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Traditional breeding of small ruminants in the North-West of Benin: practices and inventory of food resources

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ABSTRACT

    The northern part of Benin is a favourite area for ruminant breeding in view of its pastoral resources and the many other assets it has at its disposal. The objectives of this study were (i) to characterize small ruminants rearing practices in north-western Benin, (ii) to assess factors that affect the described practices (iii) and to inventory the feed resources used in the ruminant breeding. To achieve these objectives, a retrospective survey was carried out in four municipalities located at north-west Benin. The results showed that sheep and goats are mostly raised by men (94.93%). Digestive disorders (90.41%) are the main diseases encountered. The results of linear regression analysis showed that sociocultural group and education level of the respondents have a significant influence on the mode of management and the practice of castration of small ruminants. Feeding was based on fodder from natural rangelands, notably *Rottboellia cochinchinensis* and *Adenodolichos paniculatus*. These fodders content respectively, 17.71% and 20.4% of Total Nitrogen Matter (TNM). Breeders used crop residues, notably legume tops, food processing residues and fodder trees during the lean season. In view of this multitude of food resources, possibilities for improving the existing small ruminants breeding system are proposed.
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Keywords: Feeding, goat, pastoralist, rearing systems, sheep.

INTRODUCTION

    Livestock production plays an important role in economic development, especially in developing countries. It is estimated that more than 60% of the working population earns its income from livestock in

sub-Saharan Africa (Le Gall and Leboucq, 2003). In Africa, small ruminants are raised mainly for economic reasons (Ali et al., 2003; Dossa et al., 2015; Lakew et al., 2017) but also for self-consumption and sociocultural ceremonies (Dossa et al., 2007). Poultry and small ruminants are the main sources of income for poor families. In Benin, small ruminant farming is the most widely dispersed and most widely adopted by the population. According to the Food and Agriculture Organisation of the United Nations (FAO), the number of small ruminants in Benin in 2019 is estimated at 2,916,053 (1,955,811 goats and 960,242 sheep), ranking second after poultry (FAO, 2019).

The northern part of the country is reputed to be a preferred area for livestock farming and concentrates nearly 70% of the national ruminant livestock population (ANOPER, 2014). However, there is little referenced scientific data on the breeding techniques as well as the feed resources used by small ruminant breeders in North Benin. Most of the work carried out on sheep and goat farming systems in Benin has been limited to the south of the country. Among other things, they have made it possible to identify production objectives, characterize animal health management and the food resources used (Hounzangbé-Adoté, 2001; Dossa et al., 2007; Vidjannagni, 2007; Babatoundé et al., 2011). The few studies carried out in northern Benin have focused on sheep reproduction (Youssao et al., 2008) and the genetic characterization of goats (Kouato et al., 2020) in certain municipalities. The breeding system has three poles, namely the human pole, the animal pole and the environment pole (Dossa et al., 2007). Thus, breeding practices can vary according to the sociocultural groups of the breeders and the advantages offered by their immediate environment.

Feeding is an important element of successful breeding. Previous studies showed that small ruminants' feeding is mainly based on natural rangeland fodder (Sanou et al., 2016; Lakew et al., 2017; Hadbaoui et al., 2020). Sometimes, farmers bring in feed supplements such as crop residues and food processing residues (Montcho et al., 2016; Diogo et al., 2018). Moreover, nutritional values of feed resources used in small ruminants' livestock have been inventoried and analysed most in southern Benin (Vidjannagni, 2007; Babatoundé et al., 2011; Montcho et al., 2016). Diogo et al. (2018) inventoried crop residues used in the feeding of small ruminants in north-east Benin.

The southern part of Benin is very well watered by rainfall and is characterized by a high availability of fodder over a long period, unlike the northern part which is identified by high agricultural production and availability of crop residues. Vegetation in Benin, as elsewhere in the world, is very diverse and varies according to geographical zones (Houinato and Sinsin, 2002). Thus, the food resources used, which are mainly dependent on vegetation, can differ from the north to the south of the country. These disparities give rise to the need to characterize traditional small ruminant breeding systems in the north of the country in order to better identify their strengths and weaknesses and to make proposals for improved productivity. The objectives of this study were (i) to characterize small ruminants rearing practices in north-western Benin, (ii) to assess factors that affect the described practices (iii) and to inventory the feed resources used in the ruminant breeding.

MATERIALS AND METHODS
Study area

The study was conducted in the northwest of Benin (Figure 1), specifically in the departments of Atacora (municipalities of Kérou and Péhunco) and Donga (municipalities of Djougou and Copargo), a predominant area for small ruminants farming. The climate is of Sudano-Guinean type and is characterised by a rainy season from mid-April to mid-October and a dry season from mid-October to mid-April (Adomou et al., 2011). The average annual rainfall is 1150 mm with a temperature that varies between 25 and 39 °C. The relief is not very uneven in Donga, unlike that of Atacora, which is characterised by the presence of strong depressions and mountains known as the "Atacora chain". The vegetation

in a whole is made up of wooded savannah. It is dominated by species such as *Parkia biglobosa*, *Khaya senegalensis*, *Vitellaria paradoxa* and *Adansonia digitata* (Houinato and Sinsin, 2002). The soils are of a sandy-clay or lateritic nature (gravelly to stony), generally favourable to agriculture, which represents the main economic activity and occupies more than 2/3 of the active population. The main crops are *Gossypium sp.*, *Zea mays*, *Sorghum bicolor* and *Dioscorea sp*. Livestock keeping is the second activity after agriculture and is represented by cattle, sheep, goats, pigs and poultry.

According to the fourth General Census of Population and Housing (RGPH4), the population of the departments of Atacora and Donga is around 772,262 and 543,130, respectively (INSAE, 2015). The main sociocultural groups encountered in these two divisions are Bariba, Dendi, Peuhl, Lokpa, Otammari, Yôm, Djerma, Fon and Yorouba.

Sampling

Four municipalities in the divisions of Atacora and Donga were chosen to host the survey. These were Djougou and Copargo in Donga and Kérou and Péhunco in Atacora. Municipalities' selection was based primarily on the predominance of small ruminant farming, but also on their spatial distribution in the study area in order to ensure a representative sample. The choice of small ruminants' keepers to be surveyed was made at random from a list drawn up following an exploratory survey. A total of 115 ruminant breeding households were investigated using a questionnaire. In each household the head was interviewed but when he was not available, any person who was available to participate in the survey was identified and interviewed.

Data collection

All data were collected following the guidelines of the ethics committee of the University of Abomey-Calavi. In addition, no *in vivo* studies on animals or humans were conducted. Prior to the individual surveys, explanatory and awareness-raising meetings were held with some of livestock keepers in collaboration with the village chiefs and livestock technicians to present the objectives of the study. These meetings also made it possible to obtain a list of sheep and goat farmers in each municipality, from which the farmers to be surveyed were randomly selected. The latter were then approached individually to collect information using the retrospective survey methods proposed by Lesnoff (2008). The survey form took into account information on the three poles of the farming system (the human pole, the environment pole and the animal pole) (Dossa et al., 2007). Thus, the survey form took into account aspects such as the socioeconomic characteristics of the respondents, feed management, livestock management, livestock health management, available food resources, livestock farming methods and practices, dominant diseases and traditional means of control and prevention. The survey was combined with field observations, grazing monitoring and collection of droppings and voucher specimens. Herbarium specimens were mounted for food plant resources identification and they were identified and authenticated at the National Herbarium of Benin, University of Abomey-Calavi (HNB/UAC).

Analysis of faeces and fodder samples

Faeces were analysed using Mac Master technique as described by Hansen et Perry (1995), in order to identify the eggs of gastrointestinal parasites present in the study area. The bromatological analysis of *Gomphrena celosioides*, *A. paniculatus*, *Adenostemma caffrum*, *E. indica* and *R. cochinchinensis* samples was conducted at the zootechnics laboratory, University of Abomey-Calavi, according to the methodology described by the Association of Official Agricultural Chemists (AOAC 1990) and previously used by Babatoundé et al. (2011) and Garcia et al. (2020). Samples were dried in a laboratory oven and ground through a 1 mm sieve (1 mm sieve, FOSS Electric A/S, Hilleroed, Denmark), before analyses. The Dry Matter (DM), Organic Matter (OM), Total Ash (TA) and Total Nitrogenous Matter (TNM)

contents of the samples were determined according to the methodologies described previously (AOAC, 1990; Babatoundé et al., 2011; Garcia et al., 2020).

Data analysis

Data were analysed with IBM®-SPSS® version 20 software (IBM Corp, 2011). The mean and standard deviation were determined for the quantitative variables. Frequencies were calculated for the qualitative variables. Also, the Chi-square (χ^2) test was used to assess the effect of certain factors (housing type , level of education, small ruminants genotype and training in animal husbandry techniques) on the qualitative variables (animal husbandry,

ethnoveterinary practices). A series of regressions were carried out to assess the relationships between the socioeconomic characteristics of the respondents and their small ruminants rearing practices. The mode of animal husbandry, the practice of castration, the farmer-herder conflict existence, The used of feed supplements and ethnoveterinary practices were used as variables to be explained (dependent variables), followed by the respondents sex, level of education, main activity, breeding objective, sociocultural group and age as explanatory variables (independent variables). The differences were considered significant at the 5% level.
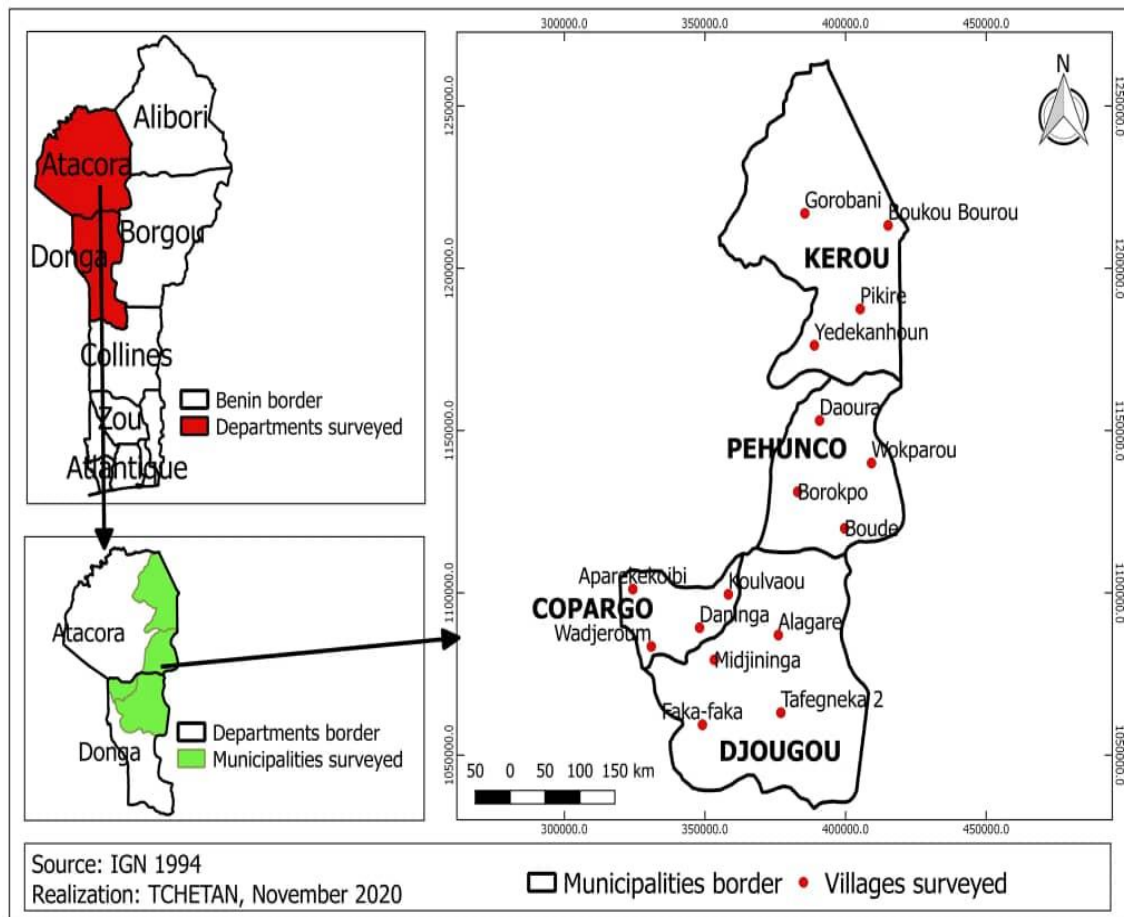

Figure 1: Map of the study area showing the location surveyed villages.

RESULTS

Socioeconomic characteristics of respondents

The majority of the small ruminants keepers surveyed were male (94.93%) and most of them had primary level (56.16%). The average age of the herders surveyed was 48 ± 12 years and each household had an average of 11 ± 5 people (Table 1). Bariba (27.40%), Dendi (19.18%) and Fulani (17.81%) were the main sociocultural groups involved in small ruminants farming in the study area. Agriculture (67.12%) and livestock rearing (24.66%) were the main activities and sheep and goats are reared mainly for socioeconomic reasons (schooling of children, dowry, ceremonies, marriage, Eid-El-Kebir festival, etc.) (63.01%).

Flocks characterization

The average size of the small ruminants herd was 32 ± 76, with a predominance of sheep (25 ± 82). Most of the small ruminants flocks encountered were of the mixed type (45.21%) (made up of sheep and goats). The Djallonke breed dominated the small ruminants' herds of the farmers' surveyed (Figure 2).

Livestock management

The results showed that the majority of the small ruminants' keepers (97.33%) do not take their animals to pasture. In fact, the animals are released into the wild and graze all the time. Identification of sheep and goats were done visually based on criteria such as colour of coat, probable physical abnormalities, spots on the feet and other parts of the body of the animal. Sheep and goats were kept mainly in semi-freedom (52.78%) and total freedom (41.67%) by the farmers. Total confinement was rarely practised (5.56%) and only concerns animals with a high market value and those being fattened for the Eid-El-Kebir festival. The majority of respondents (65.75%) had a sheepfold or goat shed to protect their animals against theft and bad weather. The management of small ruminants depended on the type of housing available for the animals ($\chi2 = 36.20$, $p < 0.001$). Indeed, farmers with a sheepfold or goat shed mainly (75%) kept sheep and goats in semi-freedom, whereas those without housing for small ruminants opted for total freedom. The housing was made of local materials and does not necessarily meet the required standards.

Small ruminants feeding

Sheep and goats in the study area were mainly fed on rangeland forage. Monitoring of grazing allowed us to identify the main forage species grazed (Table 2). These were mainly *R. cochinchinensis*, *A. paniculatus* and *E. indica*. The majority of the farmers surveyed (93.15%) use residues from food processing in their sheep and goat rations. Maize and sorghum bran, sorghum grain and milling residues were the most commonly used. In addition, 46.57% of the farmers surveyed use crop residues in the feed of small ruminants. Crop residues consist mainly of bean, soya bean and peanut dead leaves and soya bean, followed by bean husks. Crop residues were collected just after harvest, stored at home and distributed to the animals in the evening when they return from grazing. The food deficit in the dry season leads some farmers to use woody fodder to supplement the diet of sheep and goats. The main species used were *P. erinaceus*, *A. africana* and *F. sycomorus*. Mineral salts are provided to small ruminants in the form of licking stones by 12.33% of the farmers surveyed. Table 3 summarises the results of the bromatological analysis carried out on the main forage species used in the study area. The average Total Nitrogen Matter (TNM) content was 17.96% and varies from 10.4% (*G. celosioides*) to 23.03% (*A. caffrum*). On the other hand, the average Organic Matter (OM) content was

81.68% and varies from 73.71% (*E. indica*) to 97.36% (*R. cochinchinensis*).

Farmers' knowledge of reproductive parameters

The average age at first birth reported were 11.93 ± 1.31 and 11.74 ± 2.08 months for goats and sheep, respectively. According to the breeders, the average litter size for goats and sheep were 1.86 ± 0.76 and 1.29 ± 0.46, respectively. In addition, the farmers surveyed reported that the interval between births was 6.31 ± 1.69 months in goats and 7.34 ± 1.59 months in sheep. Forty-one per cent of respondents reported that they select females for breeding. The selection of males for breeding was done by 47.22% of the farmers. Small ruminants' selection was based on the breed, coat colour, size and prolificacy (for females).

Small ruminants' sale

The majority of the animals reared were intended for sale (79.16%). The sale generally took place in the livestock markets of each locality and the price of the small ruminant depended mainly on its sex (85.71%), the colour of its coat (41.43%) and the selling period (58.57%). The respondents sell an average of 6.45 ± 11.57 head of small ruminants per year.

Livestock health management

Digestive disorders (diarrhoea, constipation, indigestion) are the main diseases (90.41%) encountered on small ruminant farms in northwest Benin. They were followed by respiratory disorders (53.42%) and external parasitosis (20.56%). To treat these diseases, farmers turn to local veterinarians and livestock technicians. According to the farmers, these diseases are mostly observed in the rainy season. In addition, 27.78% of the people surveyed use ethnoveterinary practices to treat sheep and goat disorders. The main plants used were *Khaya senegalensis*, *Striga hermonthica* and *Pterocarpus erinaceus*. Castration was practised by 45.21% of farmers and concerns only goats, especially young males after weaning. Coproscopic analysis of droppings samples collected during the survey revealed the presence of strongyles eggs (84.61%), Moniezia (7.69%) and Coccidia (100%). These different digestive parasites were found in all municipalities study with the exception of Moniezia which was only observed in the municipality of Partago.

Influences of socioeconomic factors on small ruminant rearing practices

The results of the regressions showed that the socioeconomic characteristics of the farmers did not significantly influence livestock rearing practices (feed supplements and use of ethnoveterinary medicine to treat animal diseases) (Table 4). Similarly, the existence of farmer-herder conflict was not associated with the socioeconomic characteristics of the respondents (P >0.05). On the other hand, the mode of conduct and the practice of castration of small ruminants were significantly influenced by certain socioeconomic characteristics of the herders (P <0.05). Bariba prefer to keep their animals in semi-liberty, whereas the other sociocultural groups (Fulani, Dendi, Lokpa, Yom) leave their small ruminants in total freedom. Furthermore, the castration of small ruminants is practised by herders who were alphabet in local language and who practice livestock rearing and agriculture as their main activity.

Table 1: Socioeconomic characteristics of the small ruminants' keepers surveyed.

| Variables	Description	Frequency / Mean ± standard deviation
Age	-	48 ± 12
Household size	-	11 ± 5
Experience in small ruminant keeping	-	16 ± 11
Sex	Male	94.93%
	Female	15.07%
Sociocultural groups	Bariba	27.40%
	Dendi	19.18%
	Fulani	17.81%
	Lokpa	10.96%
	Yoruba	9.59%
	Kotocoli	8.22%
	Yom	6.85%
Education level	Alphabet in local language	34.78%
	Primary level	56.16%
	Secondary level	17.81%
	University level	10.96%
Main activity	Agriculture	67.12%
	Breeding	24.66%
	Others	8.22%
Production objectives	Socioeconomic	63.01%
	Sociocultural	20.55%
	Economic	15.07%
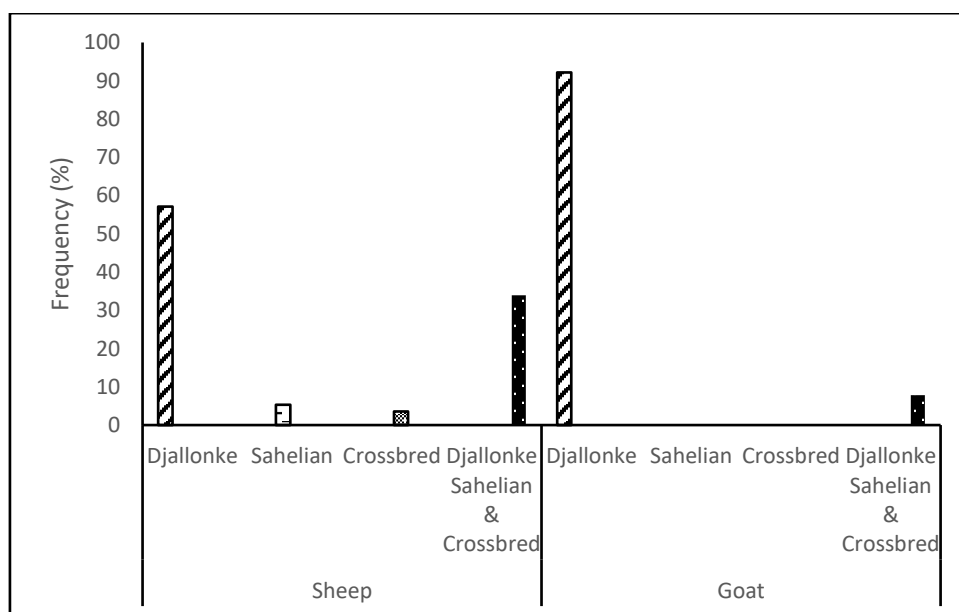
Figure 2: Characterisation of small ruminants' herds of the farmers surveyed.

Table 2: Main fodder and fodder trees used to feed small ruminants in north-western Benin.

Vernacular name	Family	Scientific name
Gannou [a]	Moraceae	*Ficus sycomorus*
Tona [a], Téme [a], Kosso [b]	Fabaceae	*Pterocarpus erinaceus*
Gberou [a], Kissi [c]	Caesalpiniaceae	*Afzelia africana*
-	Mimosaceae	*Entada africana*
Herbe fataque [d]	Poaceae	*Rottboellia cochinchinensis*
Tchadè [e]	Fabaceae	*Prosopis africana*
Tollo [f]	Poaceae	*Eleusine indica*
Sova [f], Kao [c]	Euphorbiaceae	*Flueggea virosa*
Mohr [b]	Lamiaceae	*Hyptis suaveolens*
Pklodoun [f]	Moraceae	*Ficus polita*
Karité [d]	Sapotaceae	*Vitellaria paradoxa*
Fédji Goro [b]	Fabaceae	*Adenodolichos paniculatus*
Madobier [e]	Malvaceae	*Sida acuta*
Koka [b]	Asteraceae	*Adenostemma caffrum*
Ihoundé [b]	Amaranthaceae	*Gomphrena celosioides*

[a] Bariba ; [b] Dendi ; [c] Fulani ; [d] French ; [e] Yom ; [f] Lokpa

Table 3: Bromatological analysis of the main fodder species identified in north-western Benin.

Species	Family	DM (%)	OM (%)	TA (%)	TNM (%)
Gomphrena celosioides	Amaranthaceae	92.17	82.81	17.18	10.4
Adenodolichos paniculatus	Fabaceae	93.34	90.82	9.18	20.4
Adenostemma caffrum	Asteraceae	93.95	70.67	29.33	23.03
Eleusine indica	Poaceae	91.75	73.71	26.29	18.26
Rottboellia cochinchinensis	Poaceae	97.36	90.38	9.62	17.71

DM = Dry Matter, OM = Organic Matter, TA = Total Ash, TNM = Total Nitrogen Matter

Table 4: Results of linear regression analysis.

Independent variable	Castration		Feed supplements		Ethnoveterinary practices		Farmer-herder conflict		mode of conduct	
	Coefficient	*p*-value	Coefficient	*p*-value	Coefficient	*p*-value	Coefficient	*p*-value	Coefficient	*p*-value
Sex	-1.49	0.14	0.37	0.71	0.46	0.64	0.66	0.51	0.37	0.71
Education level	-2.13	0.03 *	-0.58	0.57	-1.66	0.10	-0.72	0.48	0.15	0.88
Main activity	-1.09	0.28	1.00	0.32	0.39	0.70	0.54	0.59	-0.79	0.43
Breeding objective	0.40	0.69	0.78	0.44	0.27	0.79	0.56	0.58	-0.54	0.59
Ethnicity	-0.95	0.35	0.02	0.99	-0.58	0.57	-0.82	0.42	2.40	0.01 *
Age	-1.49	0.14	-0.46	0.65	0.14	0.89	0.02	0.99	1.29	0.20
R-squared	0.50		0.12		0.26		0.29		0.25	
Adjusted *R*-squared	0.33		- 0.01		0.02		0.06		0.01	
F-value	2.97		0.91		1.07		1.24		2.53	
p-value	0.00 **		0.52		0.41		0.27		0.02 *	

* Significant at 5%, ** significant at 1%

DISCUSSION

Due to its numerous advantages, small ruminants' farming is practised by the majority of farms in Benin. It is a highly developed activity in the northern part of the country but has often not received the attention of researchers in all its aspects. The present work has enabled a better understanding of traditional sheep and goat production practices in northern Benin and an inventory of the food resources used.

Socioeconomic characteristics of respondents and flock demographics

The results showed that sheep and goat rearing in northwest Benin is mainly practised by men. Respondent's selection seems to favour men. Indeed, the heads of household are generally men, and it is when they are absent or dead that women were interviewed. Male heads of household are responsible for bearing the major expenses of the household, and therefore take up small ruminants breeding activities that can enable them to do so. These results confirm the observations of Hounzangbé-Adoté (2001) in southern Benin, Ali et al. (2003) in Maradi, Niger, Tchouamo et al. (2005) in western Cameroon and Lakew et al. (2017) in southern Ethiopia, who concluded that sheep and goat rearing is mostly done by men. The main sociocultural groups encountered were Bariba, Dendi, Fulani, Lokpa, Yôm and Yorouba. These sociocultural groups are the most represented in the study area (INSAE, 2015). The respondents have agriculture and livestock as their main activities. This would be related to the fact that agriculture represents the main activity practised in Benin, particularly in the northern part, and occupies nearly 2/3 of the active population. Ali et al. (2003) made similar observations when working with small ruminants households in Maradi, Niger. Similarly, Tchouamo et al. (2005) found that the majority of small ruminant breeders in western Cameroon are farmers. This result also showed the level of integration of agriculture with livestock production and offers avenues for improvement of the small ruminant livestock system in the area through the integration of agriculture. The average number of small ruminants was 32 ± 76. This number appears high compared to that found in southern Benin by Hounzangbé-Adoté (2001) and Dossa et al. (2007) and in West African sub-region (Dossa et al., 2015). This shows the importance of sheep and goat farming in the study area. The herds of small ruminants are essentially made up of the Djallonke breed. The high representation of this breed in the herds is probably linked to its ability to live and produce even in environments hostile to livestock farming (Missohou et al., 2016). In addition, its size and relatively affordable cost compared to other ecotypes are among the reasons that militate in its favour.

Small ruminant breeding practice

Small ruminants were fed with fodder from the natural range. These were mainly *R. cochinchinensis*, *A. paniculatus* and *E. indica*. During the deficit period, farmers use mainly *P. erinaceus*, *A. africana* and *F. sycomorus*. These results confirm those found in western Cameroon by Tchouamo et al. (2005) and in southern Ethiopia by Lakew et al. (2017), who stated that sheep feeding is mainly provided by natural grazing. Furthermore, the main forage species identified in the present study are not in agreement with those found in South Benin by Babatoundé et al. (2011). This difference would be linked to the disparity in the distribution of fodder species in the different agro-ecological zones. In response to the low productivity of natural rangelands, especially in the dry season, farmers rely on crop residues, notably bean, soya bean and peanut dead leaves, cereal stalks, and food processing residues such as cereal bran, to cover their animals' feed needs. These results corroborate those of Diogo et al. (2018) who worked on the use of crop residues for feeding small ruminants in northeast Benin. Indeed, these authors showed that legume tops are the most used in terms of feed supplements. However, the results are not in line with those of Hadbaoui et al. (2020) who showed that sheep farmers adopt fodder crops in the face of the lack of fodder resources in the steppe environment of Algeria. As the feeding of

small ruminants in the study area is based on fodder from natural pasture, we decided to carry out a bromatological analysis on the main forage species inventoried. The results showed that the average TNM content was 17.96%. *A. caffrum* was richer in TNN, with an average of 23.03%. These results are in agreement with those of Babatoundé et al. (2011) who found that the average TNM content of forages consumed by sheep and goats in southern Benin is 30%. However, the average obtained in our study is low compared to that obtained in *Moringa oleifera* (Garcia et al., 2020). This difference may be due to the variation in nutrient values depending on the plants and the harvesting period. The average OM content of the forages inventoried was 81.68%. This value is high compared to that found in southern Benin (Babatoundé et al., 2011) and in *Leucaena leucocephala* (Santana et al., 2015). This high OM content of the forages inventoried indicates that they are rich in nutrients for covering the nutritional needs of small ruminants.

The results showed that sheep and goats are mainly kept in total freedom and semi-freedom. This can be justified by the primitive nature of the activity for the people surveyed. These modes of sheep and goat management have been observed on sheep and goat farms in Maradi, Niger (Ali et al., 2003). However, these results contradict those of Tchouamo et al. (2005) who claimed that small ruminants are mainly kept in confinement in West Cameroon.

Digestive disorders were the main diseases (90.41%) encountered in small ruminants farms in northwest Benin. These results corroborate those obtained by Hounzangbé-Adoté (2001) who stated that digestive disorders are the main pathology of small ruminants in South Benin. Mortalities due to diseases are the main constraints to sheep and goat farming in Africa (Tchouamo et al., 2005; Dossa et al., 2015; Lakew et al., 2017). This is mainly due to the inaccessibility of veterinary services and products (Le Gall and Leboucq, 2003) and the low purchasing power of farmers. Thus, to treat sheep and goats, 27.78% of respondents use traditional

medicine. Coproscopic analysis carried out on the droppings samples revealed the presence of strongyles eggs (84.61%), Moniezia (7.69%) and Coccidia (100%). These observations confirm the results of Attindehou et al. (2012) who found that the prevalence of strongyles in particular *Haemonchus contortus* in small ruminant farms is very high in South Benin.

Conclusion

The present study has made it possible to characterise the small ruminant farming in northwest Benin. Sheep and goats were raised by men who were mostly literate in the local languages Bariba, Dendi, Lokpa, Yôm, Fulfulbé and Yorouba and whose main activity were farming and livestock rearing. Small ruminants' keepers were involved in raising mainly for economic reasons. The sheep and goat houses were made of local materials and are also used to store crop residues and agricultural products. Castration is a common practice for male goats as opposed to male sheep. Digestive disorders were the main ailments encountered on the farms and their treatment involves both local veterinary officers and traditional veterinary knowledge. The animals were mainly kept in total freedom and were fed with fodder from natural pastures, notably *R. cochinchinensis*, *A. paniculatus* and *E. indica*. Farmers use crop residues, notably legume tops and cereal stalks, residues from food processing, including cereal bran, and fodder trees such as *P. erinaceus*, *A. africana* and *F. sycomorus* during the lean season. The results also showed a trend towards improved husbandry practices among educated herders or those who had received literacy training in the local language. It is therefore desirable that measures be taken to strengthen the level of education of livestock keepers, which is a guarantee of a more efficient production system. This action of reinforcing the level of education of livestock farmers can be accompanied by small training courses on livestock rearing techniques. These training sessions could focus mainly on feeding techniques, given the wide variety of food resources used and the low nutrient content of some of these resources. Similarly, it would be

useful to consider feasibility studies on the artificial cultivation of certain forage species, including *E. indica* and *A. caffrum*, in view of their nutritional value.

COMPETING INTERESTS

The authors declare that they have no competing interests.

AUTHORS' CONTRIBUTIONS

Conceptualization and methodology: SYDA, EVBA and TDH; Data collection and analysis: ET and CCA; Writing original draft: ET; Manuscript review: TDH, EVBA, MFG, ISMA and SYDA.

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