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Weight and economic performance of goats in village fattening: Influence of choice of animal and duration

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ABSTRACT: The general aim of this study, which focused on goat fattening, was to investigate, as an initial trial, the weight performance of goats, about which very little is known, with a view to developing sustainable technical and economic proposals for extensive Sahelian farming systems. The methodology was based on weekly measurements of the bucks' weight performance in an experimental batch of 11 bucks fed a ration based on local feed resources and a control batch. The control lot was monitored in parallel under the normal conditions of the area's usual extensive rearing practices. The results showed that the animals in the control batch did not regain weight, with a 3% loss in body weight. In the experimental batch, body weight varied progressively with an average increase of 7 kg per buck. The Consumption Index, which ranged from 6 to 18 kg of dry matter per kg of growth depending on the duration of fattening, shows the sharp efficiency of goats in converting local fodder resources into animal protein. The physical and ethnic characteristics of the animals had a significant influence on their increased economic value. Older, larger and medium-weight Sahelian bucks contributed more to maximising foreign exchange. The average daily gain and gross profit were higher when the duration of fattening was limited to six weeks. After this period, the profit (2047 F CFA on average per billy-goat) fell linearly, resulting only in economic losses from the 9th week onwards. Taking into account the optimum duration and the criteria for choosing the animal will lead to overall improvements in the profitability of fattening goats.

KEYWORDS: feed conversion, goat, profitability, animal characteristics, duration, extensive farming.

1 INTRODUCTION

The fattening of farmed ruminants is an activity increasingly practised by producers in Sahelian countries and Niger in particular [27, 31]. Fattening is justified by the need to overcome a number of constraints, including animal weight loss in the dry season [2, 15, 23] and low carcass yields [21-22]. In addition, the under-occupation of producers at certain times of the year and, above all, the drastic decline in the carrying capacity of rangelands due to the poor integration of crop and livestock production [26], means that intensive production systems are increasingly being applied.

In Niger, sheep and cattle fattening has been an emerging alternative for boosting competitive production and meeting strong national and sub-regional demand for meat, which explains the fairly abundant literature on these two species [3, 27, 6]. On the other hand, very little research has been devoted to specialising in goat fattening. Research has focused more on sheep [3, 7], and goat breeds have only recently been tackled [1, 4, 8], and had previously been the subject of very few studies in the field of animal nutrition.

As a result, goat rationing was most often based on the technical and economic references for sheep [24]. However, over and above racial traits, there are quite marked differences between sheep and goats in morphological and physical terms [20, 30]. Moreover, goat

farming is just as common in the livestock system, with a huge potential represented by 14.3 million head, or 36.3% of the total national livestock population [12]. The goat herd is growing steadily at a rate of 14.5% [28].

Moreover, most research on fattening has focused on feed as the only source of variation in technical and economic performance [13, 3, 7], without first imposing any particular racial, morphological or physical criteria for choosing animals. However, it is well known that improving the weight performance of a fattening operation is closely linked to a single itinerary that begins with the judicious choice of animals based on precise zootechnical and anatomical criteria [19] and includes compliance with well-coordinated sequences of rearing practices [25]. It is therefore necessary to assess the impact of phase shifts in relation to this technical itinerary on weight and economic performance.

In this study, the analysis of factors influencing economic profitability will focus on the racial and physical traits of goats, as well as the influence of the duration of fattening after regular monitoring of the bucks' weight performance. Highlighting the impact of these factors will enable concrete proposals to be made for corrective models in terms of technology with a view to the sustainable development of this fattening activity for goats in Niger.

2 MATERIAL AND METHODS

2.1 STUDY AREA

The commune of Tajaé is part of the department of Illéla. It lies between longitudes 04°01' and 05°44' East and latitudes 14° and 14°41' North. The Sahelian climate is characterised by three distinct seasons: a cold dry season from November to February, a hot dry season from March to May and a rainy season from June to October. Rainfall is governed by the West African monsoon, a humid wind prevailing in the rainy season, blowing from south-west to north-east over most of the country.

2.2 EXPERIMENTAL DESIGN AND SAMPLING

The study was carried out on bucks of the Sahelian and red breeds, which correspond perfectly to the standards of these two breeds [29]. The standard of the Sahelian goat is that of a rectilinear animal of hypermetric type, long and tall. The red goat is rectilinear, mediolinear and eumetric, of medium or small size. The experiment lasted 14 weeks and began after a 14-day adaptation period to allow the animals to adapt to the new experimental and feeding conditions.

The experimental set-up consisted of an experimental batch and a second control batch of 11 bucks each, including 8 Sahelian bucks and 3 Maradi red bucks. The 11 bucks in the experimental batch were fed a ration that was constantly adapted to changes in average live weight over the course of the experiment. Rations were distributed in 2 meals per day and refusals were collected every day. As for the control lot, it was monitored in parallel under the normal conditions of breeding practices usual in the study area. These conditions were such that the animals were left to roam and did not benefit from any feed rationing like the experimental batch.

All the animals (experimental batch and control) were identified and then followed by a number thanks to a marker. The characteristics of the two batches before the start of the trial are shown in Table 1.

Table 1. Specific composition and weight performance of the two batches used

Average characteristics	Experimental batch	Control batch
Racial composition	8 Sahel goat ant 3 Red goat	8 Sahel goat ant 3 Red goat
Age (months)	16,9±4,5	21,0±6,0
Weight (kg)	21,2±5,1	22,3±8,9
BCS	2,8±0,3	3,3±0,3
Chest size	66,0±7,9	78,0 8,8
Scapulo-ischial length	33,8±5,5	40,0 3,6
Height at withers	63,5±6,7	74,5±8,1

2.2.1 RATIONING

The 11 billy goats in the experimental batch were each kept in a block equipped with a feed trough and a drinking trough. The basic ration for this batch was identical for all animals. It consisted of groundnut or cowpea chaff, fed in two meals (08: 00 and 14: 00). Feed supplementation was carried out at 16: 00 in a single meal during the first two months of fattening and in two meals during the third month. Throughout the trial, the billy goats had free access to drinking water and the lickstone. The quantities of rations distributed during the trial and their bromatological composition changed over the course of the fattening period (Table 2). The bromatological composition of the rations was determined by adjustment using data from [14] and [18].

Table 2. Rationing and changes in quantities of food consumed

Week	Ration	Feed composition of rations (kg)					Bromatological composition			
		Peanut flour	Cowpea fane	Wheat bran	Corn flour	Cotton cake	MS	Ca	P	MAD
1	R1	0	49	8	16	4	70	264	374	5244
2	R2	0	49	7	13	8	69	268	387	6652
3	R3	14	35	8	16	7	73	386	404	6199
4	R4	0	49	10	20	7	73	273	419	6476
5	R5	0	49	11	21	7	78	280	465	6476
6	R6	49	0	11	21	11	83	687	467	6739
7	R6	49	0	11	21	11	83	687	467	6739
8	R7	51	0	14	28	11	84	706	471	6833
9	R8	51	0	19	39	10	94	723	540	6511
10	R9	37	15	21	42	9	107	622	663	6446
11	R10	51	0	23	47	4	108	730	629	4560
12	R11	51	0	28	56	0	111	728	631	3152
13	R12	51	0	28	56	0	123	745	739	3152
14	R12	51	0	28	56	0	123	745	739	3152

2.2.2 DATA COLLECTION

For the two batches, experimental and control, measurements were taken each week after restraint to keep the animal upright. Four body measurements were taken for each animal: body weight, height at withers, chest circumference and scapulo-ischial length. The last three weekly morpho-biometric measurements were taken using a tape measure. A 100 kg capacity scale was used to determine body weight. The age of the animals was determined by examining the dentition according to the scale presented by the [10], considering that in the caprine species, the animal reaches adulthood from four pairs of adult incisors [5]. Body condition was assessed by visual observation, using a six-point rating scale [9]. Changes in the market value of the bucks were analysed in focus groups and on the basis of the unit price of the carcass yield. For the participatory focus group evaluation, animal dealers and other qualified local resource persons were invited every fortnight to assess the market value of each of the billy goats in the experimental batch.

To analyse the weight performance and economic profitability of fattening, the following parameters were calculated on the basis of observed parameters:

i. Consumption index (CI) = Quantity of dry matter consumed (kg) /Total gain by weight (kg);

ii. Average daily gain (GMQ. This is defined as the growth differential between two dates;

iii. Carcass weight (kg) = 57.6 * Live weight (kg), a barometric equation established by [21] for the Sahelian billy-goat in a sedentary farming system.

iv. Formula (ii) was used to evaluate, for a given duration of fattening, the carcass weight regain (CWR) calculated from the initial live weight and the final live weight: CWR = 57.6 * (Initial live weight Final live weight)

v. The economic value gain (EVG) after a given period of fattening is therefore calculated according to the formula EVG (F CFA) = Carcass weight gain*3000 where 3000 is the local unit cost of carcass weight. This RVE was calculated at the level of the experimental batch.

vi. Gross revenue (GR) was calculated as follows: GR= Economic value gain (EVG) - cost of fattening.

vii. In addition, in focus groups, the values of animals entering and leaving fattening were assessed, making it possible to calculate the unit value of the animals' regained live weight (RVW). This VPV was calculated for each animal.

2.2.3 STATISTICAL ANALYSIS

The data collected on the experimental trial were first entered into an Excel workbook and then subjected to analysis of variance (Mixed Model for Longitudinal Data) using SPSS software. The duration of fattening (with six modalities) was the random factor introduced into the ANOVA model. Principal Component Analysis was used to assess correlations between weight and economic performance.

3 RESULTS

3.1 RATIONING AND FEED CONVERSION RATIO

As the duration of fattening increased, the amount of total dry matter in the rations rose steadily, from 67 kg to over 120 kg of dry matter (Fig.1a). Initially, more fodder was consumed than concentrates. Over the duration of the fattening period, the amount of fodder decreased from 62.5 to 37.5% of the total ration, and that of concentrates increased more or less linearly (Fig.1b) from 37.5 to 62

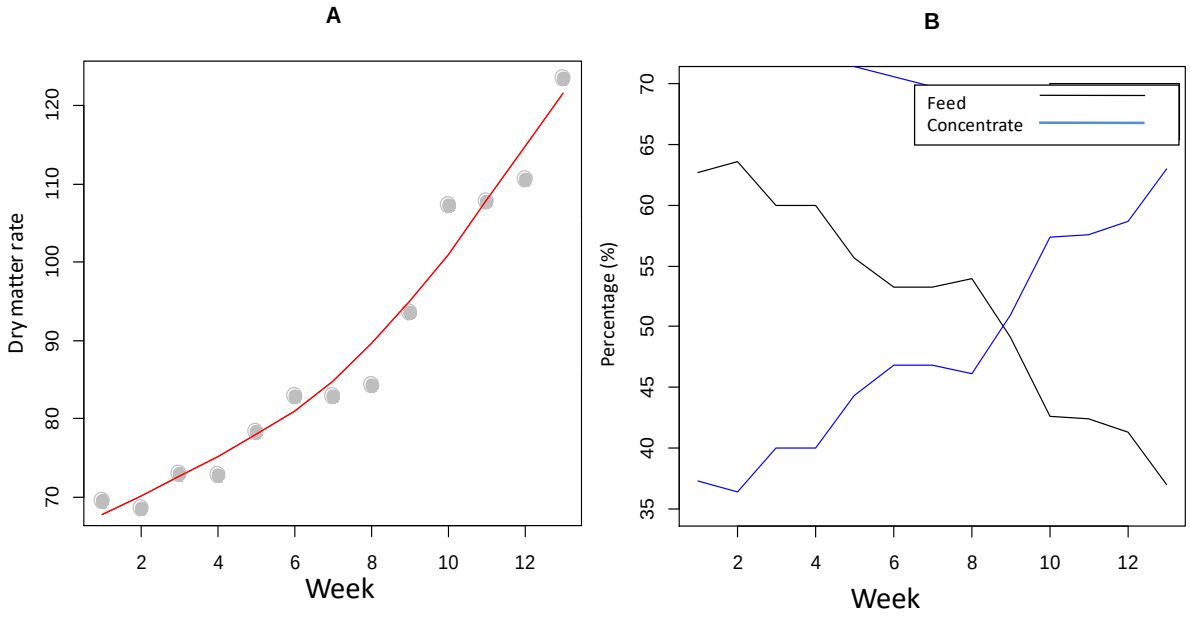

Fig. 1. Rationing during fattening

The Consumption Index (CI) also varied with the duration of fattening (Table 3). A gradual change in CI was observed as the duration of fattening increased. The highest consumption indices were observed for fattening activities lasting more than 9 weeks.

Table 3. Variation in the Consumption Index (CI) according to the duration of fattening

Duration (Week)	N	Total dry matter (kg)	Total weight gain (kg)	IC (kg DM/kg growth
1	11	70	9	8
2	11	139	13	11
3	11	212	17	12
4	11	285	46	6
5	11	363	30	12
6	11	446	37	12
7	11	529	42	13
8	11	613	48	13
9	11	707	39	18
10	11	814	46	18
11	11	922	56	16
12	11	1033	61	17
13	11	1156	71	16
14	11	1279	78	17

3.1.1 WEIGHT PERFORMANCE OF THE BUCKS

The average body weight of the bucks in the experimental batch varied progressively from an average initial value of 21 kg per buck to an average final weight of 28 kg per buck (Fig. 2). There were two significant drops in weight during weeks 5 and 8. On the other hand, no recovery in weight performance was observed in the animals of the control batch, in which an average loss of 3% of body weight was observed.

Other biometric parameters also showed significant variations. There was a gradual change in chest circumference, from an average value of 65.8 cm per buck to an average of 77.7 cm. Height at the withers fluctuated between average values of 63 and 64.8 cm.

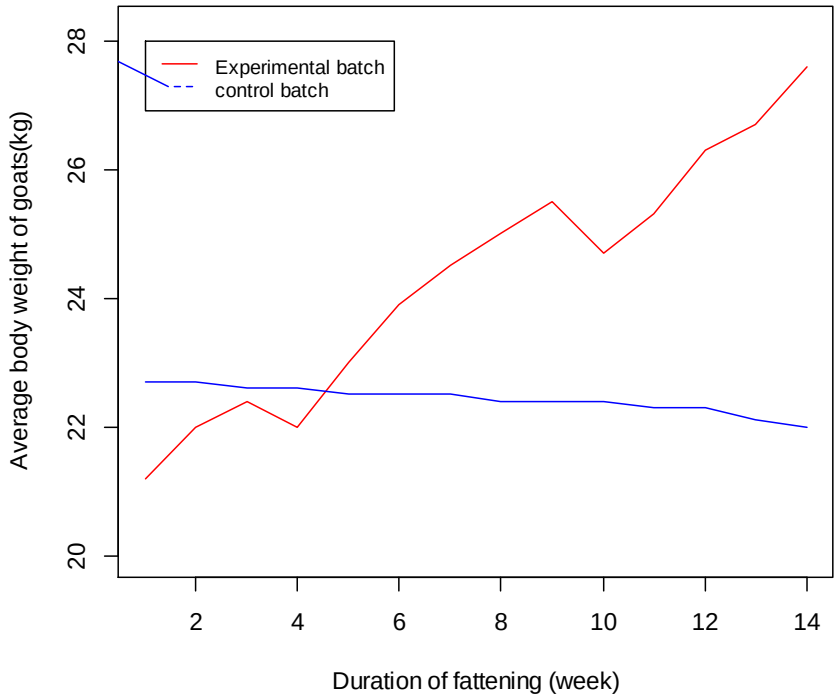

Fig. 2. Changes in weight performance during fattening

3.1.2 WEIGHT PERFORMANCE AND VARIATION FACTORS

Analysis of weight performance shows significant differences between the experimental and control batches (Table 4). Thus, for the experimental batch, differences were observed in the average weight measurements of the animals at entry and exit, resulting in a significant increase at exit from fattening. On the other hand, no regain in weight measurements was observed in animals from the control batch. The negative values for regain reflect a loss of weight performance in the bucks from this control batch.

Table 4. Comparative weight performance of plugged and unplugged billy goats

Weight measurements	Experimental batch(n=11)			Control batch (n=11)		
	Start	End	Regain	Start	End	Regain
Body weight (kg)	21.2±5.1	28.2±6.1	7.0	22.8±8.9	22.1±8.9	- 0.7
Body condition score (point)	2.7±0.3	4.7±0.3	2.0	3.2±0.3	3.3±0.3	-0.1
Chest circumference (cm)	66±7.9	71.5±4.9	5.5	78±8.8	76.5±8.1	-2.3
Withers height (cm)	62.7±5.8	66.3±8.2	3.6	74.5±8.1	76.0±8.6	-1.5

Descriptive analysis indicates a difference in means between the Sahel and Maradi red billy goats for all weight measurements both at the beginning and at the end of the experiment (Table 5). These differences between the two goat breeds were more marked for body weight. Thus, on the whole, the red billy-goat performed less well in terms of regaining the weight measurements observed.

Table 5. Comparative performance of the sahel and red billy goats

Weight and economic measurements	Sahel goat (n = 8)			Red goat (n = 3)		
	Start	End	Regain	Start	End	Regain
Body weight (kg)	23.5±3.7	31.3±3.3	7.8	15±24	20±2.8	5.0
Body condition score (point)	2.8±0.25	4.8±0.3	1.94	2.5±2.5	4.6±0.3	2.2
Chest circumference (cm)	69±6.9	73.8±3.4	4.75	58±3	65.3±2.1	7.3
Withers height (cm)	36.6±3.0	70±4.5	4.25	26.3±2.3	56.3±7.8	1.7
Average value (F CFA)	15625	30063	144378	10333	16667	6333

The descriptive analysis also revealed significant differences in weight performance between bucks aged 12 to 18 months and those over 24 months for all variables except BCS (Table 6). Thus, after 14 weeks of fattening, the animals aged over 24 months showed a higher average weight parameter, except for chest circumference, which showed a greater increase in animals aged 12 to 18 months. Only the scapulo-ischial length of the animals did not change. Also, the increase in market value between entry and exit from fattening was greater for older animals.

Table 6. Weight performance compared between age groups of billy goats

Weight and economic measurements	Age group 12 to 18 months			Age group over 24 months		
	Start	End	Regain	Start	End	Regain
Body weight (kg)	22.8±3.9	30.3±3.0	7.4	25.0±0.7	34.5±0.7	9.0
Body condition score (point)	2.8±0.24	4.8±0.25	1.9	2.8±0.4	4.8±0.4	2.0
Chest circumference (cm)	67.16±6.8	72.3±2.3	5.2	74.5±0.7	78.0±0.7	3.5
Withers height (cm)	65.3±3.2	70.3±3.8	4.8	67.0±1.4	69.5±7.8	2.5
Market value (F CFA)	15250	28917	13667	16750	33500	16750

The analysis of variance showed a significant variation in the average daily gain (GMQ according to all the characteristics of the animals described at the start of fattening ($p< 0.05$, Table 7). Variations according to age indicate that the highest AQG is obtained with animals 24 months old, while that of animals less than one year old is the lowest. Also, it is the large size that results in the highest AQG. The Maradi red billy-goat, which has a smaller size than the Sahel billy-goat, recorded the lowest AQG.

The duration of fattening also has a significant influence on average daily gain (Table 7). Tukey's multiple comparison test shows that average daily gain is highest when it is calculated over a fattening period limited to one month or one and a half months. As the duration of fattening increases beyond the one and a half month range, the AQG is more or less reduced.

Table 7. Variation in Average Quotient Gain (AQG) according to animal characteristics

Factors	Modality	N	AQG (g/jour)	Min	Max	p-value
Overall average		66	85.4±44.9	24	232	
Age	12 month	24	68.9±48.3^{a}	24	232	0.003
	18 month	30	86.4±37.1^{ab}	24	179	
	24 month	12	115.9±42.1^{b}	71	214	
Format	Medium	24	87.1±32.8^{a}	24	179	0.008
	large	24	99.1±44.8^{ab}	43	214	
	small	18	64.8±53 .0^{b}	24	232	
Breed	Red	18	65.0±53.0^{a}	24	232	0.003
	Sahel	48	93.1±39.3^{b}	24	214	
Duration of fattening	1 month	11	149.5±58.9^{a}	36	143	P<0.001
	1.5 month	11	85.2±40.3^{a}	36	232	
	2 month	11	76.9±27.0^{a}	27	116	
	2.5 month	11	62.9±21.2^{a}	29	100	
	3 month	11	65.9±23.5^{a}	26	102	
	3.5 month	11	62.1±22.6^{b}	24	101	

Principal Component Analysis (PCA) shows that the increase in animal value at the end of fattening is better explained by variations in body weight than by variations in other weight measurements (Figure 3). It is also observed that the improvement in Body condition score (BCS) does not explain the increase in the value of the animals. Thus, at the end of the trial, the total live weight of the 11 billy goats increased by 80 kg for a total increase in monetary value of 134.500 F CFA (based on the focus group evaluation of the values of the animals on entering and leaving fattening). The PCA also shows that the characteristics of the animals at origin influence their increase in economic value. For example, the oldest, largest and fattest bucks in the Sahel contributed most to maximising income (Figure 3).

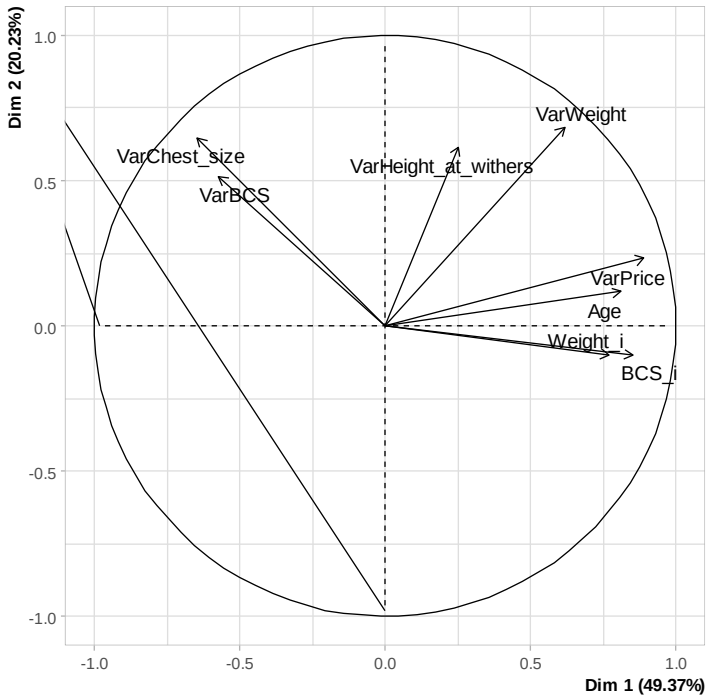

Fig. 3. Analysis of correlations between weight and economic performance

Legend: VarPrice = Variation in market values of bucks; VarWeight = Change in body weight; VarBCS = Change in Body Condition Score; VarChest_size = Variation of chest size; Weight_i: Body weight at fattening; BCS_i: Body condition score at fattening

3.1.3 ECONOMIC PROFITABILITY OF FATTENING

The weekly cost of feeding the animals increased linearly from the 1st week, with a value of 5740 F CFA, to the highest cost, observed during the 12th week (15573 F CFA for the 12th week). The variations in weekly cost were relative (11.760 to 11.985 F CFA per week) from the 6th to the 11th week of fattening. After the 11th week, the cost remained constant until fattening stopped (15.573 F CFA per week). The cumulative cost of all the expenses associated with fattening amounted to 156.183 F CFA, or an average of 14.198 F CFA per billy-goat. The total cost of veterinary care, labour and depreciation of the goat house was 9,500 CFA francs, or 6.1% of the total cost.

The ratio of the cost of fattening to regain in live body weight was very low during the first few weeks of fattening, which translates into a low unit cost of regain in live weight (Fig. 4a). This ratio increased linearly with the duration of fattening, reaching a peak at the 9th week, after which a plateau was observed.

The benefit is greatest when the duration of fattening is limited to six weeks (Fig.4). The two evaluation methods, the live weight selling price estimated in focus groups (Fig.4a), and the carcass unit price (Fig.4b), converged towards the same profile with respective maximum profits of 20292 and 22518 F CFA, or 1845 and 2047 F CFA respectively on average per billy-goat. After six weeks, there was a linear fall in profit, leading to economic losses from the 9th week onwards.

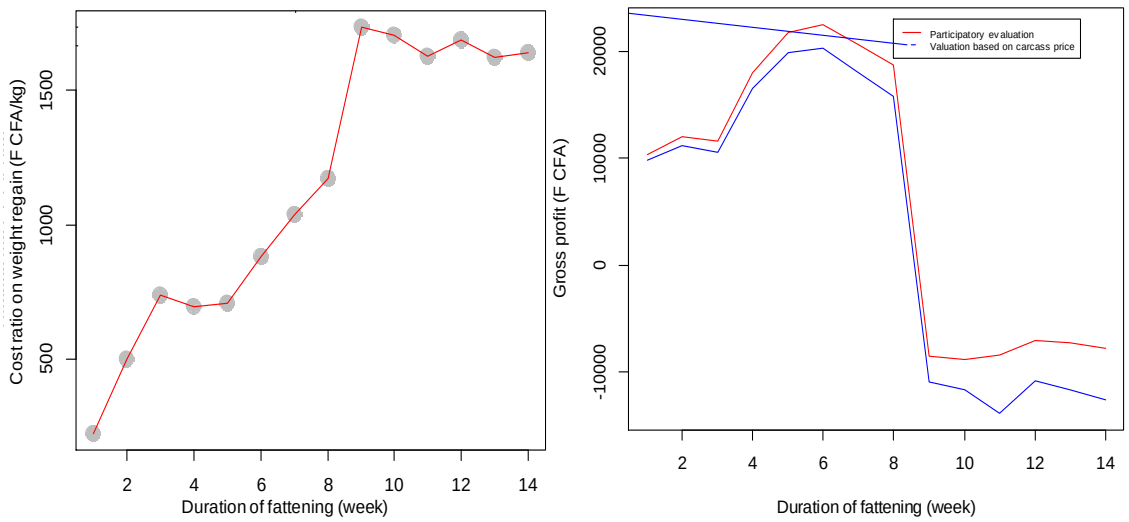

Fig. 4. Evolution of the fattening cost/weight gain ratio and total gross profit for 11 bucks

4 DISCUSSION

All the technico-economic reviews, both for sheep [24] and cattle [25], stress the link between the choice of animal and the profitability of fattening as a lucrative activity, without this being demonstrated experimentally. As the scientific basis for the choice criteria remains unequivocal, the purpose of this study is to identify the modality of each criterion that maximises the profitability of goat fattening.

An initial analysis of the influence of the racial and physical characteristics of the animals has already shown that the oldest and largest Sahelian billy goats have contributed most to maximising the Average Daily Gain (GMQ. In fact, fattening young animals always lengthens the operating time and increases the feed bill [11]. The results show that the economic age for goats can be up to 2 years, although slightly younger or even older animals have been proposed for goats [18, 4, 1] and sheep [19, 17]. Principal component analysis has shown the need to start with physically mature billy goats, large in size, light in weight, but above all associated with a slightly below-average body condition, to give priority to fat deposition over muscle tissue development [19].

The GMQ of 85.4 g/d observed in this trial is hardly comparable to the range of 50.9 to 78.3 g/d reported in Maradi red bucks [18, 8] or that of 86.21 to 117.42 g/d observed in younger red kids (Barazi et *al*., 2019), let alone the range of 49 to 95 g/d in which most of the GMQs reported in sheep fall [27, 7]. Indeed, as [19] have shown in sheep, the Average Daily Gain is significantly influenced by the duration of fattening and the age of the animals. Significant variations in this gain have also been reported in sheep according to ration composition (Samon et *al*., 2008; Dan-gomma and Kimba, 2020) [27, 7]. The addition of nutrients to rations seems to increase the GMQ.

The feed conversion ratio reflects the efficiency with which the animal converts feed into animal products. In this case, it varies from 6 to 18 depending on the duration of fattening. In sheep, the CI was evaluated at around 12 kg DM per kg growth, with no significant variation according to the duration of fattening [19]. Only the age of the animals at the start of fattening had an influence on CI, which increased with age [19]. For example, in young male sheep supplemented with Moringa oleifera residue, the feed conversion ratio was very low, at between 2.9 and 3.7 kg DM per kg growth [17]. In red goats in Maradi, the reported values of this index vary, under the influence of densified feed, from 7.1 to 10.6 kg DM per kg of growth, which suggests that goats, compared with sheep, are more efficient at converting local resources into animal protein.

The 3% weight loss observed in the control animals is thought to be linked to the dynamics of available forage on natural pastures, which gradually decline as the dry season sets in. These seasonal weight losses, which have a major impact on the production performance and health of the animals, can amount to up to 30% of their body weight [23]. Here, in this study, the weight loss is relative because the trial coincided with the onset of food shortages on pasture.

Duration is a factor influencing the profitability of goat fattening, with the economic maximum corresponding to one and a half months of active rationing. In sheep, the Average Daily Gain is significantly higher when the duration of fattening is less than nine weeks [19], which seems to corroborate the results of the present study. In fact, a longer fattening period increases the quantities of feed consumed and has a negative effect on the efficiency of feed conversion. During the latter part of the fattening period, most of the nutrients are deposited in the form of fat, which is more costly to produce in terms of energy. This would explain the gradual drop in GMQ and the increase in CI during this study.

As the quantities of feed consumed increase with the duration of the fattening period, the costs associated with feeding and maintaining the animals increase, and the profit from the operation is reduced to a greater or lesser extent. The average duration of

fattening proposed in the literature varies greatly depending on the species. Extreme durations of 7 months for sheep and 11 months for cattle have been proposed [16]. In this study, a duration of 6 weeks is required to maximise estimates at 2047 F CFA on average per billy-goat, with colossal losses of currency beyond 9 weeks. This is fairly close to the net profits of 1311 to 1373 FCFA per billy-goat reported for goat fattening [18].

5 CONCLUSION

At the end of this study, the Average Daily Gain varied significantly according to the characteristics of the animals entering fattening. The Consumption Index shows that Sahelian billy goats are highly efficient at converting local animal protein resources into foreign currency, provided that the animal is selected and the optimal duration of fattening is chosen.

The criteria that lead to a significant improvement in the profitability of goat fattening are the duration of fattening, the breed, the size, the age and the state of fatness at start-up.

Taking into account the optimum duration and the criteria for choosing the animal will lead to overall improvements in the profitability of goat fattening.

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