Adapting cattle farming to climate change in the dry and sub-humid tropical zones in Benin: how adaptation strategies affect productivity

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Keywords

Cattle, livestock production, climate change adaptation, milk production, adaptation strategies, Benin

Submitted: 27 February 2023
Accepted: 06 October 2023
Online: 30 November 2023
DOI: 10.19182/remvt.37118

Summary

Cattle farmers are developing adaptation strategies to deal with the effects of climate change. Understanding how adaptation affects livestock productivity is, therefore, essential in order to identify and prioritize the optimal strategies. Yet, few studies have addressed this issue. This study aims to fill the gap, by assessing how the adaptation strategies developed by cattle farmers in Benin affect livestock productivity. We conducted surveys with 360 cattle farmers and monitored 30 farms in Benin's dry and sub-humid tropical zones. We collected data on the socio-demographic characteristics of cattle farmers, their adaptation strategies and herd productivity. We carried out a multiple correspondence analysis, followed by an ascending hierarchical classification to establish the typology of the cattle farmers' adaptation strategies. We tested data on livestock productivity using an analysis of variance with the generalized linear model procedure of R.3.5.1. software. The results revealed three groups of adaptation strategies: integrating livestock with crop production; use of supplemental feeding and fodder crops; pastoral mobility. The choice of strategy significantly affected livestock productivity. Animal mortality rates were lower on farms that adopted supplemental feeding (2.7%), and integrated crop/livestock systems (3.3%), compared to farms with pastoral mobility (5.2%). Supplementary feeding improved calf weights at birth and at 6 months and increased daily milk offtake. Based on the results obtained, we recommend that farmers adopt supplemental feeding and integrated crop/livestock strategies in the study zones to improve herd productivity.

■ How to cite this article: Idrissou Y., Korir D., Assani Seidou A., Sanni Worogo H.S., Baco M.N., Alkoiret Traoré I., 2023. Adapting cattle farming to climate change in the dry and sub-humid tropical zones in Benin: how adaptation strategies affect productivity. *Rev. Elev. Med. Vet. Pays Trop.*, 76: 37118, doi: 10.19182/remvt.37118

■ INTRODUCTION

Livestock make a major contribution to global food production and nutrient security (Rosegrant et al., 2009). The livestock sector improves the livelihoods of the world's poorest communities and employs nearly 1.1 billion people (Rojas-Downing et al., 2017). In developing countries, livestock generate an important share of the incomes of farm households. Indeed, a large proportion of rural farm households depend on livestock for their livelihood (Thornton et al., 2002). There is an increasing demand for animal produces. In 1980, the demand for meat and milk in developing countries was 47 Mt and 114 Mt, respectively. The forecast for the year 2050 suggests that demand will reach 326 Mt for meat and 585 Mt for milk (Thornton & Gerber, 2010). Rapid population growth, urbanization and income growth are the main factors behind the increase in demand for animal products (Henchion et al., 2017). Despite the importance of livestock farming, the sector is now threatened by climate change (Idrissou et al., 2019).

Several studies have shown that climate change can affect livestock productivity (Rahut & Ali, 2018). Potential impacts include a decrease in fodder crop yield and quality (Polley et al., 2013), water availability, animal growth, milk production and livestock reproductive performance (Henry et al., 2012). Climate change also reduces

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animal production by increasing the incidence of animal diseases and mortality (Rojas-Downing et al., 2017; Rahut & Ali, 2018).

As a result, cattle farmers have been developing different adaptation strategies to sustain their livelihoods (Idrissou et al., 2019). Adaptation may be an ecological, social or economic adjustment in response to observed or future climate changes in order to mitigate their impacts (Gnanglè et al., 2015). Given the current and future context of climate change, which is causing irregular precipitation, droughts or floods (Kandlikar & Risbey, 2000), adaptation could help cattle farmers to better protect their livestock and, thereby, help guarantee not only their source of food, but their income and well-being.

In developing countries, many research studies have focused on how cattle farmers adapt to climate change (Idrissou et al., 2019). In Benin, for example, several studies have shown that to cope with less rainfall and longer periods of drought, livestock farmers now grow crops, store crop residues, use fodder crops and practice transhumance (Sounon et al., 2019; Idrissou et al., 2020a). In Ethiopia, to adapt to periods of drought or longer dry sequences, cattle farmers are diversifying their herds and practicing transhumance (Getachew et al., 2014). Similarly, cattle farmers in Burkina Faso feed concentrates to their animals and practice transhumance (Kima et al., 2015). In Kenya, cattle farmers have adopted integrated livestock and crop practices and introduced camels to diversify their herds (Cuni-Sanchez et al., 2019), to cope with less rainfall.

These studies reveal that cattle farmers have used the same herd management practices for decades. However, different practices are required for climate change adaptation (Kiema et al., 2014; Snaibi and Mezrhab, 2021). The recent strategies adopted by cattle farmers have not yet been studied (Getachew et al., 2014; Kima et al., 2015; Cuni-Sanchez et al., 2019; Idrissou et al., 2020a). Our study sets out to fill the gap. As yet, little is known about how adaptation strategies affect livestock productivity. A deeper understanding of the issue will make it possible to identify, prioritize and disseminate the most suitable strategies. The present study is therefore timely.

The general aim of this study is to analyse the link between the climate change adaptation strategies used by cattle farmers and animal performance in the dry and sub-humid tropical zones of Benin. Our objective is: i) to establish a typology of climate adaptation strategies developed by cattle farmers and highlight the changes made to traditional practices, and ii) to compare the productivity of livestock farming according to the types of adaptation strategy identified in Benin.

■ MATERIAL AND METHODS

Study zones

This study was carried out in two of the three climatic zones in Benin: the dry tropical zone (DTZ) located between 9°45' and 12°25' N and the sub-humid tropical zone (STZ) located between 7°30' and 9°45' N (Figure 1). These zones were chosen because climate forecasts indicate that they are the most vulnerable to rainfall deficit and high sunshine duration (Gnanglè et al., 2011). Furthermore, over 85% of the Beninese cattle herd is concentrated in these areas (Alkoiret et al., 2011).

In each zone, two municipalities were chosen, based on the large number of cattle farmers and preliminary interviews with technicians from the regional agricultural development agencies (Agences Territoriale pour le Développement Agricole, ATDA). The municipalities of Banikoara and Gogounou are located in dry tropical zones, while Tchaourou and Nikki are in sub-humid tropical zones. Three villages were selected in each municipality, based on their importance for cattle farming and accessibility (Figure 1).

The dry tropical zones have well-drained hydromorphic soils and lithosols. The vegetation is mainly composed of savannas with small trees (Assogbadjo et al., 2012). The mean annual rainfall is 953 mm (Idrissou et al., 2020b). The temperature varies from 24 to 31° C and relative humidity varies from 18 to 99% (Assogbadjo et al., 2012).

In sub-humid tropical zones, soils are ferruginous with variable fertility (Natta, 2003; Adomou et al., 2006). The vegetation is characterized by a mosaic of woodland, dense dry forests, tree and shrub savannas and gallery forests (Assogbadjo et al., 2012). The mean annual rainfall is 1155 mm (Idrissou et al., 2020b). Annual temperature varies from 25 to 29°C and relative humidity ranges from 31 to 98% (Neuenschwander et al., 2011).

Data collection

Data collection was carried out in three stages: the exploratory study; in-depth interviews; and farm monitoring. The objective of the exploratory phase was to identify the study villages, as well as the cattle farmers to be surveyed. The in-depth phase consisted of collecting data on the socio-demographic characteristics and the adaptation strategies developed by the cattle farmers. Lastly, during the farm monitoring phase, livestock production data was collected for animals on a few farms that had developed different types of adaptation strategy.

Exploratory study

During this phase, interviews were carried out with technicians from the ATDA in order to identify the villages and cattle farmers to be surveyed on the basis of accessibility and the number of cattle farmers in the village (in villages with over 30 cattle farmers). The following villages were identified: Koubou, Papanè, and Agbassa in the municipality of Tchaourou; Tèbo, Biro and Sakabansi in the municipality of Nikki; Lougou, Fana, and Bagou in Gogounou; and Soroko, Goumori and Founougo in Banikoara (Figure 1).

A focus group discussion was organized in each village (with from 6 to 15 people). Participants included ATDA technicians and cattle farmers, who were chosen at random from the list of cattle farmers in contact with ATDA technicians. Discussions started with a brief explanation of the purpose of the research and what was expected

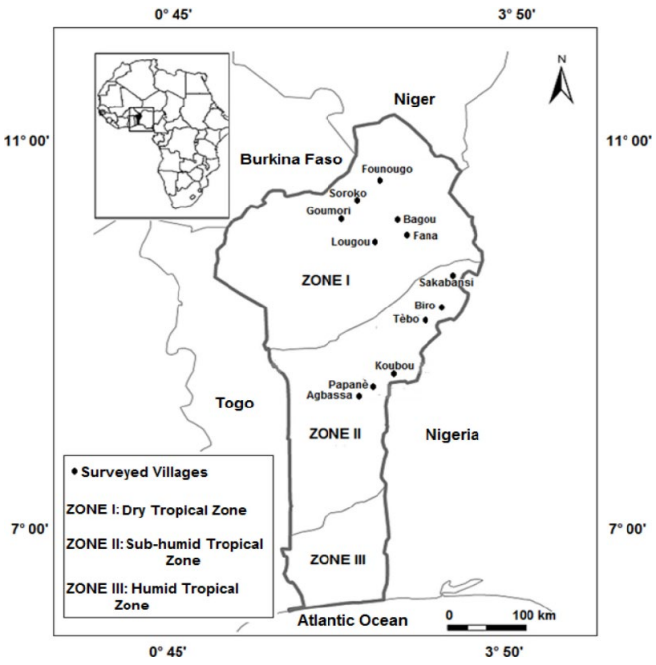

Figure 1: Map displaying the climatic zones and the location of the villages surveyed in Benin /// *Carte présentant les zones climatiques et la localisation des villages enquêtés au Bénin*

from the group. During the discussions, the questions were open, which made it possible to record the maximum number of responses. The interview guide covered the manifestations of climate change, their impact on livestock and pastoral resources (water and forage), and lastly, the new practices developed or modifications made to traditional practices to adapt to climate change. The data collected during the group discussions was used to design the questionnaire for the in-depth interviews.

During the exploratory study, interviews were carried out, which made it possible to randomly select 30 cattle farmers per village. A total of 360 cattle farmers were surveyed during this study. The criteria for choosing farmers were: i) being established in the village; ii) being a cattle farmer and iii) being at least 50 years old. The age limit was 50 years old because climate change is slow and older people can provide reliable historical information (Kaboré et al., 2019).

In-depth interviews

During the in-depth interviews with the 360 cattle farmers, data was collected using semi-structured interviews and questionnaires. The first series of questions related to the socio-demographic characteristics of the cattle farmers, including: sex, age, family status, ethnic group, household size; number of agricultural assets, level of education; contact with agricultural extension services; membership of a breeders' organization, etc. The second series of questions concerned their adaptation strategies. In the case of this study, the climate adaptation strategies are the new practices developed by the cattle farmers or the changes they have made to traditional practices. Local survey enumerators were recruited and trained for data collection. The aim of the week-long training course was to minimize bias and errors in data collection. The survey enumerators were trained to conduct interviews with cattle farmers. They were recruited from each study village and understood the local language.

Cattle herd monitoring

Data from surveys on the farmers' climate adaptation strategies (new practices and revised traditional practices) and some of their socio-demographic characteristics were used to categorize cattle farms into three groups. Thus, a sample of ten farms per group (i.e. 30 in total) was selected for monitoring over a 12-month period. Selection criteria for the monitored farms were: i) the cattle farmers must be willing to provide the necessary information at each visit and ii) have at least two cows in the herd at the start of lactation. Herd monitoring involved weekly farm visits on a specific day. During each visit, all demographic events were recorded: number of cows present, number of lactating cows, number of parturitions, number of abortions, number of mortalities, number of animals entering and leaving the herd. Milk production (quantity) and calf weights (at birth, at 3 and 6 months of age) were recorded using the monitoring sheets. The animals were identified beforehand, taking into account their name, breed, date of birth and calving rank (for cows).

Calculations

Demographic parameters

The demographic parameters of the herds monitored were calculated using the formulas proposed by Lhoste et al. (1993):

Fertility rate =
*Number of cows in advanced gestation * 100 / Number of cows*

*Abortion rate = Number of abortions * 100 / Number of cows*

*Parturition rate = Number of parturitions * 100 / Number of cows*

*Fecundity rate = Calves born alive * 100 / Number of cows*

Numerical productivity at weaning =
*Weaned Live calves * 100 / Number of cows*

*Stillbirth rate = Number of stillbirths * 100 / Number of calves born*

Pre-weaning mortality rate =
*Calves dead before weaning * 100 / Calves born alive*

Adult mortality =
*Number of dead adults *100 / Total number of adults (old≥4 years)*

*Overall mortality rate = Number of deaths * 100 / Average herd size*

Offtake Rate (OR)=
*Number of sold or slaughtered animals * 100 / Average herd size*

Gross Numerical Growth (GNG)=
*(Final herd size –Initial herd size)*100 / Average herd size*

Net Numerical Growth (NNG) =
GNG – (Immigration 100 / Average herd size)*

Numerical Yield (NY) = OR + NNG

Measuring calf weight

Initially, 150 calves were monitored for weight gain, with 50 per adaptation strategy group. The following mortalities occurred during monitoring: 4 deaths on farms with an integrated livestock/crop production strategy; 3 on farms with a supplementary feeding and fodder strategy; and 6 on farms using pastoral mobility. The remaining 137 animals included: 46 on the farms with an integrated livestock and crop strategy; 47 on farms using supplementary feeding and fodder; and 44 on farms with pastoral mobility. In each herd, calf weight was recorded at birth and at 3 and 6 months of age, using a weighing scale of 200 ± 0.1 kg. The weighing sessions occurred monthly, early in the morning before animals were given access to feed and water.

Measuring milk production

Data on milk production were initially collected from a total of 150 cows at the start of lactation, with 50 cows per farm type for each adaptation strategy group. Cows whose calves died before the end of the monitoring period were not considered in the analysis. Thus, data from 137 cows were recorded with: 46 on farms adopting the integrated crop/livestock strategy; 47 on farms using supplementary feeding and fodder; and 44 on farms with pastoral mobility. The cows were hand milked by herders twice a day (7 a.m. and 6 p.m.). Calves were allowed to suckle for about 1 minute to stimulate milk let down before being tied up in front of their dams during milking. Cows were partially milked to ensure their calves had enough milk.

After milking, calves were allowed to suckle their respective dams for 30 minutes. The daily milk offtake (i.e. milk extracted for human consumption) was the sum of the morning and evening milk offtake. It was measured using a graduated cylinder. The quantity of milk consumed by the calf (CM) was evaluated over a period of 6 months using the following formula (Ezanno et al., 2005):

$CM = 8.7 * (W6 - W0)$

Where W6 is weight at six months; W0 is weight at birth and 8.7 is the conversion index of live weight gain into milk.

Statistical analysis

The survey data was entered into Excel 2010 software and imported into R.3.5.1 software (R Core Team Development, 2018) for statistical analyses. To establish the typology of cattle farmers' adaptation strategies, we conducted a Multiple Correspondence Analysis (MCA), followed by an Ascending Hierarchical Classification (AHC), on 18 variables: 12 active variables linked to the adaptation strategies developed by cattle farmers; and 6 supplementary variables linked to their socio-demographic characteristics (Table I). The analyses were performed using the R software's FactoMineR package (Husson et al., 2016). The farms that adopted the identified groups of strategies were then compared. The Chi-square test (χ 2) was used for the categorical

Table I: Variables used for the MCA /// *Variables utilisées pour l'ACM*

Active variables	Supplementary variables
Using feed concentrate	Climatic zone
Forage cropping	Ethnic group
New crop variety	Education level
Drought tolerance crop variety	Production goal
Crop diversification	Production mode
Growing early maturing crop	Cattle breeds
Abandonment or reduction of certain crops	
Modification of agricultural calendar	
Modification of cultivation techniques	
Early departure in transhumance	
Long duration of transhumance	
Long distance transhumance	

variables. When this test indicated significant relationships, a bilateral Z test was performed. For the quantitative variables, we used the non-parametric Kruskal-Wallis test, followed by the Mann-Whitney U test. Statistical differences were considered significant at $p < 0.05$.

The frequencies of the demographic parameters of the farms monitored were calculated and compared using the Chi-square test, followed by the bilateral Z test. Data on milk production and calf weight at birth, 3 months and 6 months for each breed of cattle were subjected to an analysis of variance, using the GLM (Generalized Linear Models) procedure in the R.3.5.1. software (R Core Team Development, 2018). The factors of variation were the adaptation strategy group and the animal's breed. The comparison of means was carried out using Student's t test applied to each pair of least squares means. Results were presented as the mean ± standard error.

■ RESULTS

Socio-demographic characteristics of cattle farmers

The socio-demographic characteristics of the cattle farmers surveyed are summarized in Table II. The majority of cattle farmers surveyed are male (92%). They belong to different socio-cultural groups, as follows: Fulani (51%), Gando (30%) and Bariba (19%). Their average age is 56 ± 0.5 and they have 30 years of cattle breeding experience on average. Of all the cattle farmers surveyed, only 5% have been educated (primary school only); average household size was 11; and average herd size was 64 head of cattle. A large number of cattle farmers are members of an organization (91%) and are also in contact with agricultural extension services (66%).

Typology of climate adaptation strategies developed by cattle farmers

The first two factorial axes obtained from the MCA allowed us to generate a cumulative percentage of explained variance that was greater than 50%. This was taken into account when interpreting the results (Figure 2). The variables that contributed the most to the formation of axis 1 were linked to crop production strategies: new crop varieties, different cultivation techniques, crop diversification, growing early maturing crops, changing the agricultural calendar and growing drought tolerant crop varieties. The variables associated with the formation of axis 2 were linked to livestock production strategies: forage cropping, use of feed concentrate, abandonment or reduction of certain crops; an early departure for transhumance, involving longer distances and longer periods.

Table II: Socio-demographic characteristics of cattle farmers surveyed /// *Caractéristiques socio-démographiques des éleveurs de bovins interrogés*

Variables	Modalities	Percentage (%)
Qualitative variables		
Sex	Male	92
	Female	8
Ethnic group	Fulani	51
	Gando	30
	Bariba	19
Level of education	Educated (Primary school)	5
	Non-educated	95
Membership in an organization	Member	91
	Not a member	9
Contact with the extension services	Contact	66
	No contact	34
Quantitative variables		Mean ± SE
Age (years)	-	56 ± 0.5
Breeding experience (year)	-	30 ± 0.9
Household size (people)	-	11 ± 0.4
Cattle herd size (head)	-	64 ± 3.6

The analysis using AHC made it possible to obtain three groups of cattle farmers according to their climate adaptation strategy (Figure 2, Table III and IV).

Group I: cattle farmers that adopted integrated livestock and crop strategies

The integration of livestock with crop production (ILCP) is the climate adaptation strategy used by group I. It is a traditional practice that has been modified by cattle farmers and is now used as a climate adaptation strategy. The changes made by the cattle farmers (Table IV) include: growing new crop varieties (95%), changing cultivation techniques (85%), crop diversification (100%), growing early maturing crops (90%), changing the agricultural calendar (90%) and growing drought tolerant crop varieties (75%). During the dry season, crop residues are fed to livestock to supplement the natural rangeland. During the rainy season, livestock only graze on natural rangeland.

This integrated strategy has been developed by 41.4% of the cattle farmers surveyed, making a total of 149 cattle farmers. These farmers are sedentary, mainly located in the sub-humid tropical zone (82%) and target meat production (Table III). Most are from the socio-cultural groups Bariba (39%) and Gando (37%). Their average age is 56 and their average household size is 9. They have the smallest herds (24 head on average). They are members of a herders' organization and are in contact with agricultural extension services. There are three main cattle breeds: Borgou (63%), crossbred (15%) and Mbororo (12%). Their cattle were acquired by inheritance (51%) and purchase (43%).

Group II: cattle farmers that use supplementary concentrate feed and fodder

To adapt to climate change, all cattle farmers in this group rely on the use of supplemental feed and forage crops (SFCF), which have replaced certain cereal or leguminous crops (IV). Feed concentrates are used during the dry season in addition to natural rangeland and forage crops. During the rainy season, livestock graze on natural rangeland and are fed forage crops. This strategy was developed by

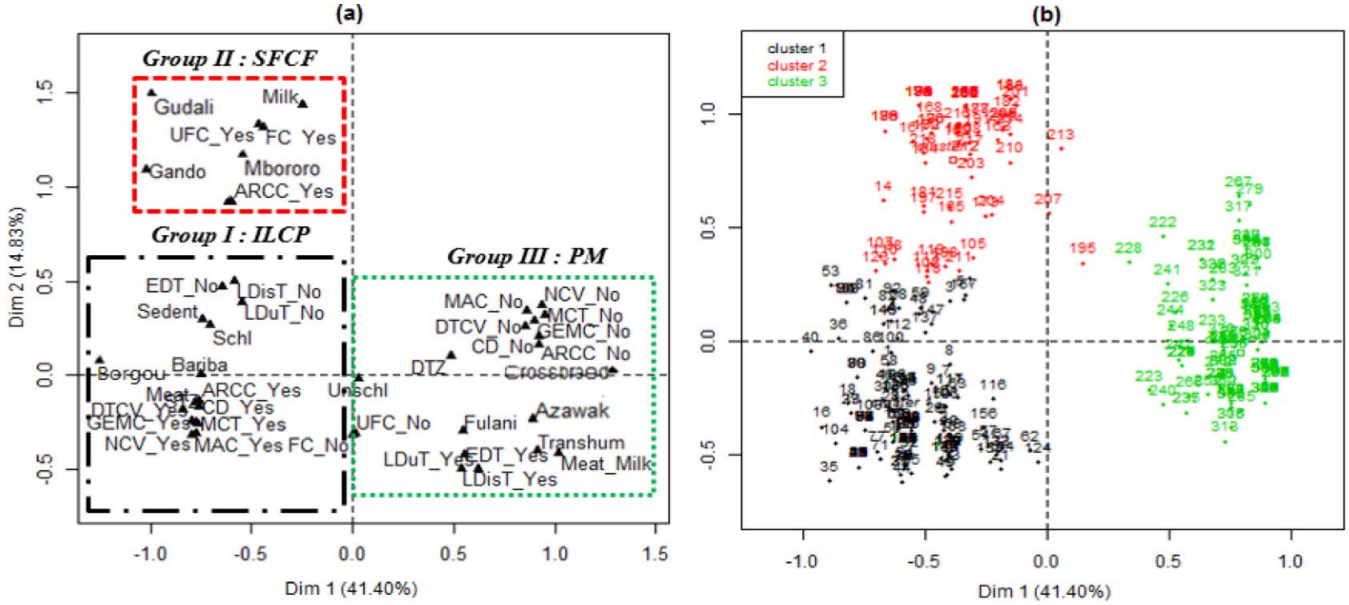

Figure 2: Graph showing groups of adaptation strategies (a) as well as cattle farmers (b) adopting these strategies /// *Graphe montrant les groupes de stratégies d'adaptation (a) ainsi que les éleveurs (b) qui les développent*

UFC : Using feed concentrate ; FC : Forage cropping ; EDT : Early departure in transhumance; LDuT: Long duration of transhumance; LDisT: Long distance transhumance; NCV: New crop variety; DTCV: Drought tolerance crop variety; CD: Crop diversification; GEMC: Growing early maturing crop; ARCC: Abandonment or reduction of certain crops; MAC: Modification of agricultural calendar; MCT: Modification of cultivation techniques; DTZ: Dry tropical zone; STZ: Subhumid tropical zone; Schol: Schooled; Unschl: Non schooled /// *UFC : Utilisation d'aliment concentré; FC : Culture fourragère ; EDT : Départ précoce en transhumance ; LDuT : Longue durée de transhumance ; LDisT : Transhumance sur longue distance ; NCV : Nouvelle variété de culture ; DTCV : Variété de culture tolérante à la sécheresse ; CD : Diversification des cultures ; GEMC : Culture à maturation précoce ; ARCC : Abandon ou réduction de certaines cultures ; MAC : Modification du calendrier agricole ; MCT : Modification des techniques culturales ; DTZ : Zone tropicale sèche ; STZ : Zone tropicale subhumide ; Schol : Scolarisé ; Unschl : Non scolarisé*

19.2% of the cattle farmers surveyed, making a total of 69 farmers. These cattle farmers are also sedentary. Their objective is to produce milk. They are mainly from the Gando socio-cultural group (63%). They are located in the dry tropical zone (85%) and their level of education is similar ($p > 0.05$) to the cattle farmers that have adopted the integrated crop/livestock strategy. Most of the farmers practicing supplemental feeding and forage are in contact with the agricultural extension services (73%) and belong to a herders' organization (92%). The main cattle breeds in their herds are: Mbororo (33%) and Goudali (26%). Average herd size is 30 heads. Animals are acquired as follows: inheritance (64%), purchase (21%) and entrusted (15%). The farmers' average age is 56 and their average household size is 8 (Table III).

Group III: cattle farmers with a strategy based on pastoral mobility

The practice of transhumance or pastoral mobility (PM) is first and foremost a way of life among the Fulani herders. Given the scarcity of resources due to climate change, the practice has been modified and has become an adaptation strategy. Herders organize an early departure for the transhumance, they travel long distances for extended periods (IV). Throughout the year, herders that adopt pastoral mobility graze their animals on natural rangeland. Some herders that have cultivable fields, feed crop residues to their animals before leaving on the transhumance. This strategy was practiced by 39.4%. of the surveyed herders (out of a total of 142). Their average age was 57 ± 0.6 years and average household size was 7 ± 0.4 (Table III). Almost all of these herders were from the Fulani socio-cultural group (93%), had not been to school (100%) and were located in the dry tropical zone (73%) where natural resources are less abundant compared to the subhumid tropical zone. They were in contact with agricultural extension services and belong to a herders' organization (92%). Their herds were made up of several cattle breeds in almost equal proportions: Borgou, Goudali, Mbororo, Azawak and crossbreds. Their average herd size was 63 heads, higher ($p < 0.05$) than for herds in the other two adaptation strategy groups. The animals in this group were largely acquired by inheritance (64%) and purchase (21%).

Productivity in relation to adaptation strategies

Herd structure

Table V presents the composition of the cattle herds monitored in relation to the adaptation strategy groups identified. In the herds where the supplementary feeding and pastoral mobility strategies were adopted, male animals made up a quarter (1/4) of the herd on average, while females represented three quarters (3/4) of the herd. In comparison, the herd composition on farms with an integrated livestock/crop strategy was approximately a third (1/3) males and two thirds (2/3) females. Herds with pastoral mobility were on average nearly 4 times and 2.4 times greater ($p < 0.05$) than herds using the integrated crop/livestock practices and pastoral mobility strategies, respectively. The proportion of cows was higher ($p < 0.05$) on farms with pastoral mobility, followed by farms with supplemental feeding ($p < 0.05$), compared to farms with an integrated livestock/crop strategy. The proportion of young heifers (1 to 2 years old) on farms with integrated and supplemental feeding strategies is higher ($p < 0.05$) than on farms with pastoral mobility. On the other hand, the proportion of 2 to 3 years old heifers and female calves is identical ($p > 0.05$) in all three groups. Herds on farms using supplemental feeding and pastoral mobility have more females ($p < 0.05$) than those with integrated livestock/crop strategies. The proportion of male calves and young bulls (1 to 2 years old) was similar ($p > 0.05$) in the three groups. On the other hand, the proportion of 2 to 3 years old bulls and reproductive bulls was different ($p < 0.05$). Indeed, the proportion of 2 to 3 years old bulls is higher ($p < 0.05$) on farms with integrated strategies, followed by farms using supplemental feeding, which in turn have a significantly higher share of 2 to 3 years old subadult bulls ($p < 0.05$) than farms using pastoral mobility. The number of reproductive bulls is higher ($p < 0.05$) on farms with integrated

strategies than on farms practicing supplemental feeding or pastoral mobility. The number of reproductive bulls in herds belonging to the latter farm groups is identical ($p > 0.05$).

Reproduction, mortality and numerical exploitation parameters

Table VI shows the reproduction, mortality and numerical exploitation parameters of the cattle herds monitored in relation to the groups of adaptive strategies adopted by farmers. In terms of reproduction, the fertility rate of cattle on farms from the three groups was not significantly different ($p > 0.05$). In contrast, the abortion rate was higher on farms with pastoral mobility ($p < 0.05$) compared to the other farm groups. The fecundity rate on farms with pastoral mobility is lower ($p < 0.05$) than on farms using supplemental feeding, while farms with integrated livestock/crop strategies lie between the two for this parameter. Parturition rate on farms that adopt pastoral mobility was lower ($p < 0.05$) than for the other two groups. Numerical yield at weaning on farms with pastoral mobility is lower ($p < 0.05$) than for the other two groups, which were almost identical for this parameter ($p > 0.05$).

With the exception of the adult mortality rate, all the mortality parameters studied were higher ($p < 0.05$) on farms with pastoral mobility. The number of stillborn calves on farms with pastoral mobility was almost 1.5 times more ($p < 0.05$) than on farms with integrated livestock/crop strategies and double that on farms with supplemental feeding and

Table III: Socio-demographic characteristics of cattle farmers adopting the different groups of adaptation strategies /// *Caractéristiques sociodémographiques des éleveurs de bovins adoptant les différents types de stratégies d'adaptation*

Parameters	Modalities	Adaptation strategies groups		
		ILCP	SFCF	PM
Pourcentage (%)				
Climatic zone	DTZ	18^{c}	85^{a}	73^{b}
	STZ	82^{a}	15^{c}	27^{b}
Ethnic group	Fulani	24^{b}	25^{b}	93^{a}
	Gando	37^{b}	63^{a}	7^{c}
	Bariba	39^{a}	12^{b}	0^{c}
Level of education	Schooled	9^{a}	5^{a}	0^{b}
	Unschooled	91^{b}	95^{b}	100^{a}
Contact with the extension	Contact	58^{b}	73^{a}	35^{c}
	No contact	42^{b}	27^{c}	65^{a}
Membership in an organization	Member	90^{a}	92^{a}	92^{a}
	Not a member	10^{a}	8^{a}	8^{a}
Cattle breeds	Borgou	63^{a}	20^{b}	13^{c}
	Goudali	10^{b}	26^{a}	20^{b}
	Mbororo	12^{c}	33^{a}	27^{b}
	Azawak	0^{a}	0^{a}	15^{b}
	Crossbred	15^{c}	21^{b}	25^{a}
Herd constitution mode	Purchase	43^{a}	22^{b}	21^{b}
	Inheritance	51^{b}	62^{a}	64^{a}
	Entrusted	6^{b}	16^{a}	15^{a}
Production goals declared	Meat	75^{a}	10^{c}	20^{b}
	Milk	10^{b}	80^{a}	15^{b}
	Meat and milk	15^{b}	10^{b}	65^{a}
Production mode	Sedentary	100^{a}	100^{a}	0^{b}
	Transhumance	0^{b}	0^{b}	100^{a}
Means ± SE				
Age	-	56 ± 0.6^{a}	56 ± 0.9^{a}	57 ± 0.6^{a}
Household size	-	9 ± 0.4^{a}	8 ± 0.6^{a}	7 ± 0.4^{b}
Cattle herd size	-	24 ± 3^{c}	30 ± 2^{b}	63 ± 4^{a}

^{a,b,c}: Values of the same line indexed by different letters are significantly different ($p<0.05$); DTZ: Dry Tropical Zone; STZ: Sub-humid Tropical Zone; ILCP: Integration Livestock with Crop Production; SFCF: Supplemental Feeding of Concentrates and Fodder; PM: Pastoral Mobility; SE: Standard error /// *Les valeurs de la même ligne indexées par des lettres différentes sont significativement différentes ($p<0.05$) ; DTZ : zone tropicale sèche ; STZ : zone tropicale subhumide ; ILCP : intégration élevage et production végétale ; SFCF : alimentation complémentaire en concentrés et en fourrage ; PM : Mobilité pastorale ; SE : Erreur standard*

Table IV: Practices characterizing each strategy group /// *Pratiques caractérisant chaque groupe de stratégie*

Parameters (%)	Adaptation strategies groups		
	ILCP	SFCF	PM
Using feed concentrate	8^{b}	100^{a}	5^{b}
Forage cropping	0^{b}	100^{a}	0^{b}
New crop variety	95^{a}	35^{b}	15^{c}
Drought tolerance crop variety	75^{a}	30^{b}	10^{c}
Crop diversification	100^{a}	25^{b}	10^{c}
Growing early maturing crop	90^{a}	30^{b}	15^{c}
Abandonment or reduction of certain crops	45^{b}	100^{a}	0^{c}
Modification of agricultural calendar	90^{a}	20^{b}	0^{c}
Modification of cultivation techniques	85^{a}	25^{b}	0^{c}
Early departure in transhumance	0^{b}	0^{b}	100^{a}
Long duration of transhumance	0^{b}	0^{b}	100^{a}
Long distance transhumance	0^{b}	0^{b}	100^{a}

^{a,b,c}: Values of the same line indexed by different letters are significantly different ($p < 0.05$); ILCP: Integration Livestock with Crop Production; SFCF: Supplemental Feeding of Concentrates and Fodder; PM: Pastoral Mobility /// *Les valeurs de la même ligne indexées par des lettres différentes sont significativement différentes ($p<0.05$) ; ILCP : intégration élevage et production végétale ; SFCF : alimentation complémentaire en concentrés et en fourrage ; PM : Mobilité pastorale*

Table V: Averaged herd structure (%) of cattle herds monitored by group of adaptation strategies /// *Structure moyenne du troupeau bovins (%) suivi en fonction des groupes de strategies d'adaptation*

Animal categories	Adaptation strategies groups		
	ILCP	SFCF	PM
Female (%)			
Female calves (0 to 1 year)	11a	11a	11a
Heifers 1st age (1 to 2 year)	10a	11a	8b
Heifers 2nd age (2 to 3 years)	9a	8a	8a
Cows (3 years and over)	39c	45b	48a
Total female	**69b**	**75^{a}**	**75^{a}**
Male (%)			
Male calves (0 to 1 year)	10a	9a	10a
Sub-adult bulls 1st age (1 to 2 years)	7a	6a	7a
Sub-adult bulls 2nd age (2 to 3 years)	9a	8b	5c
Reproductive bulls (3 years and over)	5a	2b	3b
Total male	**31a**	**25b**	**25b**
Average herd size (heads)	24 ± 3c	30 ± 2b	63 ± 4a

^{a,b,c}: Values of the same line indexed by different letters are significantly different ($p < 0.05$); ILCP: Integration Livestock with Crop Production; SFCF: Supplemental Feeding of Concentrates and Fodder; PM: Pastoral Mobility /// *Les valeurs de la même ligne indexées par des lettres différentes sont significativement différentes ($p<0.05$) ; ILCP : intégration élevage et production végétale ; SFCF : alimentation complémentaire en concentrés et en fourrage ; PM : Mobilité pastorale*

fodder. The pre-weaning mortality is higher ($p < 0.05$) under pastoral mobility than for the other two farm groups, which are almost identical ($p > 0.05$). The situation was the same for overall mortality rate.

The numerical exploitation rate was different ($p < 0.05$) for the three groups. The highest numerical exploitation rate was observed on farms with integrated livestock and crop strategies and with supplemental feeding strategies. Numerical exploitation was very low ($p < 0.05$) in farms with pastoral mobility. The growth rate parameter indicates herd growth compared to the initial number of cattle in the herd. Gross numerical growth was lower ($p < 0.05$) on the farms that developed the pastoral mobility strategies. The same trend was observed for net numerical growth. Numerical yield was higher ($p < 0.05$) on farms with integrated livestock/crop strategies than on farms with pastoral mobility.

Table VI: Reproduction, mortality and numerical exploitation parameters of cattle farming monitored clustered based on their climate adaptation strategies /// *Paramètres de reproduction, de mortalité et d'exploitation des élevages bovins suivis en fonction des stratégies d'adaptation*

Parameters (%)	Adaptations strategies groups		
	ILCP	SFCF	PM
Reproduction parameters			
Fertility rate	71.0^{a}	73.1^{a}	71.1^{a}
Fecundity rate	69.2^{ab}	75.9^{a}	66.4^{b}
Parturition rate	77.1^{a}	76.2^{a}	70.3^{b}
Abortion rate	2.6^{b}	2.2^{b}	4.2^{a}
Numerical productivity at weaning	67.2^{a}	66.6^{a}	52.9^{b}
Mortality parameters			
Mortinatality rate	3.3^{b}	2.7^{b}	5.2^{a}
Pre-weaning mortality rate	9.3^{b}	8.2^{b}	14.4^{a}
Adult mortality rate	1.3^{a}	1.5^{a}	1.3^{a}
Overall mortality rate	2.0^{b}	1.9^{b}	4.0^{a}
Numerical exploitation parameters			
Numerical exploitation rate	2.9^{a}	3.0^{a}	1.7^{b}
Gross numerical growth	3.6^{a}	3.3^{a}	2.4^{b}
Net numerical growth	2.9^{a}	2.6^{a}	1.9^{b}
Numerical yield	5.9^{a}	5.6^{a}	3.6^{b}

^{a,b,c}: Values of the same line indexed by different letters are significantly different ($p < 0.05$); ILCP: Integration Livestock with Crop Production; SFCF: Supplemental Feeding of Concentrates and Fodder; PM: Pastoral Mobility /// *Les valeurs de la même ligne indexées par des lettres différentes sont significativement différentes ($p<0.05$) ; ILCP : intégration élevage et production végétale ; SFCF : alimentation complémentaire en concentrés et en fourrage ; PM : Mobilité pastorale*

Calf growth performance

Table VII presents the least squares mean values for calf weights (at all ages considered), according to the cattle farmers' adaptation strategy. The different adaptation strategies had a significant effect ($p < 0.05$) on calf weights. At birth, at 3 months and 6 months, Borgou calves were heavier on farms practicing supplementary feeding, followed by Borgou calves from farms with integrated livestock/crop systems. Calves on farms with pastoral mobility weighed less. This observation was the same for calves of other breeds (Goudali, Mbororo and crossbreds). Thus, for the same breed, calves on farms with pastoral mobility had a low weight performance compared to the other two farm groups.

Milk production

The group of adaptation strategies developed by farmers had a significant effect ($p < 0.05$) on the daily milk offtake (Figure 3a).

Table VII: Weight (kg) of calves of each breed at birth, 3 months and 6 months of age according to the groups of adaptation strategies /// *Poids (kg) des veaux de chaque race à la naissance, à 3 et 6 mois d'âge selon les groupes de strategies d'adaptation*

Breeds	AS groups	Weight at birth	Weight at 3 months	Weight at 6 months
Borgou	ILCP	16.8 ± 1.4^{b}	33.0 ± 2.4^{b}	54.3 ± 3.9^{b}
	SFCF	18.1 ± 1.3^{a}	34.6 ± 2.2^{a}	57.1 ± 3.6^{a}
	PM	14.3 ± 2.7^{c}	30.8 ± 4.5^{c}	48.3 ± 5.3^{c}
Goudali	ILCP	22.2 ± 1.1^{b}	48.3 ± 3.6^{b}	81.9 ± 4.7^{b}
	SFCF	23.9 ± 1.2^{a}	51.5 ± 3.8^{a}	85.4 ± 4.8^{a}
	PM	20.8 ± 2.9^{c}	45.4 ± 5.3^{c}	78.8 ± 5.1^{c}
Mbororo	ILCP	22.2 ± 1.6^{b}	47.3 ± 4.9^{b}	83.9 ± 4.6^{b}
	SFCF	23.8 ± 1.6^{a}	51.1 ± 4.8^{a}	87.1 ± 4.4^{a}
	PM	20.1 ± 2.7^{c}	43.3 ± 3.8^{c}	79.5 ± 5.2^{c}
Crossbred	ILCP	19.3 ± 2.5^{b}	40.2 ± 5.4^{b}	69.3 ± 3.2^{b}
	SFCF	21.4 ± 2.6^{a}	45.0 ± 4.4^{a}	74.1 ± 4.2^{a}
	PM	17.2 ± 1.4^{c}	36.4 ± 3.3^{c}	63.1 ± 5.9^{c}
All breeds	ILCP	20.1 ± 1.7^{b}	42.2 ± 4.1^{b}	72.3 ± 4.1^{b}
	SFCF	21.8 ± 1.7^{a}	45.8 ± 3.8^{a}	75.9 ± 4.3^{a}
	PM	18.1 ± 2.4^{c}	38.9 ± 4.2^{c}	67.4 ± 5.4^{c}

^{a,b,c}: Values of the same line indexed by different letters are significantly different ($p < 0.05$); ILCP: Integration Livestock with Crop Production; SFCF: Supplemental Feeding of Concentrates and Fodder; PM: Pastoral Mobility /// *Les valeurs de la même ligne indexées par des lettres différentes sont significativement différentes ($p<0.05$) ; ILCP : intégration élevage et production végétale ; SFCF : alimentation complémentaire en concentrés et en fourrage ; PM : Mobilité pastorale*

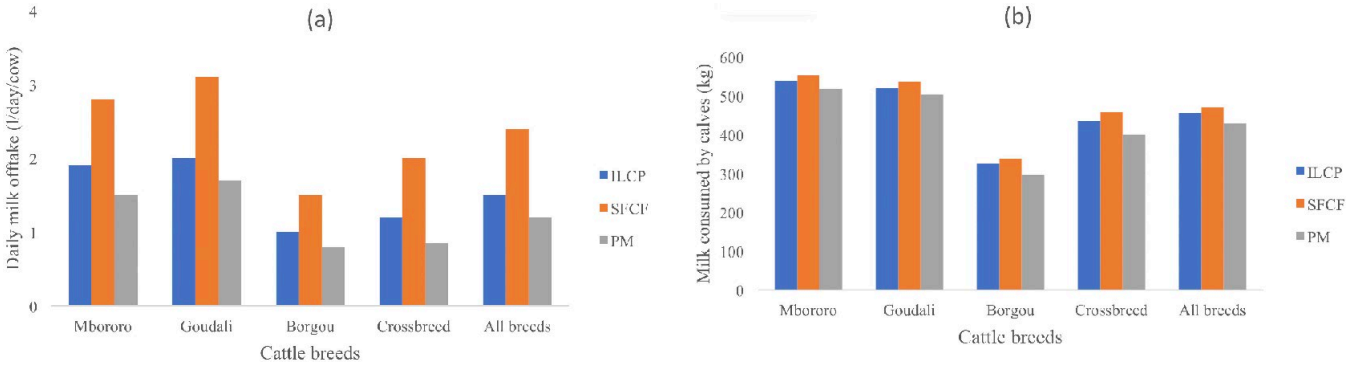

Figure 3: Daily milk offtake (a) and amount of milk consumed by the calves during 6 months (b) by group of adaptation strategies /// *Quantité quotidienne de lait trait (a) et quantité de lait consommée par veau sur une période de 6 mois (b) en fonction des stratégies d'adaptation*

Considering the daily milk offtake of all breeds, milk offtake was higher on farms with a supplementary feeding strategy (2.4 liters/day), followed by farms with integrated livestock/crop practices (1.5 liters/day), compared to farms using pastoral mobility (1.2 liters/day). The same observation was made when considering the daily milk offtake of the same breed for the three farm types. For example, Mbororo cows from farms with supplementary feeding produced more milk (2.8 liters/day), compared to Mbororo cows from farms with an integrated livestock and crop strategy (1.9 liters/day). Mbororo cows from farms practicing pastoral mobility produced less (1.5 liters/day).

The amount of milk consumed by calves during the period of 0–6 months was significantly affected ($p < 0.05$) by the adaptation strategy group (Figure 3b). Calves on farms with pastoral mobility consumed significantly less milk ($p < 0.05$) than calves from the other two farm groups.

■ DISCUSSION

Adapting to climate change requires various readjustments in terms of livestock management. It is essential to help cattle farmers ensure their food security, income and livelihood (Kandlikar & Risbey, 2000). This study revealed that cattle farmers in Benin have developed adaptation strategies, which we have classified into three groups. These strategies are consistent with those found by several authors in Africa (Kima et al., 2015; Cuni-Sanchez et al., 2019; Sounon et al., 2019). The right of land ownership may determine which group of strategies is adopted by the herder. Indeed, in this study, the integrated livestock and crop strategy and the supplementary feeding strategy are used by cattle farmers who own agricultural land. According to Kokoye et al. (2013), secure land tenure rights could be used as an incentive to encourage farmers to adopt specific strategies. When property rights are not guaranteed, expropriation cannot be ruled out (Ghei, 2009). Integrating livestock with crop and forage production requires relatively secure tenure to ensure that the cattle farmers who invest time and effort have the right to exclude others from the harvest (Amole & Ayantunde, 2016). Similarly, according to Yegbemey et al. (2013), producers are unwilling to implement adaptation strategies that may require more investment in inputs, when they do not have secure land tenure or full rights to the land. The cattle farmers who adopt the integrated livestock/crop practices and the use of supplementary feeding and forage, all own agricultural land. However, their strategies differ because they have different production objectives. The farmers who use supplemental feeding are more market-oriented because their goal is to sell milk. To improve their herds' milk production when resources are scarce as a result of climate change, they feed concentrates and grow forage crops instead of cereal and legume crops. A similar observation was reported by Amamou et al. (2018). The cattle farmers who adopt the integrated livestock/crop strategy aim to produce meat (sale of live animals) and occasionally milk. With the integrated strategy, cattle farmers grow food (cereals, legumes) for their families and use the crop residues for their animals. When they have a good harvest, the surplus is sold to buy various inputs, such as veterinary products. These results corroborate those of Kima et al. (2015). The integrated livestock and crop strategy is a very old practice. However, cattle farmers have modified it to adapt to climate change. For example, the agricultural calendar and cultivation techniques are now different with the cultivation of early maturing or drought tolerant crops.

The practice of transhumance has also been modified by herders to adapt to climate change. For example, in this study, we observed an earlier departure for the transhumance, over longer distances and for a longer duration. Pastoral mobility was developed by herders with a large number of cattle. These herders rarely own agricultural land, individually or collectively. They rely on access to pasture and water as common resources. In the context of climate change, the scarcity of these resources forces herders with large herds to practice transhumance in order to reduce the risk of mortality (Kiema et al., 2014). Transhumance may be practiced for other reasons, such as to manage floods and disease outbreaks, by varying the routes and dates of transhumance (Abdou et al., 2020). Transhumance among Fulani herders is also a way of life that expresses independence and courage. Therefore, climate change has consolidated their practices.

On farms with supplementary feeding and pastoral mobility strategies, the average herd composition in terms of the male:female ratio was a quarter male to three quarters females. This result is consistent with the observation made by Alkoiret et al. (2010) and Sounon et al. (2019) in the same country. The male:female ratio on farms using integrated strategies was higher than on farms from the other strategy groups. This could be explained by the fact that the animals were used for animal traction (ploughing). This finding is consistent with those reported by Chabi Toko et al. (2016) in Benin. Farms adopting pastoral mobility presented high abortion and mortality rates, which could be explained by the practice of transhumance. During the transhumance, herds travel long distances in search of water and fodder, which could increase the mortality rate, especially of young animals. In contrast, farms that have adopted supplementary feeding and integrated livestock/crop practices have a higher numerical exploitation rate, which could be linked to their low mortality indices. Therefore, they have more animals to sell than is the case for herders practicing pastoral mobility. These results are consistent with those of Jorat (2011), who concluded that the lower the mortality rate, the higher the exploitation rate and vice versa. However, our results contrast with those reported by Sounon et al. (2019). This disparity could be due to the method used to obtain demographic data. In our study, the data used to calculate the demographic parameters were obtained from the cattle farmers through herd monitoring for 12 months, whereas Sounon et al. (2019) used a retrospective survey. The disadvantage of retrospective surveys is that farmers may not remember all the demographic events that have occurred in a given period, which could affect the results.

For the same breed of cattle, the higher calf weight gains observed on farms with integrated livestock/crop practices and supplemental feeding strategies could be explained by the feeding conditions. Farmers that adopt supplementary feeding practices give their cattle agro-industrial by-products and fodder crops. On farms that adopt integrated livestock/crop strategies, animals benefit from crop residues in addition to the natural rangeland. Thus, animals may have a better plane of nutrition compared to herds with pastoral mobility. The calf weights recorded on farms that practice supplementary feeding and pastoral mobility were of the same order of magnitude as the values reported by Alkoiret et al. (2010).

Milk production on farms with integrated livestock/crop management and supplementary feeding practices was higher than for herds with pastoral mobility. These results corroborate those of Senou et al. (2008).

■ CONCLUSION

This study showed that to adapt to climate change, cattle farmers in Benin have changed existing practices. The different practices include: integrating livestock with crop production; supplemental feeding with concentrates and fodder; and pastoral mobility. The changes made to integrated livestock and crop production are: growing new crop varieties, modifying cultivation techniques, crop diversification, growing early maturing crops, changing the agricultural calendar and growing drought tolerant crop varieties. The

changes made to supplemental feeding practices include: growing forage crops instead of certain cereal or leguminous crops; using feed concentrate. The changes made to pastoral mobility are: early departure for the transhumance, travelling greater distances and for longer periods. The study also revealed that farms that adopt supplementary feeding and integrated livestock/crop strategies have better productivity rates than farms practicing pastoral mobility. The main differences are attributed to the higher rates of mortality and abortion in herds with pastoral mobility. Similarly, lower calf weights at all ages considered and lower milk production on farms with pastoral mobility are linked to less access to land and natural resources. Based on the results obtained, the supplementary feeding and integrated livestock/crop strategies are recommended in the study zones in order to improve cattle productivity. However, pastoral mobility is not excluded because it constitutes a climate adaptation strategy, as well as a practice that valorizes grassland with a low nutritional value.

Acknowledgements

The authors would like to thank the International Foundation for Science for its financial assistance (IFS Grant B-6189-1). They would also like to thank the Intergovernmental Panel on Climate Change (IPCC) and the Prince Albert II of Monaco Foundation (FPAM) for their financial support. The contents of this document are solely the liability of Yaya Idrissou and under no circumstances may be considered as a reflection of the position of the Prince Albert II of Monaco Foundation or that of the IPCC.

Conflicts of interest

The authors declare that there is no conflict of interest.

Author contributions statement

Conceptualization: YI, DK, AAS. Methodology: YI, IAT. Formal analysis and investigation: YI, HSSW. Writing – original draft preparation: YI. Writing – review and editing: YI, DK, MNB, IAT. Funding acquisition: YI.

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Résumé

Idrissou Y., Korir D., Assani Seidou A., Sanni Worogo H.S., Baco M.N., Alkoiret Traoré I. Adaptation des élevages bovins au changement climatique dans les zones tropicales sèches et subhumides du Bénin : comment les stratégies d'adaptation affectent la productivité des animaux

Les éleveurs de bovins développent des stratégies d'adaptation pour faire face aux effets du changement climatique. Cette étude vise à évaluer comment les stratégies d'adaptation développées par les éleveurs de bétail au Bénin affectent la productivité du bétail. Nous avons mené des enquêtes auprès de 360 éleveurs et suivi 30 élevages de bovins dans les zones tropicales sèches et subhumides du Bénin. Les données sur les caractéristiques sociodémographiques des éleveurs de bovins, leurs stratégies d'adaptation et la productivité des troupeaux ont été collectées. Une analyse des correspondances multiples, suivie d'une classification hiérarchique ascendante ont été réalisées pour établir la typologie des stratégies d'adaptation des éleveurs. Nous avons testé l'effet des types de stratégies d'adaptation sur la productivité du bétail en utilisant une analyse de variance avec la procédure de modèle linéaire généralisé du logiciel R.3.5.1. Les résultats ont révélé trois groupes de stratégies d'adaptation : intégration agriculture-élevage ; utilisation de concentrés alimentaire et installation de parcelles fourragère et mobilité pastorale. Le choix de la stratégie a eu un effet significatif ($p < 0,05$) sur la productivité des animaux. Les taux de mortalité des animaux étaient plus faibles dans les exploitations ayant adopté la stratégie basée sur l'utilisation de concentrés alimentaire et l'installation de parcelles fourragère (2,7 %) et des exploitations à stratégie d'intégration culture/élevage (3,3 %), par rapport aux exploitations avec mobilité pastorale (5,2 %). La stratégie basée sur l'utilisation de concentrés alimentaire et l'installation de parcelles fourragère a amélioré le poids des veaux de la naissance à 6 mois et a augmenté la production quotidienne de lait. Sur la base des résultats obtenus, nous recommandons aux éleveurs d'adopter des stratégies d'alimentation complémentaire (concentrés et culture fourragère) et d'intégration culture/élevage dans les zones d'étude pour améliorer la productivité des troupeaux.

Mots clés : Bovin, production de bétail, adaptation aux changements climatiques, production laitière, Bénin

Resumen

Idrissou Y., Korir D., Assani Seidou A., Sanni Worogo H.S., Baco M.N., Alkoiret Traoré I. Adaptación de la ganadería bovina al cambio climático en las zonas tropicales secas y subhúmedas de Benín: cómo las estrategias de adaptación afectan a la productividad de los animales

Los criadores de bovinos desarrollan estrategias de adaptación para afrontar los efectos del cambio climático. Este estudio pretende evaluar cómo las estrategias de adaptación desarrolladas por los ganaderos en Benín afectan a la productividad del ganado. Hemos encuestado a 360 ganaderos y hemos realizado el seguimiento de 30 rebaños bovinos en las zonas tropicales secas y subhúmedas de Benín. Se recopilaron datos sobre las características sociodemográficas de los criadores de bovino, sus estrategias de adaptación y la productividad de los rebaños. Se realizó un análisis de correspondencias múltiples, seguido de una clasificación jerárquica ascendente, para establecer la tipología de las estrategias de adaptación de los ganaderos. Hemos probado el efecto de los tipos de estrategias de adaptación en la productividad del ganado utilizando un análisis de varianza con el procedimiento de modelo lineal generalista del software R.3.5.1. Los resultados revelaron tres grupos de estrategias de adaptación: integración agricultura–ganadería; utilización de concentrados alimenticios e instalación de parcelas forrajeras, y movilidad pastoral. La elección de la estrategia tuvo un efecto significativo ($p < 0,05$) en la productividad de los animales. Las tasas de mortalidad de los animales fueron inferiores en las explotaciones que habían adoptado la estrategia basada en la utilización de concentrados alimenticios y la instalación de parcelas forrajeras (2,7 %), y en las explotaciones con estrategia de integración de cultivos y ganadería (3,3 %), respecto a las explotaciones con movilidad pastoral (5,2 %). La estrategia basada en la utilización de concentrados alimenticios y la instalación de parcelas forrajeras mejoró el peso de los terneros desde el nacimiento hasta los seis meses de edad y aumentó la producción cotidiana de leche. Basándonos en los resultados obtenidos, recomendamos a los ganaderos que adopten estrategias de alimentación complementaria (concentrados y cultivo forrajero), así como integración agricultura-ganadería para mejorar la productividad de los rebaños.

Palabras clave: Ganado bovino, producción pecuaria, adaptación al cambio climático, producción lechera, Benin