Agricultural Systems 168 (2019) 112–122

Contents lists available at ScienceDirect

Agricultural Systems

journal homepage: www.elsevier.com/locate/agsy

Change and continuity in traditional cattle farming systems of West African Coast countries: A case study from Benin

Sandrine O. Houessou[a], Luc Hippolyte Dossa[a,d,*], Rodrigue V.C. Diogo[b,c], Marcel Houinato[a], Andreas Buerkert[c], Eva Schlecht[d]

[a] Ecole des Sciences et Techniques de Production Animale, Faculté des Sciences Agronomiques, Université d'Abomey-Calavi, 03 BP 2819 Cotonou, Benin
[b] Département des Sciences et Techniques de Productions Animale et Halieutique, Faculté d'Agronomie, Université de Parakou, BP 123 Parakou, Benin
[c] Organic Plant Production and Agroecosystems Research in the Tropics and Subtropics, University of Kassel, Steinstrasse 13, Witzenhausen D-37213, Germany
[d] Animal Husbandry in the Tropics and Subtropics, University of Kassel and University of Göttingen, Steinstrasse 19, Witzenhausen D-37213, Germany

ARTICLE INFO

Keywords:
Adaptation
Diversity
Herd mobility
Pastoral systems
Resilience
Transhumance

ABSTRACT

In order to characterize current cattle farming systems with respect to herd mobility and its drivers, 803 cattle farmers were surveyed across three vegetation zones along a North-South transect in Benin. Individual interviews were conducted on the basis of a semi-structured questionnaire which included questions on the socio-economic characteristics of livestock breeders, their herd size and structure, their livestock management and other agricultural practices. Production systems were typologized using categorical principal component analysis and Two-Step cluster analysis. The main factors that differentiated the cattle farming systems were type of herd mobility, season of mobility (wet or dry season), amplitude (less or > 40 km) of herd movements, herd size, and the dominant cattle breed in the herd. The following six distinct herd types were identified: "Sedentary Crossbreed (Taurine x Zebus) Farms" (n = 174; 21.7%); "Sedentary Zebu Farms" (n = 185; 23%); "Sedentary Taurine Farms" (n = 108; 13.4%); "Low Amplitude Transhumant Zebu Farms" (n = 91; 11.3%); "High Amplitude Transhumant Zebu Farms" (n = 118; 14.7%) and "Variable Amplitude Transhumant Crossbreed (Taurine x Zebus) Farms" (n = 127; 15.8%). The study revealed that pastoral mobility was practiced by about half of the surveyed herders and remains a necessity for the cattle breeders in spite of its constraints. Farmers' social status and environmental conditions also played a significant role in the adoption of a certain herd mobility strategy. The increasing practice of transhumance by non-Fulani people –an activity that until recently was closely associated with Fulani ethnic group– combined with the larger herd sizes in southern and central compared to northern regions, the expansion of crop cultivation among Fulani herders and the southwards expansion of pastoralism to the humid and sub-humid regions revealed a paradigm shift in cattle production systems in Benin. The seasonality and continuously changing availability of grazing lands and water resources were the main drivers of the ongoing transformation in the pastoral systems. Additionally, increased herd mobility has intensified conflicts among herders, and between herders and crop farmers. Adequate interventions are crucial to sustain the current production systems. Mobile pastoralists should adopt improved herd management strategies including timely destocking, while developing and strengthening grazing and manure contracts with local crop and livestock farmers. Settled pastoralists should reduce their dependency on natural rangelands and adopt more forage cultivation. Supportive policies should include the establishment and enforcement of rules for grazing activities and improvement of pastoralists' access to market, credit and veterinary services.

1. Introduction

The keeping of livestock is one of the main sources of income and food for most rural households in sub-Sahara Africa (Thornton, 2010). In Benin, recent estimates of the contribution of the livestock sector to the national gross domestic product are lacking, but the figure in 2012 published by the National Institute for Statistics and Economic Analysis was about 5.5% (INSAE, 2012). The national livestock herd is estimated

* Corresponding author at: Ecole des Sciences et Techniques de Production Animale, Faculté des Sciences Agronomiques, Université d'Abomey-Calavi, 03 BP 2819 Cotonou, Benin.
E-mail address: hippolyte.dossa@fsa.uac.bj (L.H. Dossa).

https://doi.org/10.1016/j.agsy.2018.11.003
Received 19 March 2018; Received in revised form 28 September 2018; Accepted 4 November 2018
Available online 15 November 2018
0308-521X/

at about 2,222,000 head of cattle, 1,755,000 head of goats, 878,000 head of sheep and 431,000 head of pigs (FAOSTAT, 2016). Despite its economic importance, livestock rearing is still characterized by the predominance of traditional practices, and natural rangelands constitute the main feed resource for herbivores (Babatounde et al., 2011; Assani et al., 2015). According to Squires (2015), the productivity of a rangeland's ecosystem closely depends on rainfall as well as soil texture and depth. Hence, the uneven spatial and temporal distribution of precipitation (Barthel et al., 2009) is one of the factors explaining the heterogeneous availability of pastoral resources (forage and water) within a region. Under these conditions, herd mobility – which is known within the context of seasonal transhumance as a regular movement between relatively fixed locations (Motta et al., 2018) – becomes one of the major strategies used by pastoralists to overcome temporal and spatial shortages of forage and water resources throughout West Africa (Samuels et al., 2013; Turner et al., 2014; Zampaligré et al., 2014; Sakamoto, 2016). Criteria often used to categorize transhumance include the motivation for herds' mobility, the period/season of occurrence, the distance travelled, and the duration of stay at the location of destination (De Bruijn et al., 2001).

In Benin, previous studies on pastoralism and pastoralists' livelihood strategies (Djènontin et al., 2009; Djènontin et al., 2012; Lesse et al., 2015) distinguished two forms of transhumance: the short distance transhumance restricted to the boundaries of a given local pastoral territory and the long distance transhumance which is beyond the local territory, either within (national transhumance) or beyond (cross-border transhumance) the national boundaries. While preventing herds from causing damage to crops in farmers' fields is the main motivation for the short distance transhumance practiced mainly during the cropping season, the long distance transhumance is practiced during the dry season in order to exploit the seasonality of pastures (Lesse et al., 2015). Several proponents of seasonal mobility reported that it is the best strategy for valorizing grazing areas and guaranteeing the survival of animals (Jullien, 2006; Corniaux et al., 2012; Yacouba, 2013; Zakaria, 2014).

Despite its effectiveness in the past, this ancient strategy is increasingly exposed to serious constraints. Many authors have reported the regressive tendency of natural vegetation and change in the vegetation composition due to anthropogenic and/or livestock activities (Akpo et al., 2002; Arouna, 2012; Oloukoi, 2013; Diogo et al., 2017). Saliou et al. (2014) reported the practice of late bush fires as one of the main anthropogenic activities that threatens the availability of forage supply in Benin. According to Akpo et al. (2002), the necessity to satisfy food and other domestic demands of a rapidly growing human population has led to the extension of cultivated areas and the reduction of pastures. In addition to its negative effects on pasture availability, the encroachment of agricultural land onto traditional rangelands may cause an obstruction of traditional transhumance routes (Lesse, 2011; Sulieman and Ahmed, 2013; Zakari et al., 2015) and hence restricts herd movements. Consequently, in recent years, violent and sometimes fatal conflicts between animal herders and crop farmers but also between local and foreign cattle herders have become recurrent (Lesse, 2011; Ange et al., 2014; Lesse et al., 2015). Moreover, institutional reforms towards more effective management of natural resources have not progressed much in Benin (Delville, 2010). The ongoing decentralization process, which consists of transferring power to municipalities and local deconcentrated services to ensure proper environmental and natural resources management, has not yet come to a clear demarcation and materialization of the transhumance roads/corridors in many administrative units (Kpéra et al., 2012). According to Gangneron (2011), local administrations pay little attention to the development of pastoral activities as these are often seen as environmentally destructive activities. Hence, administrators are usually biased towards crop farmers in the management of conflicts between crop farmers and pastoralists (Pierre, 2015).

In order to adapt to ecological, spatial and social mutations, herders continue to modify herding strategies. Djènontin et al. (2009) reported the subdivision of the herd as a strategy to exploit several spaces at once, whereas Lesse et al. (2015) and Adjassin (2016) reported changes in seasonal mobility routes with sometimes very long-distance grazing movements in the dry season. According to Toutain et al. (2004) and Kpéra et al. (2012), many herders are increasingly moving towards protected areas where they illegally exploit forest rangelands and thereby expose themselves to the repression of rangers and the risks of contracting diseases through contact with wildlife. Ange et al. (2014) also reported an increased migration of herds from northern to southern Benin, with encroachments of cattle onto cultivated land as a main consequence of this shift. This increased migration towards southern regions affects the geographic distribution of cattle population in the country. Indeed – although recent data on cattle distribution is lacking in Benin – the northern semi-arid region has always been considered as the main cattle breeding zone (Gruber et al., 2009) holding 85.6% of the national cattle herd since 1977 (Turner, 1993; DE, 2011). Hence, most research on pastoralism in the country has been limited to this region and only provides a patchwork view of overlapping cattle farming systems. The need for a shift in focus from the regional to the national scale becomes evident given the aforementioned migration of cattle herd from the northern towards the southern sub-humid and humid regions which are still not recognized as pastoral regions in the national development programs (DE, 2011).

Four main cattle types are traditionally found in Benin: the Taurine breeds of Lagune and Somba mainly kept in the southern and north-eastern regions, respectively, different types of Zebus in the extreme northern region, and the Borgou, a cross-breed between Zebu and Taurine (Porter et al., 2016). According to the latter author, the Borgou breed makes up to 75% of the national cattle population and is mainly distributed in the northern and central regions (DE-MAEP, 2004). However, as argued by Bassett and Turner (2007), cattle herd migrations from semi-arid towards humid regions are often preceded by a series of social and agro-ecological adjustments which includes changes in the breed composition of the herds.

So far, there has been too little quantitative analysis of on-going changes in the traditional cattle farming systems in Benin, which our study seeks to partly overcome. We hypothesized that cattle herd sizes decline along the North-South gradient in Benin as a consequence of the aforementioned increases in migration. Furthermore, farmers' management strategies may vary according to the breed composition of the herd and the prevailing environmental conditions. This study will thus characterize the current cattle production system with respect to herd mobility and its drivers.

2. Materials and methods

2.1. Study area

The study was carried out in seven locations (Kétou, Savalou, Tchaourou, Kandi, Sinendé, Boukombé and Agonli) which are representative of three vegetation zones out of the total four that are found in Benin (Fig. 1, Table 1). The regions of Kétou and Agonli in the Guinea-Congolian zone (GCZ) are characterized by ferralitic soils with savannah and shrubs as well as mangrove. The rainfall is bimodal with an average annual precipitation of 1250 mm. In the Guinean zone (GZ), which includes Savalou and Tchaourou, the soils are of ferruginous type and the vegetation dominated by moist woodland and savannas. The annual precipitation averages 1150 mm. The Sudanian zone (SZ) included Kandi, Sinendé and Boukombe and is characterized by ferruginous soils with savanna and dry woodlands. The average annual precipitation is around 1000 mm.

These locations were selected because of the presence of a relatively high number of local cattle herds but also because of the important influx of transhumant herds from neighboring countries. Irrespective of location, crop production and livestock rearing were the main economic

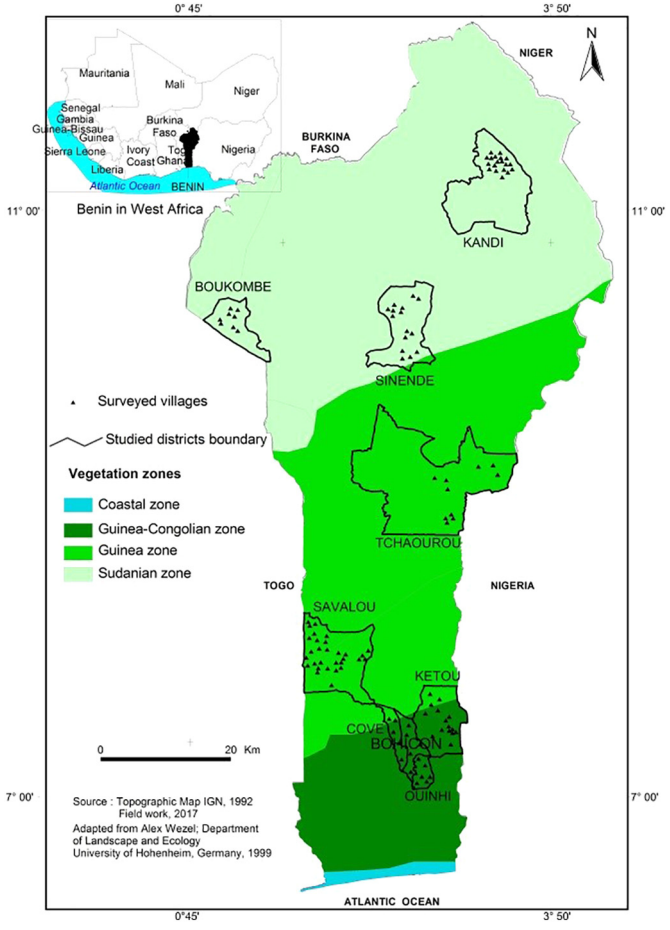

Fig. 1. Map of Benin showing the vegetation zones and locations investigated.

activities of 55% of households (INSAE, 2016).

2.2. Data collection

Due to lack of data regarding cattle farm households in all locations that could be used as basis for sampling, no random selection could be accomplished. Hence, focus groups discussions were organized in each of the research locations with officers of local extension services responsible for livestock production, and with other key resource persons to obtain lists of cattle camps and of places where cattle herds and herders gather. Subsequently, these camps and places were visited and meetings were held with cattle farmers to explain the objectives of the study, obtain their informed consent to participate in the survey, and arrange with them the adequate time for conducting interviews. Both types of villages, hosting and non-hosting transhumant herds, were taken into account in the sampling. Unequal distribution of the livestock camps resulted in unbalanced samples across the studied villages (Table 2). The individual interviews were conducted between July 2015 and May 2016, using a semi-structured questionnaire which included, *inter alia*, questions on the demographic and socio-economic characteristics of households, the size and structure of their cattle herd, their livestock management practices and their involvement in other agricultural activities.

Table 2
Number of villages and cattle herds surveyed in seven administrative units in Benin, West Africa.

Location	Villages (n)	Cattle herds (n)
Kétou	15	120
Agonli	16	50
Tchaourou	10	110
Savalou	28	120
Kandi	19	148
Sinendé	15	135
Boukombé	8	120
Total	111	803

2.3. Data analysis

The database generated from the interviews comprised 36 categorical variables and 12 continuous variables. All statistical analyses were performed with the statistical software package IBM SPSS version 20.0 (IBM Corp., 2011). The distribution of the categorical variables within and across locations was presented as frequencies and the relationships and differences were assessed using the chi-square (χ^2) test. When the χ^2 test indicated significant relationships, a *post-hoc* test was performed using the standardized residuals method. Continuous variables were presented as means together with their standard deviations and comparisons within and among locations were done using the non-parametric tests of Kruskal-Wallis W and/or Mann-Whitney U where appropriate (McDonald, 2009).

Due to the great variability of transhumance destinations and itineraries mentioned by the same farmers, we grouped the reported distances into two classes: within a radius of 40 km and beyond 40 km. These two classes were also used by Turner et al. (2014) to describe livestock mobility in semi-arid West Africa.

Table 1
General characteristics of the study locations in Benin, West Africa.

Locations	Region	Vegetation zone	Annual rainfall (mm)	Rainy Season	Climate	Average daily temperature (°C)	Area (km^2)	Population density (people/km^2)[a]	Estimates of total cattle (n)[b]
Kétou	South	GCZ	900-1300[e]	Bimodal	Sub-equatorial	24–37	1775	88	16,000
Agonli	South	GCZ	900–1300	Bimodal	Sub-equatorial	24–37	1758	132	6170
Tchaourou	Centre	GZ	1100-1200[e]	Unimodal	Tropical sub-Humid	23–32	7256	30	47,000
Savalou	Centre	GZ	1100 [e]	Bimodal	Tropical sub-Humid	23–36	2674	54	32,000
Kandi	North-East	SZ	900[d]	Unimodal	Dry tropical	21–34	3421	52	159,000
Sinendé	North-East	SZ	1057-1062[c]	Unimodal	Dry tropical	24–30	2289	39	80,000
Boukombé	North-West	SZ	1000-1200[e]	Unimodal	Dry tropical	24–36	1036	80	30,100

GZ = Guinea Zone, GCZ = Guinea-Congolian Zone, SZ = Sudanian Zone.
[a] INSAE (2012).
[b] FAOSTAT (2016).
[c] Vodounon et al. (2016).
[d] Afouda and Yabi (2016).
[e] Akoègninou et al. (2006).

For the construction of herd typologies, we first performed a Categorical Principal Component Analysis (CATPCA) according to Linting and van der Koojj (2012) to explore the relationships between the variables and to reduce the set of selected original variables to a smaller set of uncorrelated components that represent most of the information found in the original variables. The primary benefit of using CATPCA rather than traditional PCA is that CATPCA has no assumptions. It does not assume linear relationships among numeric data nor does it require assuming multivariate normal data (Linting et al., 2007). The seven variables (dominant breed in the herd, distance travelled during dry season, distance travelled during wet season, cultivated land size, cattle herd size, number of breeds in the herd and practice of transhumance) with loadings equal or higher than 0.5 on one of the two principal dimensions (Table A.1, Appendix) were selected for the final grouping, using the two-step cluster analysis; a similar cut-off level was used by Dossa et al. (2011). The final herd groups were profiled by cross-tabulating the variable "cluster membership" by both qualitative and quantitative explanatory variables used in the clustering algorithm. Subsequently, the cluster solutions' validity and stability were assessed through discriminant and multinomial logistic regression analyses performed on a set of variables that were not used in the cluster analysis. In the multinomial regression analysis, χ^2 statistic was used to assess the differences in cluster membership probabilities between the final and reduced models and to ascertain the significance levels of all predictors (independent variables) in the final model (Dossa et al., 2015). The different clusters were then compared using the χ^2 test for the categorical variables and the non-parametric Kruskal–Wallis test followed by the Mann–Whitney *U* test for *post hoc* comparison of the continuous variables. Statistical differences were considered significant at $P < 0.05$.

3. Results

3.1. Socio-economic characteristics of cattle farmers and reasons for cattle keeping

Significant differences were observed between vegetation zones ($P < 0.01$) with regard to the socio-cultural group of the surveyed cattle farmers, their age, level of education, main occupation, and source of income (Table A.2, Appendix). Irrespective of vegetation zone, the farmers were in their large majority male, married and illiterate. Apart from the Sudanian zone (SZ) where the *Otammari* (also called *Betamaribè* or *Somba* known as a small indigenous community from the Atacora mountain in North West Benin) socio-cultural group predominated, most cattle farmers in the Guinea Zone (GZ) and Guinea-Congolian Zone (GCZ) were from the Fulani ethnic group and practiced livestock keeping as their main activity which also represented their main source of income. Although significant differences were observed across vegetation zones, 91.7% of farmers were involved in crop production. In addition to crops, cattle were the most important animal species kept.

Except for farmers from Sinendé and Kandi in the SZ for whom cultural and prestige reasons were of utmost importance, financial reasons were mentioned by the majority of surveyed farmers. This was often followed by cultural reasons except for Tchaourou in the GZ where the second most reported reason was prestige. Other livestock species kept included pig, goat and poultry with significant ($P < 0.001$) variations. Poultry were widely kept irrespective of vegetation zone.

3.2. Cattle herd sizes and composition across locations and regions

The average size of cattle herds was 45 ± 1.97 heads. It varied significantly ($P < 0.001$) across vegetation zones (Table 3), with the largest herd sizes of > 50 heads recorded in GCZ and GZ, and the smallest (< 25 heads) observed in SZ. There were also significant ($P < 0.001$) differences between vegetation zones in terms of cattle herd composition (Table A.3, Appendix). However, irrespective of vegetation zone, herds were dominated by breeding cows (40%). The proportion of breeding bulls in the herds was generally low (11.5%), being significantly lower (< 6%) in GZ and GCZ than in SZ. Similar results were also recorded for the distribution of oxen across vegetation zones.

Table 3
Distribution (%) of Cattle herds' size in the GCZ in southern, GZ in central and SZ in northern Benin.

Herd sizes	Vegetation zone				
	Total	GCZ	GZ	SZ	χ^2
	(*n* = 803)	(*n* = 170)	(*n* = 230)	(*n* = 403)	
< 25 heads	41.0	14.1[a]	5.7[b]	72.5[c]	374.102
26–50 heads	30.0	31.2[a]	43.0[b]	22.1[c]	
> 50 heads	29.0	54.7[a]	51.3[b]	5.5[c]	

[abc]Within a row, values with different superscript letters are significantly different at $P \leq 0.001$ level (Chi-square test); GZ = Guinea Zone, GCZ = Guinea-Congolian Zone, SZ = Sudanian Zone.

3.3. Regional distribution of cattle types

The number of genotypes per herd varied from 1 to 5. The most heterogeneous herds in terms of breed composition were found in GZ followed by GCZ (Table 4). A total of nine types of cattle were mentioned with their local names by the surveyed herders. These included two taurine types (*Boboji* and Somba), five Zebus types (*Yakanaji* known as White Fulani, *Gudali or bokoloji* known as Sokoto Gudali, *Bodeeji* known as Red Fulani or M'bororo, *Djelliji* known as Peulh Nigérien, and *Dageeji* plus two hybrids (*Bargouji/ Muti/Keteeji*) known as Borgou and one unnamed type.

Respondents identified the taurine cattle mainly by their small size and short horns with variable coat color that contrasted with the large size and long horns of the zebus - with the exception of the Gudali which is characterized by the absence of horns. The white color was reported as the dominant color of zebus except for zebu *Bodeeji* which generally has a red coat color. Farmers used indiscriminately the name *Bargouji* or *Muti* or *Keteeji* to describe a crossbreed between zebu and taurine cattle. The unnamed crossbreed type was the result of crossing two or several of the other cattle types. The most frequently mentioned genotypes were the *Bargouji, Yakanaji* and unnamed crossbreed types. The latter was the most widely spread type of cattle; with the exception of SZ, it was present in > 60% of herds surveyed in each vegetation zone. The presence of the *Bargouji* type was more reported in Kandi and Sinendé in SZ whereas the *Yakanaji* and Gudali types were mostly mentioned in GZ and GCZ, and finally the Somba type was specific to SZ.

3.4. Cattle farm typology

In the CATPCA, the original variables were grouped into two dimensions that accounted for about 41% of the total variance. The alpha-Cronbach coefficient for the overall model was very satisfactory (0.879). The indicator variables that showed high loadings (> 0.5) on one of the two dimensions were: dominant breed in the herd, amplitude of dry and wet season movements, cultivated land size, cattle herd size, number of breeds in the herd, and practice of transhumance.

In the two-step cluster analysis performed on the above mentioned variables, a final six-cluster solution was retained because it had a satisfactory average silhouette measure (0.7) and provided maximum differentiation of the farms as well as a better interpretability. Multinomial logistic regression analyses that used cultivated land size,

Table 4
Distribution of cattle types/ breeds in the GCZ in southern, GZ in central and SZ in northern Benin.

		Vegetation zone				
Variable	SEM	Total	GCZ	GZ	SZ	χ^2
		(n = 803)	(n = 170)	(n = 230)	(n = 403)	
Number of cattle types per herd (n)	0.04	1.8	1.9[a]	2.9[b]	1.11[c]	–
Cattle type (%)	Bargouji	44.0	4.1[a]	40.4[b]	62.8[c]	168.64
	Yakanaji	47.1	94.7[a]	87.0[b]	4.2[c]	598.73
	Gudali	15.6	25.9[a]	34.3[a]	0.5[b]	145.13
	Dageeji	9.0	17.6[a]	18.3[a]	0.0	79.73
	Bodeeji	6.5	9.4[a]	13.5[a]	1.2[b]	39.28
	Boboji	8.6	11.2[a]	21.7[b]	0.0	89.94
	Djelliji	2.1	0.0	0.0	4.2	17.24
	Cross-breed	56.4	62.9[a]	74.8[b]	43.2[c]	63.23
	Somba	14.3	0.0	0.0	28.5	133.22

[abc] Within a row, values with different superscript letters are significantly different at P ≤ 0.001 level; GZ = Guinea Zone, GCZ = Guinea-Congolian Zone, SZ = Sudanian Zone.

proportion of oxen owned, number of breeds in the herd, herder's ethnicity, herder's origin, herder's main occupation, and animal categories involved in herd mobility as explanatory variables showed a 75.4% correct classification. The Cox and Snell pseudo R-square of the model was 0.901. The model Chi-Square was statistically significant at P < 0.001 and the goodness-of-fit equal to 1, indicating a good fit.

As shown in Table 5, the six cattle herd types distinguished were: "Sedentary Crossbreed (Taurine x Zebu) Farms" (SCF, *n* = 174; 21.7%); "Sedentary Zebu Farms" (SZF, *n* = 185; 23%); "Sedentary Taurine Farms" (STF, *n* = 108; 13.4%); "Low Amplitude Transhumant Zebu Farms" (LTZF, *n* = 91; 11.3%); "High Amplitude Transhumant Zebu Farms" (HTZF, *n* = 118; 14.7%) and "Variable Amplitude Transhumant Crossbreed (Taurine x Zebu) Farms" (VTCF, *n* = 127; 15.8%). The profiles and farms' characteristics are shown in Tables 6, 7, 8a & Table 8b.

3.4.1. Sedentary Crossbreed (Taurine x Zebu) Farms (SCF)

This group was found in GZ and SZ. It gathered 35.1% of herds in Tchaourou, 31.6% in Savalou and 28.2% in Sinendé. Most farmers in this group were native (*i.e.* indigenous) but from various socio-cultural or ethnic groups (*Fulani, Bariba and Monkolé* by order of importance). In general, 61.5% of them reported livestock keeping as their main occupation. Compared to farmers from other groups, they cultivated significantly (P ≤ 0.001) larger sizes of land (5.8 ± 0.54 ha) and valued manure as fertilizer. Their herd size was small and averaged 25 ± 1.49 heads of cattle with an important proportion of oxen (18% in a herd). The dominant cattle breed was the Zebu x Taurine cross named *Bargouji*. Farmers managing SCF did not practice any form of transhumance.

3.4.2. Sedentary Zebu Farms (SZF)

This group was found in all vegetation zones. It gathered 32.4% of herds in Savalou, 24.9% in Kandi, 14.6% in Tchaourou and 14.6% in Agonli. Farmers from this group shared some similarities with those from the SCF type (no transhumance; livestock keeping as main occupation; cultivation of large areas of land for those who had cultivation as secondary activity). It is the most heterogeneous group in terms of socio-cultural origins, with more than half of the farmers belonging to the Fulani group. Herd sizes were significantly larger and proportion of oxen lower compared to other non-transhumant counterparts. The dominant cattle breed in these herds was the White Fulani also called *Yakanaji* (61.1% of herds).

3.4.3. Sedentary Taurine Farms (STF)

This group consisted exclusively of herds from the Boukombé municipality in SZ. Most cattle farmers in this group were native (89.8%) and from the *Otammari* socio-cultural group. Compared with farmers from other social groups, they owned the smallest herd size composed exclusively of the West African Shorthorn Somba breed. The large majority (90.7%) of these farmers reported crop cultivation as their main occupation. Like their counterparts from the SCF, SZF, and VTCF groups, they cultivated large areas of land and used manure for soil fertilization. They were all non-transhumant. Compared with their counterparts from SCF and SZF groups, they made fewer use of crop residues for feeding their animals.

3.4.4. Low Amplitude Transhumant Zebu Farms (LTZF)

This group is mainly found in GZ and GCZ. It gathered herds from Agonli (24.2%), Savalou (23.1%), Tchaourou (18.7%) and Kétou

Table 5
Distribution of cattle farming systems identified in the GCZ in southern, GZ in central and SZ in northern Benin.

		Farming system							
Vegetation Zone	Location	Total	SCF	SZF	STF	LTZF	HTZF	VTCF	χ2
		(n = 803)	(*n* = 174)	(n = 185)	(n = 108)	(n = 91)	(n = 118)	(n = 127)	
GCZ	Kétou	14.9	1.1[a]	7.0[a]	0.0	19.8[a]	71.2[a]	2.4[a]	1533.56
	Agonli	6.2	0.0	14.6[b]	0.0	24.2[b]	0.8[b]	0.0	
GZ	Tchaourou	13.7	35.1[b]	14.6[c]	0.0	18.7[a]	1.7[b]	2.4[a]	
	Savalou	14.9	4.0[a]	32.4[b]	0.0	23.1[a]	26.3[c]	0.8[a]	
SZ	Kandi	18.4	31.6[c]	24.9[c]	0.0	5.5[cd]	0.0	33.1[b]	
	Sinendé	16.8	28.2[c]	3.8[ad]	0.0	1.1[d]	0.0	61.4[c]	
	Boukombé	14.9	0.0	2.7[d]	100.0	7.7[c]	0.0	0.0	

[abc]Within a column, values with different superscript letters are significantly different at P ≤ 0.001 level; GZ = Guinea Zone, GCZ = Guinea-Congolian Zone, SZ = Sudanian Zone; SCF = sedentary crossbreed (Taurine x Zebu) herds; SZF = sedentary zebu farms; STF = sedentary taurine farms; LTZF = low amplitude transhumant zebu farms; HTZF = high amplitude transhumant zebu farms and VTCF = variable amplitude transhumant crossbred (Taurine x Zebu) farms.

Table 6
Profiles of the different types of cattle farming systems identified in the GCZ in southern, GZ in central and SZ in northern Benin.

Parameter		SCF	SZF	STF	LTZF	HTZF	VTCF	$\chi 2$
		(n = 174)	(n = 185)	(n = 108)	(n = 91)	(n = 118)	(n = 127)	
				Means ± SD				
Herd size (n)		25.3^{a} ± 1.49	64.4^{b} ± 6.11	11.1^{c} ± 1.27	61.8^{be} ± 4.82	69.3^{e} ± 3.56	37.4^{f} ± 3.18	–
Dominant breeds in herd (%)	Bargouji/Muti/Keteeji	100.0^{a}	4.9^{b}	0.0	20.9^{c}	0.0	100.0^{a}	1668.38
	Yakanaji	0.0	61.1^{a}	0.0	64.8^{a}	100.0^{b}	0.0	
	Gudali/Bokoloji	0.0	1.6	0.0	1.1	0.0	0.0	
	Dageeji	0.0	3.2	0.0	0.0	0.0	0.0	
	Bodeeji	0.0	0.0	0.0	1.1	0.0	0.0	
	Boboji	0.0	1.6	0.0	1.1	0.0	0.0	
	Djelliji	0.0	0.0	0.0	5.5	0.0	0.0	
	Unnamed crossbreed	0.0	27.6^{a}	0.0	3.3^{b}	0.0	0.0	
	Somba	0.0	0.0	100.0^{a}	2.2^{b}	0.0	0.0	
Distance travelled in DS (%)	0 km	100.0^{a}	81.1^{b}	100.0^{a}	0.0	0.0	0.0	1471.86
	≤ 40 km	0.0	0.0	0.0	100.0	0.0	0.0	
	> 40 km	0.0	18.9^{a}	0.0	0.0	100.0^{b}	100.0^{b}	
Distance travelled in WS (%)	0 km	100.0^{a}	85.9^{b}	100.0^{a}	100.0^{a}	100.0^{a}	37.0^{c}	402.14
	≤ 40 km	0.0	9.7^{a}	0.0	0.0	0.0	63.0^{b}	
	> 40 km	0.0	4.3	0.0	0.0	0.0	0.0	

abc Within a row, values with different superscript letters are significantly different at P ≤ 0.001 level; WS: wet season; DS: dry season; SCF = sedentary crossbreed (Taurine x Zebu) farms; SZF = sedentary zebus farms; STF = sedentary taurine farms; LTZF = low amplitude transhumant zebu farms; HTZF = high amplitude transhumant zebu farms and VTCF = variable amplitude transhumant crossbred (Taurine x Zebu) farms.

(19.8%). Most of the farmers were immigrant (73.6%) from the Fulani ethnic group and were engaged in crop farming. In comparison with their counterparts in other groups, they owned significantly larger herds (on average 62 heads of cattle) with a lower proportion of oxen. The herds were dominated by the *Yakanaji* breed (64.8% of herds). Most of the herders (95.6%) reported livestock keeping as their main occupation. They cultivated a significantly (P ≤ 0.001) smaller land area and they highly valorized manure for cropland fertilization – similarly to farmers from the three first groups. They practiced low amplitude transhumance (within 40 km distance) with their entire herd during the dry season.

3.4.5. High Amplitude Transhumant Zebu Farms (HTZF)

This group is exclusively found in GZ and GCZ. It was composed of 71.2% and 26.3% of herds in Kétou and Savalou, respectively. Farmers from this group shared similar characteristics with those of the LTZF group in terms of their socio-cultural and geographic origins, their main occupation, their herd sizes and the area of land they cultivated. The herds were composed exclusively of the *Yakanaji* breed. In contrast to LTZF, they practiced high amplitude transhumance (beyond 40 km distance) during the dry season with their entire herd.

3.4.6. Variable Amplitude Transhumant Crossbreed (Taurine x Zebu) Farms (VTCF)

This group was mainly encountered in the SZ (61.4% and 33.1% of

Table 7
General household characteristics across cattle farming systems identified in the GCZ in southern, GZ in central and SZ in northern Benin.

		Farming system						
Parameter		SCF	SZF	STF	LTZF	HTZF	VTCF	$\chi 2$
		(n = 174)	(n = 185)	(n = 108)	(n = 91)	(n = 118)	(n = 127)	
Ethnicity (%)								
	Peulh	58.6^{a}	67.0^{a}	10.2^{b}	93.4^{c}	89.8^{c}	85.8^{c}	847.85
	Bariba	24.1^{a}	10.3^{b}	0.0	1.1^{c}	8.5^{b}	9.4^{b}	
	Otammari	0.0	1.1^{a}	89.8^{b}	2.2^{a}	0.0	0.0	
	Monkolé	16.1^{a}	5.9^{b}	0.0	0.0	0.0	4.7^{b}	
	Fon/Mahi	0.0	6.5	0.0	0.0	0.0	0.0	
	Yoruba	1.1^{a}	9.2^{b}	0.0	3.3^{ab}	1.7^{a}	0.0	
Origin (%)								
	Native	85.6^{a}	45.9^{b}	89.8^{a}	26.4^{c}	5.1^{d}	85.8^{a}	324.89
	Immigrant	14.4^{a}	54.1^{b}	10.2^{a}	73.6^{c}	94.9^{d}	14.2^{a}	
Main occupation (%)								
	Livestock keeping	61.5^{a}	78.9^{b}	9.3^{c}	95.6^{d}	100.0^{e}	84.3^{b}	306.87
	Crop farming	37.9^{a}	20.5^{b}	90.7^{c}	4.4^{d}	0.0	15.7^{b}	
	Trade	0.6	0.5	0.0	0.0	0.0	0.0	
				(Means ± SD)				
Cultivated land size (ha)		5.8^{a} ± 0.54	4.5^{a} ± 0.41	6.4^{b} ± 0.34	2.0^{c} ± 0.30	1.0^{c} ± 0.13	7.5^{b} ± 0.75	–
Proportion of oxen in the herd (%)		17.9^{a} ± 2.49	2.3^{bc} ± 0.70	6.1^{c} ± 1.60	0.4^{b} ± 0.32	0.0	6.5^{ac} ± 1.42	–

abc Within a row, values with different superscript letters are significantly different at P ≤ 0.001 level; SCF = sedentary crossbred (Taurine x Zebu) farms; SZF = sedentary zebu farms; STF = sedentary taurine farms; LTZF = low amplitude transhumant zebu farms; HTZF = high amplitude transhumant zebu farms and VTCF = variable amplitude transhumant crossbred (Taurine x Zebu) farms.

Table 8a
Cattle management practices across cattle farming systems identified in the GCZ in southern, GZ in central and SZ in northern Benin.

	Farming system						
	SCF	SZF	STF	LTZF	HTZF	VTCF	$\chi 2$
Parameter	(n = 174)	(n = 185)	(n = 108)	(n = 91)	(n = 118)	(n = 127)	
Feeding (%)							
Grazing only	78.2	92.4	88.0	94.5	95.8	83.5	32.35
Grazing + supplement	21.8	7.6	12.0	5.5	4.2	16.5	
Stubble grazing (%)							
Yes	36.2^{a}	47.0^{b}	12.0^{c}	34.1^{a}	30.5^{a}	18.1^{a}	52.29
No	63.8^{a}	53.0^{b}	88.0^{c}	65.9^{a}	69.5^{a}	81.9^{a}	
Valorization of manure (%)							
Yes	76.0^{a}	81.1^{a}	100.0^{b}	81.3^{a}	56.1^{c}	57.3^{c}	81.22
No	24.0^{a}	18.9^{a}	0.0	18.7^{a}	43.9^{c}	42.7^{c}	

abc Within a row, values with different superscript letters are significantly different at P ≤ 0.001 level; SCF = sedentary crossbred (Taurine x Zebu) farms; SZF = sedentary zebus farms; STF = sedentary taurine farms; LTZF = low amplitude transhumant zebu farms; HTZF = high amplitude transhumant zebu farms and VTCF = variable amplitude transhumant crossbred (Taurine x Zebu) farms.

herds in Sinendé and Kandi, respectively). Similar to the LTZF and HTZF groups, most VTCF farmers were native Fulani people. They owned medium size herds with a high proportion of oxen, which differed from the other transhumant herd types. About 84.3% of them reported livestock keeping as their main occupation; yet, they also cultivated large areas of land (7.5 ± 0.75 ha) with a medium level of manure valorization. About 63% of VTCF farmers practiced a low amplitude transhumance (within 40 km distance) during the wet season and a high amplitude transhumance (beyond than 40 km distance) during the dry season, with part of their herd (mainly lactating cows) left at their permanent encampments.

4. Discussion

4.1. Typology of cattle farming systems

Six distinct cattle herd types were identified in our study. The most salient factors differentiating these types were practice or non-practice of transhumance, periods and amplitude of herd movements, herd size, and dominant breeds. In contrast to the latter variable, the first four variables have often been used to differentiate pastoral systems in sub-Saharan Africa (Nyssen et al., 2009; Djènontin et al., 2012; Zakaria, 2014; Turner et al., 2014; Béchir et al., 2015). Evidence presented here supports the hypothesis that the breed composition of the herds influences pastoralists' herd management strategies.

4.2. Herd mobility practices and its drivers

4.2.1. Herd mobility practices

With respect to herd mobility, the six farm types differentiated in our study could further be grouped in sedentary and transhumant systems. The sedentary system encompasses the SCF, SZF and STF types whereas the transhumant system includes the LTZF, HTZF and VTCF types. The sedentary systems in our study are very similar to the "village-based management system with dispersion" previously described by Schlecht et al. (2004) and by Turner and Hiernaux (2008), whereby

Table 8b
Cattle management practices across cattle farming systems identified in the GCZ in southern, GZ in central and SZ in northern Benin.

	Farming system						
	SCF	SZF	STF	LTZF	HTZF	VTCF	$\chi 2$
Parameter	(n = 174)	(n = 185)	(n = 108)	(n = 91)	(n = 118)	(n = 127)	
Reasons for transhumance (%)							
None	100.0^{a}	73.5^{b}	100.0^{a}	0.0	0.0	0.0	730.16
Access to PR	0.0	11.4^{a}	0.0	63.7^{b}	53.4^{bc}	43.3^{c}	
Avoid conflicts	0.0	8.1^{ab}	0.0	2.2^{bc}	9.3^{a}	0.8^{c}	
Access to PR and avoid conflicts	0.0	7.0^{a}	0.0	34.1^{b}	37.3^{b}	55.9^{c}	
Frequency of movements (%)							
None	100.0^{a}	73.5^{b}	100.0^{a}	0.0	0.0	0.0	1018.18
Once a year	0.0	20.0^{a}	0.0	100.0^{b}	100.0^{b}	37.0^{c}	
Twice and more a year	0.0	6.5^{a}	0.0	0.0	0.0	63.0^{b}	
Periods of transhumance (%)							
None	100.0^{a}	73.5^{b}	100.0^{a}	0.0	0.0	0.0	1098.03
DS only	0.0	12.4^{a}	0.0	100.0^{b}	100.0^{b}	37.0^{c}	
WS only	0.0	7.6	0.0	0.0	0.0	0.0	
Both seasons	0.0	6.5^{a}	0.0	0.0	0.0	63.0^{b}	
Categories of animals moved (%)							
None	100.0^{a}	73.5^{b}	100.0^{a}	0.0	0.0	0.0	878.97
Whole herd	0.0	16.2^{a}	0.0	84.6^{b}	91.5^{b}	34.6^{c}	
Non-lactating animals	0.0	10.3^{a}	0.0	15.4^{a}	8.5^{a}	65.4^{b}	

abc Within a row, values with different superscript letters are significantly different at P ≤ 0.001 level; SCF = sedentary crossbred (Taurine x Zebu) farms; SZF = sedentary zebus farms; STF = sedentary taurine farms; LTZF = low amplitude transhumant zebu farms; HTZF = high amplitude transhumant zebu farms and VTCF = variable amplitude transhumant crossbred (Taurine x Zebu) farms; PR: pastoral resources; WS: wet season; DS: dry season.

livestock are kept inside the village and fed with available resources within the village territory. They include herding systems in which herds are moved back and forth to the village grazing areas on a daily basis, and are comparable to both the home range herding described by Baker and Hoffman (2006) and the systems involving livestock movements around homesteads termed “micro-mobility” (Butt, 2016).

The low and high amplitude transhumant systems, namely LTZF and HTZF, are very similar to those observed by Banoin and Jouve (2000) in the county of Mayahi in Niger. However, contrary to these authors' findings, the herds in Benin are moving particularly far in dry season. LTZF and HTZF also share similarities with the proximate and distant encampment mobility system described by Turner et al. (2014). The VTCF system, which represents a combination of the low and high amplitude transhumant systems, was previously also described by Djènontin et al. (2012).

4.2.2. Socio-economic drivers

The results of our study show that the socio-economic characteristics of the cattle farming households influence their herd management strategies and may consequently affect the productivity of their herds. For instance, ethnicity plays a significant role in the adoption of a specific herd mobility strategy. Sedentary herding is more likely practiced by native farmers of different ethnic groups who cultivate crops as their main occupation, than by agro-pastoralists from the Fulani ethnic group for whom livestock is the main source of income. This confirms that the practice of transhumance remains the domain of Fulani people (Jabbar, 1993; Jabbar et al., 1995; Ayantunde et al., 2011) who were managing > 85% of the transhumant herds in our study regions. Hence, the practice of transhumance by non-Fulani people as observed for LTZF and HTZF reveals an evolutionary pattern of herding practices. This finding is in line with observations of Banoin and Jouve (2000) and Umutoni et al. (2016) in Niger and Mali, respectively. The change may be attributed to increasing environmental challenges, changing social contexts, increasing food demands and population pressure, which all lead to increasing difficulties in accessing pastoral resources. Further, it suggests that herd mobility has become a necessity and is no longer a mere element of Fulani lifestyle as reported by Crane (2010) and Ayantunde et al. (2011).

However, it is striking that cattle breeders involved in the variable amplitude crossbreed transhumant system (VTCF) are mostly Fulani people who have historically been livestock breeders (Bierschenk, 1992) and have increasingly adjusted themselves to changing social, political, economic and ecological circumstances by becoming sedentary and engaging in cropping activities.

While sedentarization (the shift to sedentism) and livelihood diversification through the adoption of crop cultivation is not a new phenomenon among pastoralists in East Africa (McCabe et al., 2010), in West Africa (Thébaud and Batterbury, 2001; LaRovere et al., 2005), and more specifically in northern Benin (Droy and Bidou, 2015), it is the expansion of crop cultivation among Fulani pastoralists which is new. This increasing adoption of crop cultivation over time among pastoralists reflects some changes in cultural and social norms (Bonfiglioli, 1990). However, native herders have easier access to land and therefore to pastoral resources in contrast to immigrants. This privilege was reflected in the marked difference in cultivated land size between these two social groups. The easy access to land and pastoral resources has also been reported by Okoruwa et al. (1996). We therefore argue that herds managed by native herders can endure longer periods of forage and water scarcity without far-distance movements because of the privilege of exploiting locally available pastoral resources. Yet, Fulani herdsmen – either native or immigrants –have limited access to land and pastoral resources (Gangneron, 2011) and this lack of social and political integration into modern Benin society (Bierschenk, 1992) remains an obstacle to the development of livestock production (Pierre, 2015). Similar observations were made in Ghana by Bukari and Schareika (2015).

4.2.3. Herd composition as an important driver

Herd size and breed composition are also two major criteria distinguishing the studied cattle systems. In agreement with previous observations of Boutrais (2007), the cattle breeds kept by Fulani agro-pastoralists are different from those kept by their transhumant counterparts in our study areas. Among the three sedentary farm types, two (SCF and STF) were very similar to each other and included small numbers of animals from the indigenous breeds, either *Bargouji* or Somba. The two farming systems are also essentially found in SZ. These farm types contrast with LTZF and HTZF, which are large farms of Zebu cattle mainly encountered in GCZ and GZ in southern and central region.

Larger herd sizes in the south compared with those in the northern vegetation zones also indicate a paradigm shift in cattle husbandry in Benin since the southern region has not been traditionally considered as pastoral territory (Hestin, 2012). Further, the influence of herd size on its management as observed in our study is in line with previous observations by Alkoiret et al. (2011) and Kaimba et al. (2011). This finding confirms that small herds are often not involved in transhumance. Kaimba et al. (2011) explains this situation by the faster depletion of resources (pastures and water) with larger numbers of animals and the subsequent need to migrate and search for resources elsewhere. In addition, the presence and numerical importance of Zebu cattle in the southern vegetation zones contrast with the formerly known geographic distribution of cattle breeds in Benin (DE-MAEP, 2004).

Even though the presence of trypanosomiasis-transmitting tsetse flies has long been considered the factor curbing the expansion of zebu to humid and subhumid zones, current climatic changes combined with the expansion of farmlands and increased urbanization have significantly pushed back the tsetse belt (Blench, 1999; Ayantunde et al., 2014). The introgression of non-trypanotolerant zebu in the environment of trypanotolerant taurine breed represents a threat to the genetic integrity of the latter. The dominance of taurine and crossbreed cattle in the STF and SCF may explain their restricted mobility given that these small-framed breeds have lower feed requirements per adult animal than larger-sized zebu breeds (Ayantunde et al., 2007).

4.2.4. Environmental drivers

Although sedentary and transhumant herds coexist in the same geographical area, a general trend of predominance of one type over the other has been observed at each investigated location.

The widespread presence of sedentary systems in SZ, especially in the Boukombé municipality, may be related to the fact that *Otammari* farmers keep small size herds as secondary activity and for ploughing their agricultural fields (Dossa and Vanvanhossou, 2016). Moreover, the particularity of the hilly landscape in this region offers fewer possibilities for long-distance herd movements. Nyssen et al. (2009) have also pointed to terrain features as an important determinant of home range herding and non-transhumance practices among pastoralists in mountainous Tigray. Additionally, although hired Fulani herders in Boukombé manage large herds of entrusted animals, they are usually not allowed by the absentee owners to practice transhumance in spite of feed shortage during the dry season. This lack of trust between hired herders and absentee owners was also observed in northern Côte-d'Ivoire by Bassett (1994). In such a context, cattle farming will hardly be sustained without any strategy to improve the availability and quality of feed and water resources.

In addition to the size of the herd, herd mobility is also strongly influenced by the availability of resources within the home territory. This may in part explain the practice of short distance transhumance in GZ and GCZ (in Tchaourou, Agonli and Savalou). Moreover, most of the herds in these localities are transhumant herds from Nigeria which increasingly settle since these locations have relatively abundant pastoral resources and offer more security than the central and northern regions of Nigeria.

The favorable climatic conditions and the existence of several sources of water in tributaries of the *Ouémé* and *Okpara* Rivers in Agonli (GCZ) and Tchaourou (GZ) explain their attractiveness to transhumant herds from neighboring municipalities and other countries. In addition, the low population density in Tchaourou, estimated at about 30 inhabitants per square km^2 (INSAE, 2015), and the presence of the protected *Wari Maro* forest play an important role for the availability and access to local pastoral resources. Population density has previously been reported to significantly affect access to pastoral resources (Okoruwa et al., 1996; Turner et al., 2014). According to the latter author, mobility tends to increase with increasing population density. This is actually the case of Kétou in the GCZ where high population densities combined with increasing urbanization compromise the availability and access to resources and explain why most herders in this municipality move their herds > 40 km away from their habitual homesteads. This also holds true for Savalou and probably explains the coexistence of low and high amplitude transhumances in this municipality.

The fact that the VTCF system was mainly observed in the SZ (in Sinendé and Kandi) may be explained by the expansion of agriculture in these localities, which leads to the shrinkage of pastoral resources. Indeed, large areas are devoted to the cultivation of cotton (Houéhanou et al., 2008), a major cash crop of the country since 1990. Hence, the practice of low amplitude transhumance in the wet season has become imperative to avoid crop damage, whereas the dry season transhumance is essentially driven by the search for pastures. This system is similar to the semi-transhumant system previously described by Djènontin et al. (2012). Yet, the large size of land cultivated by (Fulani) VTCF farmers engaged in this production system is similar to land holdings of native farmers and suggests that these Fulani households are in transition to the sedentary system.

Hence, we hypothesize that sedentary farms in the SZ (SCF in Sinendé and SCF and SZF in Kandi) will respond to increasing difficulties in assessing pastoral resources by reducing the size of their herds and investing more in crop production. Such changes in pastoralist livelihood strategies have been previously reported by Majekodunmi et al. (2017). In contrast, farmers who currently practice low amplitude transhumance (LATZF) in GZ and GCZ will most likely increase the amplitude of their transhumant movements or move into other regions because they have fewer possibilities to cultivate large sizes of land. However, the adoption of sedentary farming systems in response to different challenges does not ensure the sustainability of livestock production. As pointed out by Ensminger and Rutten (1991), sedentarization may increase the risk of overgrazing, rendering many common pool grazing systems no longer viable. This is particularly true in the present context where crop residues are less valorized and the adoption of fodder cultivation by settled pastoralists almost absent.

4.3. Crop-livestock integration

Overall, the results of the current study show a close association of crop and livestock activities in all identified systems as well as the expansion of mostly sedentary agro-pastoralism to the detriment of mostly mobile pastoralism, which has so far been considered as the main livelihood system of Fulani herders. The association of cropping with livestock activities has repeatedly been evoked as a coping strategy used by African farmers and pastoralists to adapt to a changing ecological and also socio-economic environment (Seo, 2011; Zampaligré et al., 2014; Dedehouanou, 2014).

Yet, the degree of crop and livestock integration varies between cattle farming systems. The integration was strong with respect to manure use for soil fertilization (by > 50% of the respondents, irrespective of cluster) but weak with respect to capturing the value of crop residues through animal feeding, even by owners of large areas of cropland who are supposed to produce a lot of residues. The lower valorization of crop residues for feeding livestock could however be explained by their multiple uses. Indeed, crop residues are also used to protect soil against erosion and as organic fertilizer (Valbuena et al., 2012; Roxburgh and Rodriguez, 2016; Rodriguez et al., 2017), especially in areas where soils are highly susceptible to erosion. This explains the competing use of these resources as outlined by Rodriguez et al. (2017).

In addition, the significantly higher proportion of oxen in herds of respondents who cultivated larger areas of land in GZ and SZ indicates the importance of animal traction for the production systems, especially in northern Benin (De Haan, 1992; Houéhanou et al., 2008).

Nevertheless, the potential offered by crop-livestock integration is still underexploited along the cross-country transect, which confirms the much earlier claim by McIntire et al. (1992) that crop and animal production are not well integrated in sub-Saharan Africa. Our results are consistent with the notion that intensification through crop-livestock integration is a more advantageous strategy for farmers than for herders (Vall et al., 2012). We further argue that crop cultivation by herders is mainly not geared at increasing the efficiency of their livestock system but at diversification of their income sources. It is also a way for continuous food supply to the household and a risk management strategy.

4.4. Policy implications

The highest priority initiative towards sustainable livestock development in Benin is the design and implementation of pastoral-sensitive policies, which recognize mobile pastoralism not as a threat but as a viable production system and way of life. Like in many West African countries, the government of Benin has recently initiated the development of a legislation to regulate pastoralism. This law, if adopted by the parliament, will provide a legal basis for actions. However, further policy options for sustaining the current pastoral systems are needed and should include:

(i) promoting the development of strong public and private institutional arrangements that favor the cooperation between settled and non-settle stakeholders and the coexistence of different livestock herders,
(ii) facilitating participative/community-based management of pastoral resources including the restoration of degraded rangelands and water resources,
(iii) providing infrastructure services (markets for livestock and feeds, access to credits) and veterinary services for improved livestock management strategies including herd destocking, feed supplementation, and health management,
(iv) clear delineation of transhumant livestock corridors,
(v) promoting and valorizing relevant traditional knowledge and livestock management techniques, and
(vi) promoting technical innovations tailored to each production system.

5. Conclusions

Transhumant and sedentary cattle farming systems co-exist in Benin. Six distinct farming systems including three sedentary and three transhumant types were identified in this study. The most salient factors distinguishing these systems were practice or non-practice of transhumance, periods and amplitude of herd movements, herd size, and the breeds dominating the herd. In addition to these factors, the farmers' social–cultural origin, the local resources availability, and demographic conditions such as population density and level of urbanization also play a significant role in shaping cattle systems across Benin.

Even if the practice of transhumance remains the domain of landless Fulani people, it has recently evolved with changing cultural and social norms. Herd mobility has become a necessity to face environmental and social challenges and to facilitate herds' year-round access to pastoral

resources. While transhumance is increasingly practiced by non-Fulani people, there has been a marked expansion of crop cultivation among Fulani pastoralists. The ongoing changes in pastoral systems may compromise resilience and sustainability of farming systems.

Competing interests

The authors have declared that no competing interests exist.

Acknowledgments

The authors express their sincere gratitude to all participating farmers for their valuable help and cooperation during the field work. Many thanks to anonymous reviewers for their constructive criticism and to Mrs. Jennifer Provost from the University of Göttingen for English language editing and proofreading. This study was financially supported by the VolkswagenStiftung, Hannover, Germany [Grants Az 89 367 and 89 368].

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