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Typology of goat feeding systems in Benin

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Feeding is one of the limiting factors of productivity in goat production in developing countries. That's why this study was carried out to characterize the feeding systems used in goat farming in Benin. Accordingly, a semi-structured survey was conducted among 533 goat farmers in 6 agro-ecological zones in Benin. Data were collected on socio-demographic characteristics, breeding practices and feeding methods. A typology of goat feeding systems was developed using a factorial analysis of mixed data followed by an ascending hierarchical classification. The results of the study revealed three main types of feeding systems. These are feeding systems based on the use of: (i) natural pasture in a free-grazing system, (ii) natural pasture, crop residues and concentrates in a semi-controlled breeding system, and (iii) natural pasture, crop residues and concentrates in a controlled breeding system. The implementation of a programme to improve goat feeding and management systems will contribute significantly to increasing goat productivity. It will also contribute to food security in the rural community.

Keywords: Benin, *Capra hircus*, feeding practices, management practices

INTRODUCTION

In Africa, small ruminants play an important role in agropastoral systems (Kassa, 2021). Their provision of meat and milk contributes significantly to household food security (Gnanda et al., 2016; Assen and Aklilu, 2012). Among small ruminants, goat rearing is widespread in Benin. It represents an influential factor in socio-economic development, especially in rural areas (Ahmed and Mohamed, 2017). Indeed, goats are considered as a source of savings that can be easily mobilised by small farmers, as their rearing is within the reach of all social strata (Manirakiza, 2020; Mataveia et al., 2018; Ahmed and Mohamed, 2017). Furthermore, the use of goat is highly valued in traditional ceremonies and in catering during various celebrations (Suluku, 2022; Kouato et al., 2021; Kouamo et al., 2021). This affinity of the Beninese population for goats has led to an increase in its production by 29.5% over the last decade (Behingan et al., 2022). The most recent estimate the national goat population is 2.4 millions (DSA-Bénin, 2021). This makes goats the third most important livestock species in Benin, after poultry and cattle (Behingan et al., 2022). Despite the multiple socio-economic benefits of goat rearing, the production performance of this animal resource in Benin is still poor (Missohou et al. 2016; Devendra, 2010). This poor performance of goats is largely due to inadequate nutrition and diseases (Mataveia et al., 2018; Gnanda et al., 2016). Indeed, goats depend on natural pastures whose quality varies seasonally (Faouzi, 2016). In this context, the development of the goat production sector in Benin requires the adoption of new feeding strategies. The aim of this study is therefore to characterise goat feeding systems. This will

enable us to propose strategies for improving productivity on farms.

MATERIALS AND METHODS

Study area

This study was carried out in 16 municipalities spread over six of the eight agro-ecological zones (AEZs) of Benin. The classification of AEZs is based on the definition of homogeneous zones based on soil characteristics, geomorphology and climate (PNUD/ECVR, 1995). The selection of the zones covered by the study took into account well-founded and predefined criteria, such as the combination of the territorial approach and the commodity chain approach in favour of goat rearing. The six agro-ecological zones considered are Zone I, Zone III, Zone V, Zone VI and Zone VII (Figure 1).

Sampling

A total of 533 goat farmers were interviewed individually. The number of farmers interviewed was determined per municipality. For this purpose, an exploratory survey was carried out on 50 randomly selected farmers to determine the proportion “p” of respondents involved in goat production. The number of farmers interviewed “n” was then calculated per municipality (Dagnelie, 1998) before being related to the population of each agro-ecological zone according to the number of municipalities considered per AEZ.

- n is the number of goat farmers interviewed per municipality,

- p is the proportion of respondents per municipality,

- U20.975 is the quantile of a standard normal distribution for a probability value of 0.05,

- d is the marginal error set at 8%.

Data collection

A semi-structured survey was conducted among 533 goat farmers from August to September 2020 using a smartphone with the KoboToolbox data collection tools. The data collected during the survey are related to: (i) socio-demographic characteristics of the farmers (age, gender, level of education, ethnicity, religion, marital status, and occupation), (ii) goat farming methods (Free grazing, fixed stakes, mobile stakes, and stalls), (iii) goat feeding practices, (iv) production objectives, and finally (v) the reasons for raising goats. It is important to note here that there is a significant difference between “fixed stakes” and “mobile stakes” in terms of farming practice. In the case of “fixed stakes” (Figure 2), the goat is tethered to the stake on the farm or in the yard of the house, and the farmer goes out to look for the fodder, which he brings with him to feed the animal. In the case of “mobile stakes” (Figure 3), the small ruminant is tethered in the field to graze. And when the fodder within the reach of the goat runs out (Figure 3a), the farmer moves the stake to another place where there is fodder for the small ruminant to graze (Figure 3b).

Statistical analysis

Descriptive statistics were used to analyse data on socio-demographic characteristics and farm management. Kendall’s concordance test was used to rank the data on production objectives, goat breeding reasons and feeding practices. A factorial analysis of mixed data (AFDM) was used to obtain a representation of the farms in the form of projections of plans defined by the factorial axes. Then, a hierarchical ascendant classification (HAC) was used to group the farms according to their proximity to each other. The numerical classification was then used to carry out the typology of

feeding practices using the FatoMineR package. Data analysis was carried out using R4.1.3 software (R Core Team, 2022).

RESULTS

Socio-demographic characteristics of goat farmers

The socio-demographic variables taken into account were gender, ethnicity, main activity, level of education, and training in animal husbandry (Table 1). Out of the 533 farmers surveyed, more than half (56.8%) were men. However, in AEZ 3 and 5, women outnumbered men. A high degree of ethnic diversity was observed among the goat farmers. The Fons (26.8%), the Peulhs (24.8%) and the Yorubas (20.4%) are the three ethnic groups at the top of the ranking of goat producers. Most of these producers have no or low level of formal school education.

Among households that own goat herds, only 5.82% practice animal husbandry as a main activity. Actually, agriculture is the main occupation of most (54.6 %) goat breeders. In addition to farmers and breeders, there are traders, civil servants and other contributors to economic life who raise goats. Of all this diversity of actors involved in goat rearing, barely one-tenth (9.0 %) have received formal training in animal husbandry.

Production goals and reasons for raising goats

Economic interest is the first reason for goat production in Benin (Table 2). Then, cultural habits and passion lead a large part of the population to engage in goat farming. Households also choose to keep goats for the consumption of their products and for their hardiness.

Meat production ranks first among the products targeted for goat rearing (Table 3). This is followed by the use of manure. Milk comes third.

Goat farming practices

Figure 4 shows the goat farming practices in Benin according to the seasons (Dry and rainy). During the dry season, almost all (89.7%) of the goats are left to graze freely. This free grazing practice is total in EAZ1, while in EAZ2, 3, 5, 6 and 7, it varies from 85.2% to 94.2%. During the dry season, none of the farmers raise goat on stakes (fixed or mobile). However, in the rainy season, the goats are reared on free grazing (34.1%), on fixed stakes (34.0%), on mobile stakes (12.6%) and in stalls (19.3%).

Seasonal use of feed resources

Table 4 shows the subgroups of feed resources used to feed goats in the rainy and dry seasons. In all seasons, natural pasture is the main source of feed for the animals. Apart from natural pasture, agro-industrial by-products, crop residues and mineral supplements are used by goat farmers. However, crop residues are used more in the dry season than in the rainy season. Apart from agro-ecological zone 1 (AEZ1), where fodder crop (artificial pasture) is used, it is observed that this last category of feed resources, as well as compound feeds and multi-nutrient blocks are not really included in the goat feeding practices of the breeders.

Characterisation of feeding practices

The results of the factorial analysis show that the first four components explain 53.3% of the information in the initial database (Table 5). In addition, the hierarchical classification carried out on the factorial analysis of the mixed data made it possible to classify the farmers into three groups according to their feeding practices. Thus, three different types of feeding systems were identified

(Figure 5).

First system (cluster 1): Feeding system based on the use of natural pasture in a free-grazing system.

Farmers in this group (51.6%) have an average of 15 goats, which are mainly fed on natural grazing. Apart from crop residues (75.1%) and kitchen waste (24.1%), the farmers in this group do not use any concentrates as feed supplements. The animals here are left to graze freely. Sometimes, there are exposed to bad weather.

Second system (cluster 2): Feeding practices based on the use of natural pasture, crop residues and concentrates in a semi-controlled rearing system.

This category of farmers has an average flock of 24 goats and represents 44.1% of the respondents. The use of crop residues (43.7%) and feed concentrates (42.6%) by the breeders is relatively important. Depending on the cultural season and environmental factors, goats are kept in stalls, on stake or on free grazing.

Third system (cluster 3): Feeding practices based on the use of natural pasture, crop residues and concentrates in a controlled breeding system.

The respondents in this cluster represent only 4.32% of the goat farmers. They have an average herd of 19 goats, which they feed in confinement. Here, the animals are fed on stakes or in stalls. In addition to fodder and crop residues, more than 85% of the goat farmers in this group provide their animals with supplementary feed. They use compound feeds, agro-industrial by-product, salt licks, etc., to promote the performance of their animals. It is in this category of breeders that we have the few goat milk producers.

DISCUSSION

Socio-demographic characteristics of goat farmers

In Benin, the majority of goat farms are owned by men. Similar results have been found in other African countries with Suluku et al. (2022) in Sierra Leone, Laouadi et al. (2018) in Algeria, Wasso et al. (2018) in Congo and finally with Guingouain (2017) in Togo. As men are the heads of households, they are also the owners of livestock. However, it is actually women and children who look after these small ruminants most of the time (Suluku et al., 2022). Meanwhile, it should be noted that in some cases, women also have their own goat herd. This is the case in AEZs 3 and 5, where women outnumber men. This is also the case in Senegal, where Sow et al., (2021) found a higher proportion of women goat owners than men. For both men and women, goat rearing is undertaken to serve as a source of savings. For this reason, the goat is considered as a ‘mobile bank’ (Suluku et al., 2022) by rural communities. And because the goat market is always available, cash can be easily mobilised from this ‘mobile bank’ to enable producers to respond to financial emergencies, especially during the lean season.

All ethnic groups are involved in goat rearing. This high ethnic diversity around goat farming shows that there is no socio-cultural taboo against the use and consumption of goat meat and co-products (Zinsou et al., 2021, Sunder et al., 2016, Peacock, 1996). The lack or low level of education of goat producers reflects the level of education of the rural population in Benin. The same trends have been observed by other researchers in Benin (Behingan et al., 2022, Kouato et al., 2020). This educational vulnerability of producers is also a limiting factor in their ability to receive proper training in goat rearing. This is probably one of the reasons why up to 91% of goat farmers have never received formal training in goat husbandry. The other reason would be that goat keeping is a sideline activity for the vast majority of goat breeders. Unfortunately, the lack of formal training in

goat husbandry is a serious limitation to good goat management. As a result, goat farmers will find it extremely difficult to properly plan the expansion of their activity (Suluku et al., 2022). The productivity of goat farms will therefore improve significantly if appropriate training alternatives are provided, taking into account the level of education of the breeders. Goat rearing will therefore have a bright future if younger people, who are better educated than their elders and who take care of the animals, are involved in the various training courses.

Production goals and reasons for rearing goats

Goats are primarily kept in Benin for economic reasons. Then, cultural habits, passion for breeding and feeding of goat meat and products are the reasons mentioned by producers. Finally, goats are chosen by farmers for their hardiness. Indeed, goats are very resilient and well adapted to difficult conditions (Adeola et al. 2023;Serranito et al., 2021; Kosgey et al., 2006). They have interesting production capabilities such as prolificacy, fertility, resistance to drought and disease (Baker and Gray, 2004; Kosgey et al., 2006). They have the ability to walk long distances (Boyazoglu et al., 2005), jump and climb in shrubs (De, 2022; Lewinson and Stefanyshyn, 2016) to access feed resources that are often inaccessible to sheep and cattle. The ability of goats to better defend themselves in nature and to withstand harsh living conditions has meant that all strata of the local population have always been interested in rearing this animal resource, which has gradually become part of their cultural habits. The economic importance of goat rearing for the producers in this study has also been mentioned in other findings in Benin (Challaton et al., 2022), Africa (CTA, 2006) and worldwide (Lohani, 2021).

Goats have been a traditional source of meat and co-products since the beginning of civilisation (Casey and Webb, 2010). Goat meat has always been highly valued in the human diet (Mouhous et al., 2021). It is one of the main sources of animal protein. Its meat is very delicious and highly appreciated by Beninese consumers. This is probably why goat production in Benin is mainly for its meat. However, it is clear that the production of goat’s milk is not really part of the production habits of the vast majority of goat farmers. Only a minority of breeders are involved in this production and make it their main objective. The few farms producing goat’s milk in Benin use the Maradi red goat and the Saanen breed and have a niche market for their products. Goats are known to be very good milk producers (Miller and Lu, 2019). Commonly referred to as the “poor man’s cow” (Iqbal et al., 2008). Goat’s milk is as nutritious, and more digestible than cow’s milk (Zhao et al., 2022; Chauhan et al., 2021). It plays an important role in immune stimulation, growth promotion and disease prevention (Turkmen, 2017). In many parts of the tropics, goats are important milk producers (Csapóné Riskó and Csapó, 2019). They contribute significantly to human nutrition in many developing countries (Getaneh et al. 2016; Devendra, 1999). Establishing an incentive policy to introduce goat milk production and consumption into the local population’s habits will contribute significantly to addressing the challenges of malnutrition and poverty in Benin. Whether it is for meat or milk production, many farmers use goat manure as fertiliser for their fields and gardens. This is why manure comes second in the Kendall ranking. However, this goal is of little importance to the goat producers.

Goat farming practices

In general, goats are left to graze freely during the dry season. Free grazing as the main goat management system has also been reported in Ethiopia (Tilahun, 2023), Algeria (Ouchene-Khelifi, 2021), Congo (Wasso et al., 2018) and Cameroon (Tendonkeng et al., 2013). However, during the rainy season, the practice of free grazing is significantly reduced in favour of fixed stakes, mobile stakes and pens. This tendency towards sedentarisation of goats during the cropping season is mainly justified by farmers’ concern to protect crops in the fields. Only animals kept in bare field concessions are allowed to graze freely during this period. Farmingg practices aimed at sedentarisation through staking and penning have also been observed by other researchers in Benin (Challaton et al., 2022, Dahouda et al., 2019) and Togo (Djagba et al., 2020). These practices would be mainly due to the lack of grazing land or well-established fodder crops in areas where

food crops are not prevalent. It would therefore be relevant to promote the establishment of artificial pastures in livestock areas to improve the management of ruminants in general and goats in particular.

Seasonal use of feed resources

In all seasons, natural grazing is the predominant source of animal feed. Apart from natural grazing, goat farmers use agro-industrial by-products, crop residues and mineral supplements. However, the use of crop residues is higher in the dry season than in the rainy season. Other studies (Saidani et al., 2019; Dahouda et al., 2019; Kadi et al., 2016) have also reported that goats are fed with crop residues, hays, straw, fodder shrubs and agro-industrial by-products during the lean season. The use of agro-industrial by-products is indeed one of the factors that encourage breeders to produce despite the decline in natural resources (Montcho et al., 2018). It also improves animal nutrition and reduces pressure on natural vegetation (Montcho et al., 2018; Koura et al., 2017). This adaptive practice by farmers during droughts contributes to improved animal productivity and is ecologically beneficial (Dickhoefer et al., 2011).

Typology of feeding practices

This study has established a typology of three groups of feeding practices. The first, based on the use of natural pastures in a free-grazing system, is the predominant one. Farmers in this group have a small number of goats and feed them almost exclusively on natural pasture. There is no supplementation with concentrates. The few cases of supplementation are limited to crop residues and kitchen waste. In addition, the animals in these groups are generally left to fend for themselves and are more exposed to bad weather and disease. They are often left in the yards of the concessions or housed in precarious and unhygienic buildings (Saidani et al., 2019). According to Pacheco (2006), these buildings tend to be poorly functional, with poor ventilation and lighting. These are risk factors for goat health and productivity. The goat farmers in this group are similar to those in the extensive farming system described by Behingan et al., (2023). These farmers are certainly not engaged in livestock production as their main activity.

In the second group, breeders' practices depend on the season. During the dry season, the animals are usually left to graze. However, during the rainy season, only the animals that are kept away from the fields are allowed to graze freely. The others are kept on stake (fixed or mobile) or fed in stalls/pens. Here, there is a clear improvement in feed supplementation compared to the first group. In addition to crop residues, animals in this group receive agro-industrial by-products consisting of bran, oilcake and brewer's grain (Odjigue, 2022; Montcho et al., 2018; Koura et al., 2017). Some also give their animals compound feed, multi-nutrient blocks and salt licks (Djagba et al., 2020; Montcho et al., 2018). Although this supplementation practice is not sufficient in the goat farms in this second group, it helps to improve animal performances while reducing pressure on natural vegetation (Montcho et al., 2018; Koura et al., 2017). This type of practice, based on grazing, is considered a multifunctional and ecologically sustainable system (Dumont and Bernués, 2014; Dickhoefer et al., 2011).

The third group of goat farmers is a minority. Goats are fed on natural pasture here too. However, regardless of the season, the goats are not taken out to graze at all (zero grazing). Instead, they are kept and fed in stalls. Besides, the small ruminants are fed with feed supplements in this case too. This feed supplementation is quite disparate from one farm to another. This does not allow us to consider all goat producers in this group as part of the intensive system, as mentioned in other findings in Benin (Behingan et al., 2023; Bankole et al., 2005). In fact, there are goat farmers in this group with low means of production who, for safety reasons, prefer to keep and feed their animals in stalls. For them, the supply of inputs (feed and other) for the animals often does not meet the requirements. This results in a production system that is either extensive or semi-intensive. On the other hand, there are goat farmers who have sufficient feed and health inputs to induce good animal production (intensive production system). For the latter, the low number of producers is

linked to the fact that goat milk production requires technical skills and financial resources that are beyond the reach of most breeders. This may also be due to the fact that the use of goat's milk is not yet part of Beninese culture. Efforts are still needed to increase the production of goat meat and milk in Benin.

CONCLUSION

This study highlights three types of feeding practices. These are feeding practices based on the use of: (i) natural pasture in a free-grazing system, (ii) natural pasture, crop residues and concentrates in a mixed farming system and (iii) natural pasture, crop residues and concentrates in a controlled farming system. The feeding of goat herds is therefore based on the use of natural pasture. However, feed supplementation is poorly practiced or not practiced at all on most goat farms in Benin. The implementation of a programme to improve the goat feeding system will make a significant contribution to increasing goat productivity and household food security.

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