those reported by Idrissou et al. (2017) and Dossa et al. (2007) and higher than the rate of 2% obtained by Mopaté, Zeuh, Adoum & Nadjissara (2014) for the WLLG. The abortion rate obtained in the present study for the RMG approximates the value of 15% reported by Diawara, Hiernaux, Mougin, Gangneron & Soumaguel (2017). The higher rate of abortion recorded in RMG herds compared with the two other herd types, are in line with previous observations by Missohou et al. (2016) in the West African region, might be

**Table 5**

Numeric offtakes parameters of Red Maradi goat herds and indigenous goat herds in the Alibori department in north of Benin.

Offtake parameters (%)	Goat breeds			P-value
	WADG (n = 28)	RMG (n = 34)	WLLG (n = 18)	
Numerical offtake rates	39.7 ± 9.3 <sup>a</sup>	99.5 ± 27.5 <sup>b</sup>	24.5 ± 5.1 <sup>a</sup>	0.005
Gross numeric growth rate	36.5 ± 17.8 <sup>a</sup>	110.1 ± 25.9 <sup>b</sup>	-0.03 ± 9.7 <sup>a</sup>	0.003
Net numeric growth rate	27.8 ± 17.2 <sup>a</sup>	106.7 ± 26.2 <sup>b</sup>	-4.5 ± 10.5 <sup>a</sup>	0.000
Numeric yield	67.5 ± 19.5 <sup>a</sup>	206.2 ± 37.1 <sup>b</sup>	19.9 ± 8.4 <sup>a</sup>	0.000

<sup>a,b</sup> Within a row, values with different superscript letters are significantly different at  $P \leq 0.001$  level.

WADG = West African Dwarf Goat; RMG = Red Mardi Goat; WLLG = West African Long-legged Goat.

explained by its higher susceptibility to diseases in rainy season and seasonal variations, but also by feed constraints. In the dry season, animals are fed with insufficient amounts of poor quality fodder that expose the animals to feed stress. The latter could be one of the causes of recurrent abortions.

The recorded prolificacy rates were relatively high, especially for the WADG and RMG. The rates in primiparous WADG and RMG does are similar to those recorded by Tchouamo, Tchoumboue & Thibault (2005) in the western province of Cameroon, Ketema (2007) in southern Ethiopia and Missouhou et al. (2016) in West Africa. In addition, the results show that, irrespective of goat breed, the litter size (prolificacy) increased with the parturition rank and therefore confirm the effect of the parturition rank on this parameter (Idrissou et al., 2018). The prolificacy rate obtained for the RMG in our study is much higher than values obtained in Maradi, its original environment reported by Marichatou et al. (2002) and Moussa (2011). This improvement in the prolificacy of the RMG in our study could be attributed, on the one hand, to the improvement of its level of acclimatization to the conditions of the study area, and on the other hand, to its crossbreeding by 59.3% of farmers with other local goat types, especially with the WADG, known for being very prolific. In fact, the RMG distributed by the PPAO/-WAAPP project were mostly already pregnant females. Hence, their mating with bucks of native breeds in their new environment took place after their first kidding, as there was hardly any Maradi buck available.

The kidding rates, almost similar for both RMG and WLLG, were higher than those obtained by Diawara et al. (2017) in Mali but much lower than values reported for local breeds in Ethiopia (Ketema, 2007) and Cameroon (Tchouamo et al., 2005).

The stillbirth rate was higher in the RMG herds and varied in function of birth ranks. This result could be explained by the breeding practices (tethering), feed stress and disease outbreaks to which the RMG are exposed in their new environment. Indeed, in tethering system, the animals are deprived of their usual mobility during which they search for feed resources to cover their needs while the farmers do not provide them with sufficient feed and water. This significant difference among breeds for the stillbirth rate certainly explains the significant difference among breeds obtained for the productive rate, this rate being lower in RMG and WLLG than in WADG. It is worth noting that the productive rate calculated in this study is higher than those reported by some authors (Abdou, 2013; Mopaté et al., 2014; Moussa, 2011).

The increase in stillbirth rate observed at the second parturition might be due to inappropriate provision of nutrition and healthcare to pregnant does. The stillbirth rate recorded for the WADG in this study is slightly lower than the rate of 8.2% reported by Idrissou et al. (2017) for the same breed in the department of Borgou in Northern Benin. This could be related to slight variation in climatic conditions between the different study areas.

The annual mortality rates recorded in the present study showed

significant differences between goat breeds. They were higher for RMG than for indigenous WADG and WLLG. They also varied between animal categories within the same breed, being higher for young females aged from 0 to 12 months. These results could be attributed to difference in herd management practices and to dietary constraints as reported by Gizaw, Tegegne, Gebremedhin & Hoekstra (2010) and Gobena (2016). With regards to RMG, the results obtained in the present study are higher than the average value of 15% reported by Moussa (2005) and Diawara et al. (2017) in Niger. This difference may be explained by the various pathologies that generally affect the health status of young animals and especially young goats (Baah, Tuah, Addah & Tait, 2012; Kamissoko et al., 2013), but also by the non-provision of appropriate care to new-born animals by some breeders and / or the non-use of veterinary services by others in case of disease. High young female mortality rates will negatively impact herd growth and profitability.

Sale was the main offtake form of animal exits; this result is consistent with those of Diawara et al. (2017). The recorded higher offtake rate in RMG herds could be explained by the increasing demand for RMG from PPAO Red Maradi project non-beneficiaries' farmers willing to use this breed to upgrade their WADG or WLLG, as most of the RMG offtakes were purchased for breeding purposes. The negative growth rate recorded for the WADG and WLLG is probably due to poor reproductive performance of does associated with high losses due to thefts and mortalities, and no replacement of removed animals.

#### 4.3. Milk production of red Maradi goat

RMG has a good milk potential. The average quantity of milk obtained per milking (0.6 – 1 liter) corroborates the value of 0.5 to 1.5 kg of milk per day during a lactation period ranging from 100 to 120 days reported for this breed (Robinet, 1967). But, milking Red Maradi does is still not widespread in the study area, partly due to its very recent introduction. In addition, milking is only done during two weeks after kidding. The milk of RMG is well appreciated by its consumers. However, some socio-cultural groups considered goat milking and its consumption as a taboo (Dubeuf, 2010). Similar observations were made by Dossa, Sangaré, Buerkert & Schlecht (2015) among goat farmers in Mali, Burkina Faso and Nigeria.

## 5. Conclusion

Besides crop cultivation, goat farming constitutes an important source of livelihoods for rural communities in Northern Benin. However, goat farmers' breeding and herd management practices do not allow the animals to express their genetic potential. Furthermore, goat farmers are faced with many constraints. This results in low herd productivities. The study showed that the reproductive parameters are better for WADG followed by RMG. Recorded mortality rates were higher in all age categories of RMG than in other goat types. In contrast, the RMG had the benefit of producing high amount of milk than indigenous WADG and WLLG. Offtake rates in RMG herds were also high because of increasing demand of RMG animals as breeding stock. These results suggest that RMG could effectively be used in well-designed breeding programs to upgrade local goats for improved meat and milk production, but only after significant improvements in farmers' housing, feeding and healthcare management practices have been achieved.

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#### Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence

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