



Characteristics of Farming of the Kirdi Goat (*Capra hircus*) in the Far North Region, Cameroon

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A study on the characterization of kirdi goat (*Capra hircus*) breeding was carried out in eight localities in the Far North region of Cameroon. The aim was to highlight the socio-economic and zotechnical components of kirdi goat breeding in the said region. The study was based on a survey of 986 households in eight localities in the region. The study revealed that the majority of breeders were men (80.03%), with the most common age group being between 45 and 60. Married people are the most numerous (85.25%), and 54.92% of breeders are Christians. However, the main activity of livestock farmers is farming (59%), and the objective of livestock farming is to increase the number of animals (75.78%). Livestock are purchased (89.35%) and labour is provided by the family (94.18%). Annual household income ranges from 100,000 to 150,000 FCFA. From a zotechnical point of view, the size of the herd varies from 1 to over 45 head, and is a mixed farm.

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The main livestock management method is divagation (54.08%), the most common housing is the hut (84.96%), and the animals are grouped by species (56.87%). Supplementation is based on harvest by-products. In terms of health, 77.54% of farmers vaccinate their animals, and the most frequent symptom is diarrhoea (22.31%). Mating is not controlled at all by breeders (88.06%), 95.52% of breeders declare that they have recorded multiple births and 75.93% have obtained double births. In view of the above, this study shows that kirdi goat breeders have considerable know-how in managing their operations.

Keywords: Kirdi goat; zootechnics; characterization; breeding; far north.

1. INTRODUCTION

Livestock farming is one of the major activities in the Sudano-Sahelian zone, and the most profitable of all traditional activities [1]. It represents an essential source of income for 30% of the rural population, and for many ethnic groups, livestock is the primary means of accumulating wealth. For some groups, it's the only activity that gives rise to regular marketing. Around the world today, goat farming is playing an increasingly important role in national economies, as it is a factor in economic development, particularly in rural areas [2,3,4,5,6]. In Cameroon, goat farming is practised throughout the country and, with 6,506,334 head, this species is the third most important in terms of numbers, behind cattle and poultry [7]. Goat farming is a versatile supplier of high-fiber, noble foods. It plays an important role in food security, poverty alleviation and social cohesion. It is practiced by almost 70% of the working population either as a main or secondary activity after agriculture [8]. Hardiness and the ability to make the most of poor plant resources make goats subsistence animals in many less-developed countries with a dominant objective of meat production [9]. Among goats, more than the half of the population is made up of Kirdi goats, concentrated in the North and Far North regions [10]. This variety of dwarf short-haired goat is found in the southern part of the Lake Chad basin (in Chad, Cameroon and Nigeria). Its coat offers a great diversity of colours [11]. This species is more particularly bred by the so-called "kirdi" people, who comprise a group of heterogeneous ethnic groups in northern Cameroon [12]. This group includes the Toupouri, Massa, Moundang, Guiziga, Mafa or Matakam, Mofou, Dii, Guidar, Baya, Zoulgo, Mada, Namchi, Fali, Tikar, Mousseye etc [12].

In order to better understand and appreciate the contribution of kirdi goat production to the local and national economy, and to improve the breeding of this species, the present study was

initiated with the aim of highlighting the main socio-economic and zootechnical components of kirdi goat breeding in the Far North region of Cameroon.

2. METHODOLOGY

2.1 Study Environment

The study was conducted in the Far North region of Cameroon. It is located between 10° and 13° North latitude and 14° and 16° East longitude [13]. It is bounded to the south by the Northern Region (Mayo Louti Division), and to the East by the Chari River and its confluence with the Logone, which separate it from Chad as far as Lake Chad. The western boundary with Nigeria is formed by the Mandara Mountains and a conventional demarcation as far as Lake Chad. The Far North Region comprises six (6) Divisions and forty-seven (47) sub-divisions [14]. It covers an area of around 34,263 Km², or 7.20% of the national territory. In human terms, it is inhabited by a population estimated at 4,186,844 people in 2017, or 18.01% of the national population, for a density of 122 inhabitants/km² [7]. Surveys were carried out in eight localities in the region (Yagoua, Kar-Hay, Maga, Kaélé, Ndoukoula, Meri, Tokombéré and Mokolo) (Fig. 1).

The climate of the Far North region is of the Sudan-Sahel type, characterized by an average temperature of 35°C, a maximum of 44°C in April and a minimum of 16°C in January [13]. Overall, it is a hot environment with a concentration of rainfall over three to four months ranging from 400 to 1100 mm and a long dry season [15]. This is a grazing area where extensive and semi-intensive livestock farming is carried out (sheep and goat fattening). The vegetation consists of wooded savannah, herbaceous cover, forest galleries, steppe and thorny plants. The herbaceous stratum consists mainly of annual grasses (e.g. *Hyparrhenia diplandra*, *Bracharia decumbens*, *Panicum maximum*), which are important in goat nutrition.

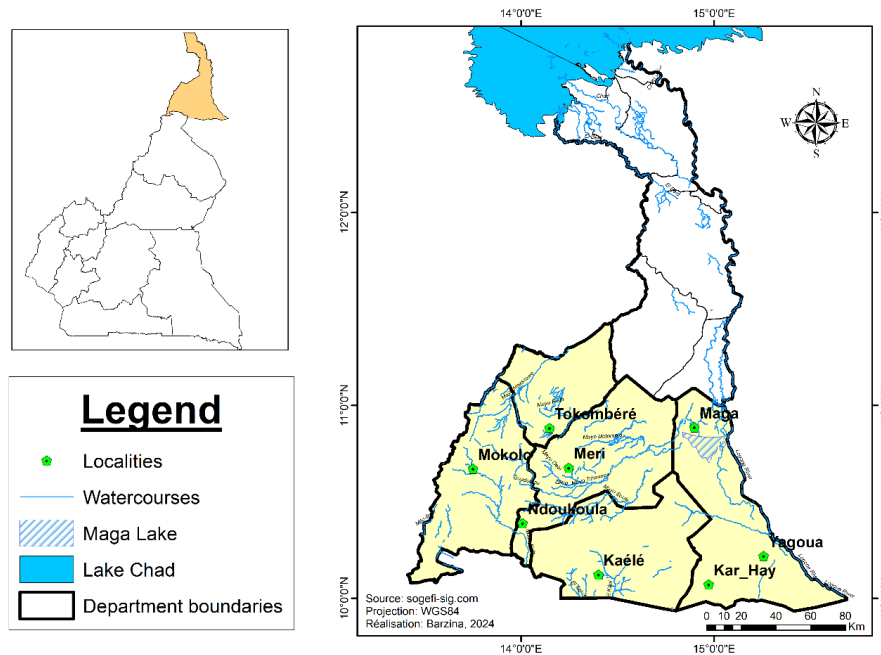


Fig. 1. Presentation of the study area

2.2 Sample of Households Surveyed

In the absence of information on the total number of farmers with kirdi goats in the Far North region of Cameroon, or on the proportion of the region's kirdi goat population, it was estimated that 50% of households in the Far North region have at least five kirdi goats per herd. Based on this assumption, we determined the theoretical minimum number of breeders that were representative for the zone as a whole, using the following formula reported by Dagnelie [16] as shown in the following equation:

$$n = \frac{u_{0,975}^2 \times p(1-p)}{d^2}$$

Where n is the number of respondents in the study area; p is the proportion of individuals breeding kirdi goats; $U_{0,975} \approx 1.96$ is the quantile of a standard normal distribution for a probability value of 0.05; and d is the marginal error set at 5%. Thus, on this basis, n theoretical minimum required calculated is roughly equal to 385 breeders, but the study was carried out on 986 breeders, which is well above the expected number.

2.3 Data Collection

The data were collected by means of a survey of the head of the household or any person owning

a kirdi goat, whether male or female. The survey took place from February to May 2021 in 5 Divisions of the Far North region, more specifically in eight localities, namely: Yagoua, Maga, Kar-Hay, Kaélé, Ndoukoula, Meri, Tokombéré and Mokolo. The criteria for selecting the farmers surveyed were as follows: be the head of household or his deputy, have at least five kirdi goats, and be available to answer questions. The choice of these localities was guided by the presence of a large number of goats on the one hand, and on the other by the fact that these are areas where ruminants are predominantly reared, according to the 2021 report of the Far North Regional Delegation for Livestock, Fisheries and Animal Industries.

The questionnaires were administered on each farm in the form of individual interviews. The questions dealt with the management of the farm and the socio-economic and zootechnical aspects of kirdi goat farming. In all 08 localities, the data were collected by the interviewers in languages that were clearly understood by both parties (interviewer and respondent).

The data obtained were entered and analysed using SPSS 20.0 software. The descriptive analysis of the qualitative variables was expressed as frequencies and the different modalities were calculated. The data were processed and represented in the form of figures and tables using Excel 2016.

3. RESULTS

3.1 Socio-economic Characteristics of Farmers

The socio-economic characteristics of the farmers are presented in Table 1. Kirdi goat rearing is a socio-economic activity that is found not only in rural areas but also in urban and peri-urban areas in the Far North region of Cameroon. This type of livestock farming not only diversifies the rural population's sources of income, but also enables financial autonomy and solid integration between agriculture and livestock farming. Agricultural by-products (cowpea and groundnut stalks, millet stalks and others) are used to feed the goats, and the dung they produce is used to fertilise arable land.

Table 1 shows that the majority of kirdi goat farmers are men (80.03%), compared with an average of 19.97% of women. On the other hand, in certain localities such as Meri, Tokomberé, Ndoukoula and Kar-Hay, 30.85%, 22.01%, 22.58% and 22.68% of the breeders are women respectively. This predominance of men is linked to the fact that in the Far North region, men are primarily responsible for everything that belongs to a household, even if these belong to women or children. This activity is practised by four age groups, but the (31-45) and (46-60) age groups are more representative, with (28.34%) and (34.51%) respectively. These two groups are followed by farmers over 60 years old. The latter represent 22.09% of the population surveyed. This explains why kirdi goat farming is more reserved for people of advanced age or adults.

The majority of breeders in the study area are married, with rates of 80.44%, 79.37%, 90.18%, 72.6%, 94.58%, 93.58%, 86.19% and 85.09% respectively in Yagoua, Meri, Mokolo, Kaélé, Maga, Tokombéré, Ndoukoula and Kar-Hay. On the other hand, in some localities, there are almost no divorced kirdi goat breeders, as in Mokolo, Ndoukoula and Kar-Hay, where the rate is 0%. 7.53% of the breeders surveyed were single and 5.94% were widowers. Livestock farmers with a primary level of education are most numerous, at 27.53%, 25.4%, 35.71%, 33.33%, 27.9%, 26.6%, 30.9% and 47.36% respectively in the localities of Yagoua, Meri, Mokolo, Kaélé, Maga, Tokombéré, Ndoukoula and Kar-Hay. They are followed by those who

have had no education at all, with an average of 19.81% in the study area. In Yagoua and Kar-Hay there are no farmers who have attended Koranic school, and in Ndoukoula and Kar-Hay there are no farmers who have attended higher education. Overall, it can be seen that the majority of farmers have at least a basic education. This is certainly an advantage from the point of view of developing innovations relating to the health protection and feeding of kirdi goats.

Three main religions are present in the study area: Christianity, Islam and Animism. The majority of farmers are Christians, with an average representation rate of 54.92%, followed by Muslims with 31.28% and animists with 13.80%. In Maga, 47.29% are Muslim. At Kar-Hay, 35.09% of farmers are animists. Agriculture remains the main activity in the study area. The results also show that for very few people, the main activity is livestock rearing. Fishing is the main activity in the Logone plain, with only 8.7% of the population in Yagoua and 25.58% in Maga. This practice is justified by the proximity of the Logone river to Yagoua and the presence of the Maga artificial lake, which is a potential supplier of fish to the Far North region of Cameroon.

There are several reasons why people in the area keep kirdi goats. Overall, the main objective is to increase the number of animals (75.78%). On the other hand, only 10.42%, 1.69% and 8.36% of goat breeders respectively breed for sale, self-consumption or sacrifice. In Mokolo (22.32%) and Ndoukoula (20.33%) the objective of sale is more representative than in the other localities, with 14.07%, 7.75%, 7.14%, 4.59%, 3.62% and 3.51% in Kaélé, Maga, Meri, Tokombéré, Yagoua and Kar-Hay respectively. In Ndoukoula and Tokombéré, on the other hand, none of the farmers declared that they raised goats for their own consumption. The Kirdi goat plays a very important social role among the Kirdi peoples. It is used for sacrifices (baptism, marriage, birth and others), and also plays a key role in traditional sacrifices. In Tokombéré, 22.93% of farmers use Kirdi goats for sacrifices, in Kar-Hay 9.65%, in Mokolo 8.93%, in Meri 9.52%, in Yagoua 5.07%, in Kaélé 5.19%, in Ndoukoula 6.25% and in Maga 2.32%. It is also regarded as a farmers' bank that can be used in times of need.

Table 1. Socio-economic situation of livestock farmers

Parameters	Modalities	Study area frequency (%)								Total frequency
		Yagoua	Meri	Mokolo	Kaélé	Maga	Tokombéré	Ndoukoula	Kar-Hay	
Sex	Male	82,61	69,04	82,14	88,15	87,6	77,98	76,42	76,31	80,03
	Female	17,4	30,95	17,86	11,85	12,4	22,01	23,58	23,68	19,97
Age groups (years)	[15 - 30]	23,19	12,7	14,29	14,81	13,18	18,35	8,13	15,79	15,06
	[31 - 45]	24,64	32,54	41,07	22,96	27,13	21,1	40,65<	16,67	28,34
	[46 - 60]	31,16	30,16	28,57	35,56	41,86	37,61	31,71	39,47	34,51
	[> 60]	21,01	24,6	16,07	26,67	17,83	22,94	19,51	28,07	22,09
Marital status	Single	11,6	3,17	6,25	20	1,55	5,5	1,62	10,52	7,53
	Married	80,44	79,37	90,18	72,6	94,58	93,58	86,19	85,09	85,25
	Divorced	0,72	4,76	0	0,74	0,77	0	3,25	0	1,28
	Widow	7,24	12,7	3,57	6,66	3,1	0,92	8,94	4,39	5,94
Level of education	Primary	27,54	25,4	35,72	33,33	27,91	26,61	30,9	47,36	31,85
	Secondary 1st cycle	25,36	11,9	24,11	22,23	6,97	15,6	20,32	21,92	18,55
	Secondary 2 nd cycle	15,94	7,14	6,25	17,77	3,1	8,25	11,4	4,4	9,28
	Higher	2,9	2,38	1,78	3,7	0,77	4,58	0	0	2,01
	Koranic	0	12,7	1,78	5,92	22,48	23,86	8,94	0	9,46
	Village literacy	3,62	11,11	14,28	8,15	10,85	8,25	8,94	7,01	9,03
None	24,63	29,36	16,07	8,88	27,91	12,84	19,5	19,3	19,81	
Religion	Christian	68,12	54,76	56,25	57,78	45,73	56,88	46,34	53,51	54,92
	Muslim	15,22	32,54	33,04	26,67	47,29	38,53	45,53	11,4	31,28
	Animist	16,66	12,7	10,71	15,55	6,98	4,59	8,13	35,09	13,80
Main activity	Agriculture	55,79	52,38	62,5	65,93	39,53	66,97	67,48	61,4	59,00
	Breeding	7,97	5,55	2,68	8,89	6,98	10,09	3,25	6,14	6,44
	Retail	4,35	11,9	4,46	5,93	11,63	8,26	11,38	3,51	7,67
	Fishing	8,7	0	0	0	25,58	0	0	0	4,28
	Employee	12,32	12,7	8,93	8,15	10,85	5,5	6,5	16,67	10,20
	Crafts	0	3,97	8,03	4,44	0	2,75	1,63	0	2,60
	Other	10,87	13,5	13,4	6,66	5,43	6,42	9,76	12,28	9,8

Table 1. Socio-economic situation of livestock farmers (continued)

Parameters	Modalities	Frequency in the study area (%)							Frequency total	
		Yagoua	Meri	Mokolo	Kaélé	Maga	Tokombéré	Ndoukoula		Kar-Hay
Breeding objective	To increase livestock numbers	86,23	76,19	63,39	75,56	82,95	68,81	71,54	81,58	75,78
	Sale	3,62	7,14	22,32	14,07	7,75	4,59	20,33	3,51	10,42
	Ownconsumption	2,9	2,38	1,79	1,48	2,33	0	0	2,63	1,69
	Sacrifice	5,07	9,52	8,93	5,19	2,32	22,93	3,25	9,65	8,36
	Other	2,17	4,76	3,57	3,7	4,65	3,67	4,88	2,63	3,75
Length of time in breeding (years)	[1 - 10]	24,64	11,9	19,64	24,44	12,4	38,53	4,06	21,93	19,69
	[11 -20]	40,58	30,95	39,29	38,52	37,21	33,03	26,83	33,33	34,97
	[21 - 30]	17,39	22,22	23,21	16,3	19,38	22,02	34,15	14,91	21,2
	[> 31]	17,39	34,92	17,86	20,74	31,01	6,42	34,96	29,82	24,14
Method of acquisition	Purchase	89,85	82,54	89,29	85,93	89,15	87,15	93,5	97,37	89,35
	Family heritage	8,7	13,49	6,25	12,59	10,85	7,34	4,06	2,63	8,24
	Donation / gift	1,45	3,97	4,46	1,48	0	5,5	2,44	0	2,41
Workforce	Family	96,38	96,83	85,71	87,41	91,47	99,08	100	96,5	94,18
	Salary	2,17	0,79	1,79	5,18	4,65	0	0	0	1,82
	Family and Employee	1,45	2,38	12,5	7,41	3,88	0,92	0	3,5	4,00
Averageannualincome (FCFA)	[≤ 50 000]	19,57	27	10,71	13,34	27,91	14,68	21,95	28,95	20,51
	[50 000 – 100 000]	28,98	26,98	34,82	35,56	10,85	30,27	17,88	27,19	26,57
	[100 000 – 150 000]	43,48	42,85	45,54	37,78	38,76	44,95	54,47	37,72	43,19
	[> 150 000]	7,97	3,17	8,93	13,33	22,48	10,1	5,7	6,14	9,73
Averageannualexpenditure (FCFA)	[≤ 10 000]	70,29	39,68	30,36	47,41	24,03	76,15	43,09	62,28	49,16
	[10 000 – 25 000]	24,64	43,65	44,64	31,85	48,84	20,18	43,09	32,46	36,17
	[25 000 – 50 000]	2,9	13,49	13,39	9,63	13,95	2,75	10,57	3,51	8,77
	[>50 000]	2,17	3,17	11,61	11,11	13,18	0,92	3,25	1,75	5,89

The length of time farmers have been breeding kirdi goats varies from 1 to more than 30 years. The most representative category was (11-20) years, followed by [>31] years with 34.97% and 24.14% respectively. These two categories indicate that kirdi goat farming has been practised for decades. Farmers who have been farming for between (20-30) and (1-10) years account for an average of 21.2% and 19.69% respectively. However, the main method of acquiring livestock in the area is still purchase (89.35%), compared with 8.24% who receive animals from a family inheritance and 2.41% from a gift. It is the farmer himself who builds up his herd with his own financial resources. The majority of labour is provided by the family (94.18%), and ranges from 99.08% to 100% in Tokombéré and Ndoukoula respectively. Few farmers use hired labour (1.82%).

The average annual contribution of kirdi goats to household income ranged from 50,000 to over 150,000 CFA francs per year. Most of the farmers surveyed (43.19%) stated that they had an average annual income of between CFAF 100,000 and CFAF 150,000, followed by those with an income of between CFAF 50,000 and CFAF 100,000 (26.57%). Farmers with an average annual income of 50,000 CFA francs or less and those with an income of more than 150,000 CFA francs were respectively 20.51% and 9.73% representative of the entire study area. Kirdi goat rearing is an income-generating activity for households. Although this activity makes a remarkable contribution to subsidising household needs, farmers are just as aware of the role it plays. The average annual expenditure in CFAF on kirdi goat rearing varies from less than 10,000 to more than 50,000 CFAF. The figures are as follows: 49.16% of farmers spend less than 10,000 CFA francs, 36.17% spend between 10,000 and 25,000 CFA francs, 8.77% spend between 25,000 and 50,000 CFA francs, and 5.89% spend more than 50,000 CFA francs. According to observations and interviews with farmers during the survey phase, this expenditure is more likely to be spent on the prevention and treatment of certain diseases, the purchase of feed supplements (oilcake and cottonseed hulls) and livestock equipment (feed troughs and drinking troughs).

The kirdi goat fulfils major socio-economic functions in the life of the farmer. In short, this livestock is a source of income that farmers draw on in many circumstances: food purchases and family needs; children's schooling; family health;

religious events; baptism and marriage ceremonies; receiving distinguished guests; traditional sacrifices.

3.2 Zootechnical Characteristics of the Farm

3.2.1 Number of kirdi goats

The Kirdi goat is one of the goats bred by the Kirdi people. It is found particularly in the Far North region of Cameroon and also on the other side of the Logone River in neighbouring Chad and Nigeria. Fig. 2 shows the number of Kirdi goats reared per farmer. These results show that farmers with between [5-15] head are in the majority (45.61%) throughout the region. This rate is highest in Tokombéré (64.22%), followed by Maga (50%) and Ndoukoula (47.96%). Breeders with (16-30) head are also not negligible (33.58%). Observations of 49.10%, 45.61% and 37.03% respectively of farmers in Kar-Hay, Kaélé and Mokolo. In general, the smaller the herd, the higher the number of breeders, and the larger the herd, the lower the number of breeders.

3.2.2 Other farmed species

Chickens are the most common species in the study area (Fig. 3). In Yagoua, Meri, Mokolo, Kaélé, Maga, Tokombéré, Ndoukoula and Kar-Hay 36.68%, 42.26%, 39.75%, 37.24%, 38.1%, 34.42%, 40.98% and 39.6% of farmers respectively keep hens. They are followed by sheep farmers with 20.27%, 23.22%, 24.59%, 27.27%, 28.57%, 22.22% and 22.3% respectively in Yagoua, Meri, Mokolo, Kaélé, Maga, Tokombéré and Ndoukoula. Cattle are highest in Yagoua, Kaélé, Maga, Ndoukoula and Kar-Hay with 15.64%, 14.08%, 14.29%, 13.11% and 14.04% respectively. Ducks are reared mainly in Yagoua and Maga, with 12.55% and 15.87% of kirdi goat farmers respectively. Guinea fowl are produced exclusively in the arrondissements of Kaélé, Ndoukoula and Kar-Hay, with 5.87%, 1.64% and 7.58% respectively of the population of the study area. Donkeys, which are an essential labour force for harnessing and transport, are reared by 11.61%, 13.11% and 13.55% of the population in Meri, Mokolo and Tokombéré respectively. Although religion has an influence on the production of certain species, pig rearing is no exception. It is practised to a slightly greater extent in Yagoua, Tokombéré and Kar-Hay.

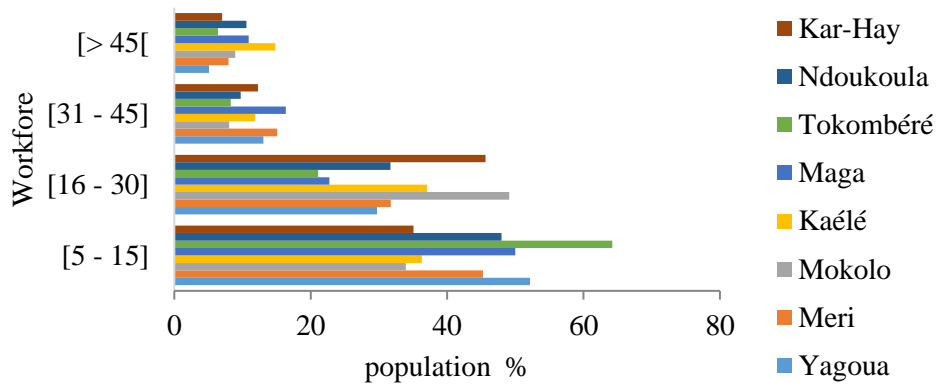


Fig. 2. Kirdi goat numbers

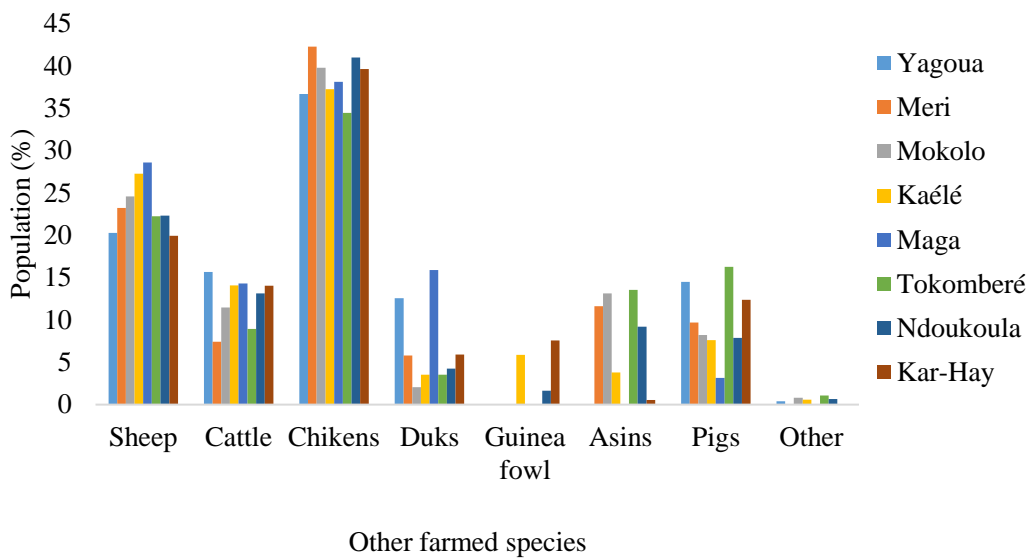


Fig. 3. Other farmed species

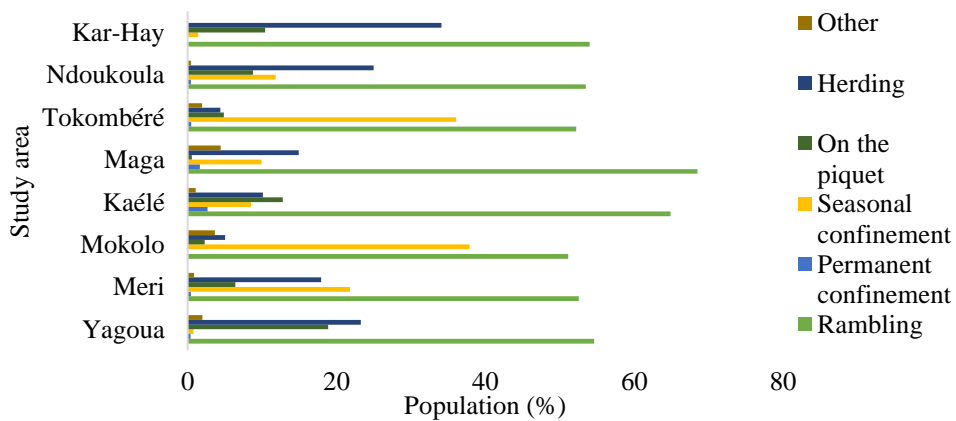


Fig. 4. Husbandry of kirdi goat

Table 2. Type of housing and grouping of Kirdi goats

Parameters	Modalities	Study area frequencies (%)								Total frequency
		Yagoua	Meri	Mokolo	Kaélé	Maga	Tokombéré	Ndoukoula	Kar-Hay	
Housing type	Case	81,88	77,78	66,07	95,56	100	71,56	100	86,84	84,96
	Enclosure	0	12,7	16,07	0	0	15,6	0	0	5,54
	Hangar	0	0	0	4,44	0	0	0	0	0,55
	Chamber	18,12	0	0	0	0	0	0	13,16	3,91
	Other	0	9,52	17,89	0	0	12,84	0	0	5,08
Type of grouping	All together	31,16	53,17	54,46	44,44	36,43	65,14	28,46	20,18	41,68
	Byspecies	65,94	46,83	45,54	52,59	58,14	34,86	71,54	77,19	56,57
	By category of animal	2,9	0	0	2,96	5,43	0	0	2,63	1,74

3.2.3 Husbandry of the kirdi goat

Fig. 4 shows that permanent grazing (56.43%) is the main way in which kirdi goats are kept, as it is practised by 54.08%, 53.51%, 52.2%, 68.51%, 64.9%, 51.14%, 52.56% and 54.62% respectively in Yagoua, Meri, Mokolo, Kaélé, Maga, Tokombéré, Ndoukoula and Kar-Hay. This means that animals are using the natural pastures all day long, without any control or monitoring. This is followed by herding (16.88%), seasonal confinement (16.04%) and staking (8.12%) throughout the zone. Guarding, seasonal confinement and staking are practised most often in the rainy season to prevent the destruction of crops by goats. However, kirdi goat breeders in the localities of Mokolo, Tokombéré and Meri are the ones who practise seasonal confinement, herding and staking the goat the most, with 36.1%, 37.91% and 21.8% respectively. These practices can be justified by the lack of places available for grazing animals and the constant occupation of grazing areas by agriculture and housing. Apart from these types of management, permanent stabling is the most popular form of management for Kirdi farmers who fatten goats.

3.2.4 Type of housing and grouping of kirdi goats

Table 2 shows the type of housing and grouping of kirdi goats. There are several types of housing. The hut remains the best shelter for the kirdi goat in the study area. It is used 100% by kirdi goat breeders in Maga and Ndoukoula and 95.56% in Kaélé. The pen was used

exclusively as housing for kirdi goats in Mokolo, Meri and Tokombéré, with 16.07%, 15.6% and 12.7% of kirdi goat breeders respectively. The use of the bedroom as a shelter for the kirdi goat is also a feature of breeders in Yagoua (18.12%) and Kar-Hay (13.16%). Kirdi goat breeders who group their animals by species are more in the majority with 65.94%, 52.59%, 71.54% and 77.19% respectively in the localities of Yagoua, Kaélé, Ndoukoula and Kar-Hay. Whereas in the localities of Meri, Mokolo and Tokombéré the most practised grouping mode is "tous ensemble" "all together" with 53.17%, 54.64% and 65.14% respectively by herders. In this mode, the kirdi goat shares accommodation with other animal species.

3.2.5 Types of feed

The most common types of feed used by Kirdi goats are crop by-products and hay (Fig. 5). In the study area, natural pasture is the main source of feed. Other ingredients are supplemented. Cowpea stover is used much more in Yagoua and Kaélé, with frequencies of use of 41.52% and 40.5% respectively. Groundnut hulls are used more in Meri, Ndoukoula, Tokombéré and Mokolo, at 32.24%, 34.27%, 31.31% and 30.26% respectively. Millet stalks are used more in Maga, Ndoukoula and Tokombéré, with frequencies of 40.12%, 27.25% and 26.21% respectively. Hay and rice straw are used more in Maga with 27.27% and 13.42% respectively. In general, it is important to note that the use of agricultural by-products is linked to the crops grown in the various localities.

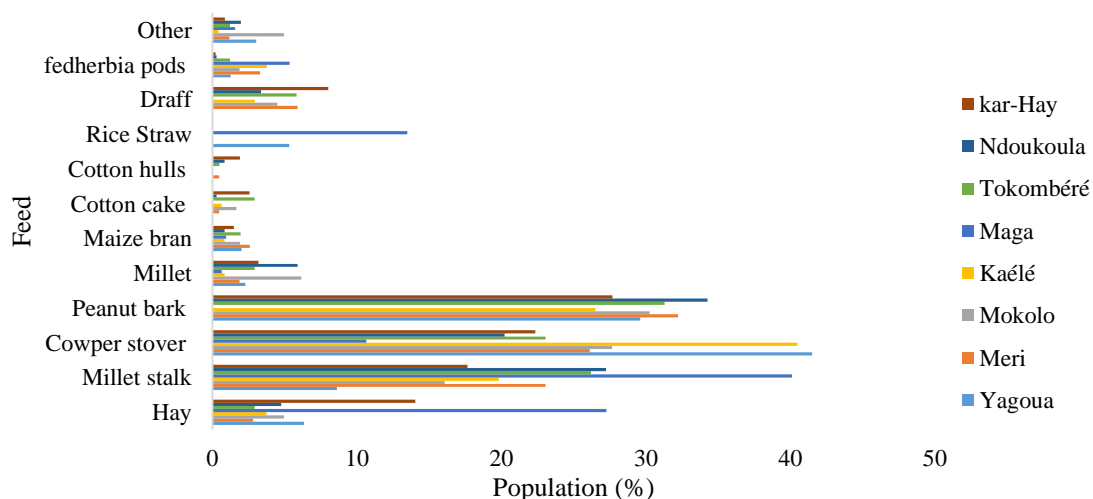


Fig. 5. Types of feed

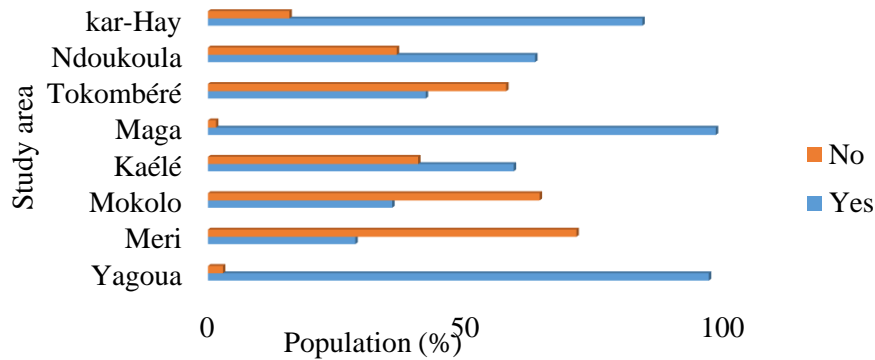


Fig. 6. Availability of drinking water

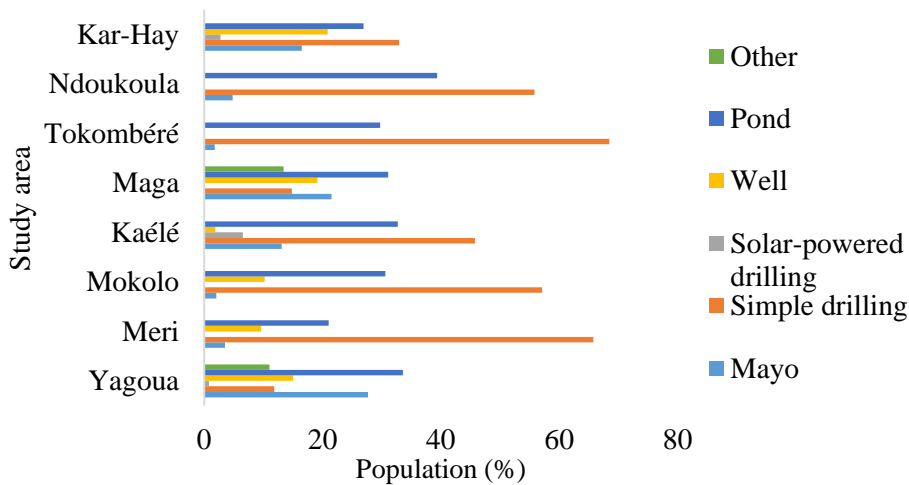


Fig. 7. Watering source

The aim here is to use agricultural by-products as animal feed, which is the key to an integrated agriculture-livestock system. Agro-industrial by-products such as cotton cake and cotton hulls are little used by Kirdi goat farmers. Those who do use them do so for goat fattening. And sometimes this use is linked to cotton growing in the area. In recent years, the use of fedherbia pods has gradually become part of animal supplementation. In the past, animals obtained the pods directly from the wild. Nowadays, however, they are collected by children and sometimes sold at livestock feed outlets. Fodder crop production has not yet been integrated into the animal production system in the Far North region of Cameroon, especially among kirdi goat breeders. However, fodder crop production is a lever for improving animal feed. It enables farmers to manage their animals' feed intake, even during the lean season.

3.2.6 Watering kirdi goats

Having water available in sufficient quantity and quality helps to maintain animal and plant health. The quantity and quality of available water resources are currently posing increasingly complex problems that are difficult to resolve in some areas of the Far North region. Fig. 6 shows the availability of water for watering animals in the study area. In the localities of Yagoua, Maga and Kar-Hay, 97.1%, 98.45% and 84.21% of kirdi goat farmers respectively claim to have drinking water available to water their goats. This availability of water is also linked to the presence of watercourses such as Lake Maga, the Logone River and its tributaries, the mayo and the SEMRY irrigation canals. This part of the study area belongs to the flood plain of the River Logone. In Tokombéré, Mokolo and Meri, the rates were 42.2%, 35.75% and 28.57% respectively. This part of the study area, which is

part of the Mandara Mountains, has low water availability. Farmers say they have difficulties in watering their animals. Between the Mandara Mountains and the Logone Plain, there is the foothills area of Kaélé and Ndoukoula, where 59.6% and 63.41% respectively of livestock farmers claim to have drinking water available for their animals.

The water used to water the animals comes from several sources. Natural sources (ponds, mayo) and those created by man (boreholes, wells, etc.). Fig. 7 shows the sources used to water animals. The figure shows that in Meri, Mokolo, Tokombéré and Ndoukoula, the most common source of drinking water for goats is the human-powered borehole. This type of water is used by 65.78% of the Meri population, 57.14% in Mokolo, 68.48% in Tokombéré and 55.82% in Ndoukoula. In Yagoua and Maga, however, livestock farmers say that their animals consume the most mayo and pond water. These figures are 33.59% and 21.53% for ponds and 27.06% and 31.1% for mayo in Yagoua and Maga respectively. This use of pond and mayo water in Yagoua and Maga could be explained by the fact that they belong to the Logone plain, which retains rainwater in the ponds and mayos for longer.

3.2.7 Health and prophylaxis of the kirdi goat

Animal diseases are a major constraint on the development of livestock production and the Kirdi goat in particular. Aware of the damage caused to their herds, kirdi goat breeders have resorted to the vaccination campaigns carried out since 2020 by the Livestock Development Project (PRODEL) and the International Committee of the Red Cross (ICRC) against Small Ruminant

Plague (SRP) in the study area, in partnership with the Ministry of Livestock, Fisheries and Animal Industries (MINEPIA). The aim of the campaign is to eradicate Small ruminant plague (SRP), an extremely contagious and fatal disease of small ruminants. Fig. 8 shows the frequency of farmers agreeing to have their animals vaccinated. This study shows that the majority of Kirdi goat farmers is interested in vaccinating their goats. In Kar-Hay, Ndoukoula, Tokombéré and Kaélé, 89.47%, 86.18%, 82.57% and 84.44% of farmers respectively accepted vaccination. On the other hand, 22.46% of farmers in the study area refused to vaccinate their animals on the pretext of losing them.

Animal diseases manifest themselves in various ways. Fig. 9 shows the various symptoms encountered in the study area. Diarrhoea (22.31%) was the most frequent sign encountered on the farms by the majority of farmers, followed by respiratory problems (13.71%), lameness, external parasites and nasal discharge, with 12.53%, 12.38% and 12.01% of farmers respectively noting the presence of these parasites on their farms. However in some cases, the signs sometimes vary depending on the animal's environment. Respiratory problems were most common in Yagoua, Maga, Kaélé and Mokolo, where 15.62%, 14.56%, 13.99% and 17.78% of farmers respectively reported seeing these symptoms in their animals. Lameness was found on farms in Tokombéré, Meri and Kar-Hay, with frequencies of 19.11%, 16.63% and 13.32% respectively. External parasites were slightly more common in Kaélé, Ndoukoula, Kar-Hay and Yagoua, at 15.14% and 12.56% respectively. Ndoukoula and Tokombéré had the highest rates of diarrhoea, at 26.56% and 25.12% respectively.

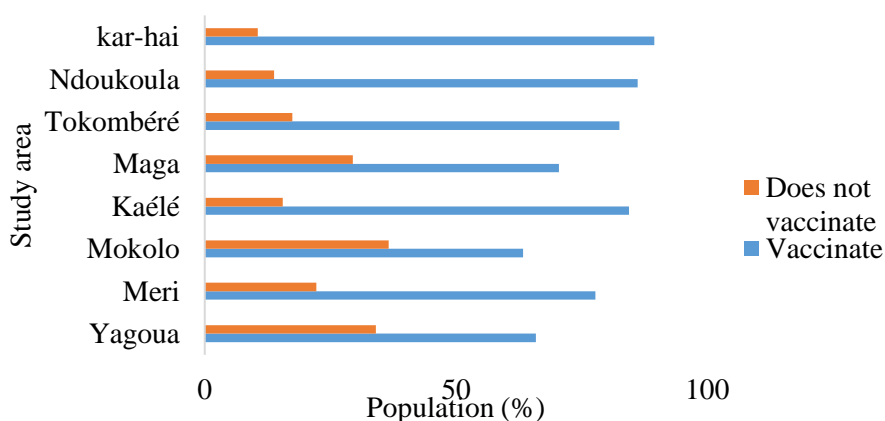


Fig. 8. Vaccination practice

Table 3. Reproduction parameters

Parameters	Modalities	Study area frequencies (%)								Total frequency
		Yagoua	Meri	Mokolo	Kaélé	Maga	Tokombéré	Ndoukoula	Kar-Hay	
Matingmethod	Uncontrolled	79,29	100	98,47	85,25	88,08	84,34	94,87	74,18	88,06
	Controlled	20,71	0	1,53	14,75	11,92	15,66	5,13	25,82	11,94
Multiple births	Yes	100	93,65	97,32	92,59	91,47	100	93,50	95,61	95,52
	No	0	6,35	2,68	7,41	8,53	0	6,50	4,39	4,48
Number of spans	Double	75,36	70,63	81,25	69,62	74,41	83,48	77,23	75,43	75,93
	Triple	13,76	7,93	6,25	8,88	6,97	6,42	10,56	7,89	8,58
	Quadruple	10,87	15,08	9,82	14,07	10,07	10,09	5,69	12,28	10,99
Multiple first births	Yes	72,46	68,25	65,17	69,62	62,01	77,98	60,16	64,03	67,46
	No	27,53	31,74	34,82	30,37	37,98	22,01	39,83	35,96	32,54
Number of litters	Double	56,52	58,73	57,14	59,25	50,38	68,80	49,59	51,75	56,52
	Triple	5,79	5,55	4,46	3,70	4,65	3,66	6,50	4,38	4,84
	Quadruple	10,14	3,96	3,57	6,66	6,97	5,50	4,06	7,89	6,09

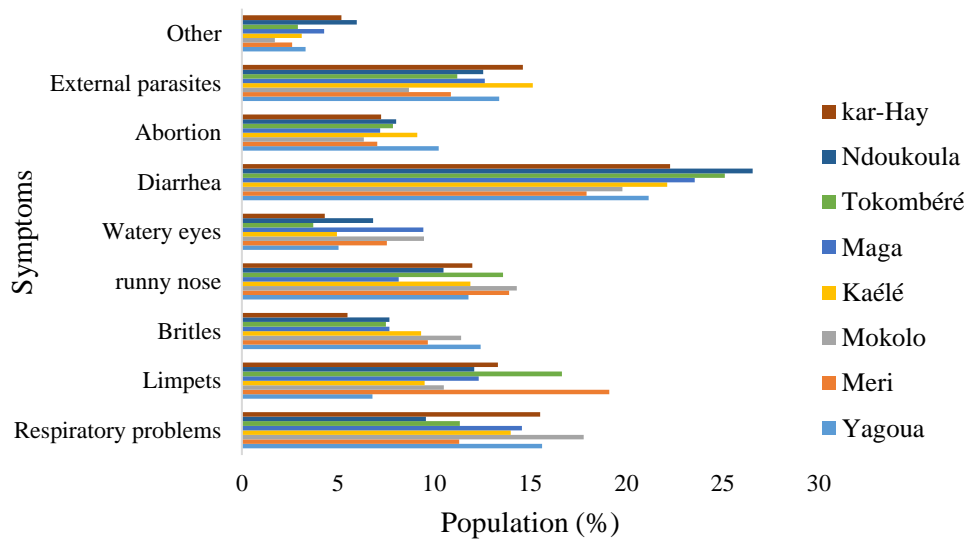


Fig. 9. Type of symptoms

3.2.8 Reproduction of the kirdi goat

Table 3 shows some of the reproductive parameters studied in this study. It shows that kirdi goat mating is not controlled by the farmers and is mainly carried out at pasture (88.06%). This phenomenon was observed at 100% in Meri. However, 25.82% and 20.71% of farmers in Kar-Hay and Yagoua respectively reported that the mating of their goats was controlled at the goat shed. Most farmers (95.52%) in the zone as a whole said that they had recorded multiple kirdi goat births on their farms. In Yagoua and Tokombéré all respondents (100%) reported having recorded at least one multiple birth. Three types of multiple birth were observed (double, triple and quadruple). Double births were the most frequent on the farms (75.93%), followed by triple births (8.58%) and quadruple births (10.99%). In this study, 67.46% of the population reported multiple births to primiparous females on farms, compared with 32.54%. Of these multiple births, 56.52% were doublets, 4.84% triplets and 6.09% quadruplets. All these parameters studied can be influenced by: the animal's sexual development, its diet, its state of health, its age and the environment in which it lives.

4. DISCUSSION

4.1 Socio-economic Characteristics of Kirdi Goat Farmers

The household survey of the socio-economic characteristics of kirdi goat rearing enabled us to

understand the rearing practices to which kirdi goats are subjected. The localities surveyed are part of Cameroon's Sudano-Sahelian zone, which alone accounts for almost 3/4 of the country's sheep and goat population [17]. According to the results obtained, the majority of kirdi goat breeders are men (80.03%), which would be linked to their position as head of household. These observations differ from those of Karimou [18] who reported that 80% of the respondents were female in a study on the socio-economic and zootechnical importance of red goat farming in Niger. With regard to the age of the people surveyed, the age ranges (31-45) and (46 – 60) are more representative. The advanced age of kirdi goat owners is due either to a certain lack of interest in this activity on the part of young people, or to a lack of financial resources or rural exodus. Most of these breeders are married and their main activity is farming. The high proportion of married people among those surveyed reflects their level of social responsibility and experience in managing and herding animals. In terms of education, most farmers had an average level of education (primary and secondary). These results were confirmed by Sitou [19] in a study of the typology of small ruminant farming in the city of Niamey in Niger. The analysis of the objective showed that 75.78% of kirdi goat breeders are primarily concerned with increasing the herd. This result was reported by Tendonkeng [20] in southern Cameroon. On the other hand, Sitou [19] in Niger observed that the objectives of small ruminant breeders varied according to the type of breeding practised

(contemplative breeding, fattening, milk production, etc.).

This study has shown that purchase is the favorite method of acquisition by breeders (89.35%). This is the most used method by Kiridi goat breeders. This can be explained by the fact that breeders, who are mostly farmers, are now interested in breeding and investing their capital in livestock. In fact, Kiridi goats are mainly kept by families, as is the case for Sahelian goats in Niger [21] and Fulani sheep in Niger [22]. These results corroborate those found by Lawal [23] in urban and peri-urban farms in Niamey, Niger, and those observed by Sitou [19] in Niger, where the role of children was decisive in small ruminant farming.

The most representative average annual income per household is between 100,000F and 150,000F CFA. This amount is lower than the results of Karimou [18], who found 388,815F CFA/household/year of income exclusively from the breeding of Maradi red goats in Niger. This low contribution from the sale of Kiridi goats to household income in the Far North region could be explained by the sporadic occurrence of certain epizootics that decimate this species, the practice of breeding that is not directed directly towards sale, and the practice of an extensive system. As a result, livestock breeders, who are mostly farmers, are turning livestock breeding into a sentimental activity. The Far-North region is one of the most densely populated in the world, so this should make it easier to sell these products and give producers an opportunity to increase their income from the animals. In this way, Kiridi goat farming must go beyond the role of a simple traditional activity and respond to the explosion in local demand for animal proteins in the face of an exponentially growing population.

4.2 Zootechnical Characteristics of Kiridi Goat Farming

4.2.1 Other species reared and management methods

The present study has shown that breeders with between (5-15) are the most representative, although those with (16-35) are also not negligible over the study area. It also revealed the diversity of other animal species reared by Kiridi goat farmers (cattle, sheep, poultry, donkeys, etc.). It is also clear from these results that roaming is the predominant farming system

in the study area. Under this system, animals are left to their own devices, but they are also exposed to disease vectors. These observations are similar to those of Sitou [19] who found that permanent roaming is also the main livestock management mode in the city of Niamey in Niger. According to Tendonkeng [20], permanent roaming is also the main livestock management method in the Mvildivision of southern Cameroon.

4.2.2 Kiridi goat habitat

In most, it was found that the dwelling was a traditional hut (84.96%). This result can be explained by the high cost of the construction materials used to build improved goat houses. This technique of using shelters specifically for goats is a particularity of the Sudano-Sahelian zone of Cameroon. These results corroborate those found by Karimou [18] where the majority of Sahelian goat breeders (76.9%) in Niger have a traditional type of habitat. Meanwhile, Gnanda [24] in the Burkina Faso sahel reports that over 50% of farmers use thorny enclosures for their animals.

4.2.3 Animal supplementation

Supplementation was observed in the majority of farms with crop and processing by-products (groundnut and cowpea stalks, millet stalks, millet, maize bran, local beverage draff). These results are confirmed by Sitou [19] on small ruminants in the city of Niamey in Niger, according to whom 85.45% of livestock farmers in urban areas and 82.76% in rural areas use supplementary feeding. This practice is explained by the scarcity of pasture to make up for the animals' food deficits during certain periods of the year (February, March and April). This particular focus differs from the findings of Lawal-Adebowale [25] in Nigeria, which demonstrated the low intake of feed or forage by goats. Some farmers argue that goats are able to live on areas with scarce pasture, as they can take advantage of overhead grazing or plant debris [26]. Others say that goats do not eat much or that they are less sensitive to food deficits than sheep [27]. As a result, cowpea and groundnut haulms, cereal bran and millet stalks are the main feed supplements most appreciated by ruminants. They are used mainly in the dry season, when grazing becomes a little scarce. Intensified supplementation could therefore be a solution to the lack of grazing.

4.2.4 Health monitoring

When it comes to monitoring animal health, owners pay particular attention to ensuring that their animals are healthy. The results show that a significant proportion (77.54%) of farmers vaccinate their animals against Small Ruminant Plague (SRP). This finding was reported in Niger by Karimou [18] and Abdou [22], where 86.1% of red goat farmers in Maradi carry out this activity and 85.75% of Fulani sheep farmers vaccinate their animals against Small ruminant plague. But this activity is not carried out on a regular basis by public authorities in Cameroon. This compromises the preventive immunity that we would like to give animals. As a result, there have been sporadic outbreaks of mortality due to Small Ruminant Plague. However, farmers who do not have their animals vaccinated have reported animal deaths or witnessed deaths of animals vaccinated against SRP.

Indeed, this pathology is regularly cited as one of the serious obstacles to the productivity of small ruminants in the Far North region of Cameroon. The impact of Small ruminant plague (SRP) as one of the main causes of goat mortality was reported in West Africa by Traoré [28]. Diarrhoea was the main symptom recorded in this study. It causes the animal to lose weight and, if nothing is done, death ensues. This symptom can be the cause of diseases such as anthrax, cowdriosis, digestive strongylosis of herbivores, etc., which cause huge losses in livestock. It can also be the cause of variations in the goats' diet.

4.2.5 Reproduction management

This study shows that the average age of females at breeding varies from 13 to 15 months. These observations are similar to those found by Marichatou [29] in a study of the zootechnical performance of goats in Niger. They differ from and are inferior to those of Mayeriya [30] in the Democratic Republic of Congo in a study on the determination of puberty and age at first kidding of goat kids on family farms in Lubumbashi, who stated that the average age at first kidding varies between 18 and 26 months. This difference could be justified by the feeding and geographical location of the study area. Breeding was not controlled at all by the farmers (88.06%). These results are consistent with those reported in northern Benin where breeding was uncontrolled in farms [31]. In this system, animals are left in the wild and cross-breeding is carried out by

grazing. There is no particular monitoring except in cases where the animal is ready for delivery. The most frequently observed multiple birth method is the double birth (75.93%). This result was also reported by Tchouamo [32] and Marichatou [29].

5. CONCLUSION

At the end of this study, we can conclude that kirdi goat rearing can be considered as an activity that improves the resilience of the population of the Far North region of Cameroon. Its rearing constitutes a significant income-generating activity for households.

Kirdi goat rearing is mainly carried out by men. Married people are the most represented and are mainly involved in farming as their main activity. The level of formal education, although low, is offset by long experience in the activity. The aim of breeding is to increase the number of livestock, and buying is the best way for breeders to acquire kirdi goats. As for the workforce, it is family-based and livestock farming plays a key role in the socio-economic life of the farmers. Income from breeding is used primarily for family health.

The animals are kept exclusively in an opened area. This is the characteristic of extensive livestock farming. In the rainy season, the animals are looked after by children aged between 6 and 12, or are on stakes, and most farmers house their animals in huts. The animals are still fed on natural pasture. Supplementation with harvest by-products (groundnut vines, cowpea vines, cereal bran and millet stalks) is common. However, when it is sufficient, it leads to improvements in animal performance (stoutness, good health, good reproduction, etc.). The symptoms most frequently observed in animals on farms are diarrhoea, respiratory infections and others. Twin births are a great asset to the development of this species, and breeders of this species dream of increasing the number of their animals and gaining access to added value.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc have been used during writing or editing of manuscripts. This explanation will include the name, version, model, and source of the

generative AI technology and as well as all input prompts provided to the generative AI technology.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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