


The role of cross-border transhumance in influencing resident herders' cattle husbandry practices and use of genetic resources

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For centuries, the humid West African coastal country of Benin attracts cattle herders from neighboring Sahelian countries such as Niger, Burkina Faso and Nigeria. Each year, several thousands of cattle are trekked over hundreds of kilometers to Benin following established and non-established transhumance corridors. This cross-border mobility has been shown to play an important role in ensuring the productivity of the transhumant herds through adequate late dry season access to pastoral resources. Yet, its effects on the traditional agro-pastoral production systems that are encountered along the routes in Benin have never been explicitly investigated. Therefore, we collected socio-economic household data, herd characteristics and management data from 104 resident herders and 38 transhumant herders in 2 vegetation zones of Benin. To determine whether or not the proximity to transhumance corridors affects sedentary production systems, characteristics of cattle herds and farmers' management practices were compared between villages close to (within a 25 km buffer) and far from (outside a 25 km buffer) transhumance corridors within and between vegetation zones using non-parametric statistical tests. Existing relationships between resident and transhumant herders were also identified and characterized. Subsequently, herd characteristics and management practices were compared between resident herders having relationships with transhumant herders and those without. Herd sizes of resident herders living close to transhumance corridors were larger ($P < 0.01$) than those of their counterparts living far away. Also, proximity to transhumance corridors had positive effects on herd management practices. The relationships between resident and transhumant herders were governed by a variety of interests including encampment/manuring contracts, exploitation of grazing lands and watering points, trading and bartering of cattle. This exchange of cattle is an important driver of change in the breed composition of local herds and represents an opportunity for resident herders to enhance their herds' productivity through crossbreeding. However, the mere replacement or indiscriminate crossbreeding of local cattle breeds with those kept by transhumant herders threatens the sustainability of the traditional resident herding systems by increasing the risk of genetic erosion and loss of valuable adaptive traits in indigenous animal genetic resources.

Keywords: cattle breeds, pastoralism, sedentary system, social networks, transboundary animal mobility

Implications

This study provides insight into the diverse relationships developed by transhumant herders from the Sahel with resident herders along the transhumance routes in Benin. It highlights the opportunities and risk presented by cross-border cattle mobility for local cattle production and genetic resources in countries hosting transhumant herds. Its findings are relevant for improving the legal bilateral and regional arrangements put in place to facilitate herd mobility by

including appropriate measures to preserve local breeds from losing important adaptive traits through indiscriminate and poorly planned crossbreeding.

Introduction

Livestock production is an agricultural, economic, social and cultural activity in West Africa. The production systems include village-based sedentary/agro-pastoral and transhumance-based mobile types of livestock raising (FAO, 2012). The latter type is the most widespread livestock

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system in the region and involves cyclical movements of herders and their herds between fixed points (Motta *et al.*, 2018). Transhumance is an age-old practice of pastoralists to cope with ecological variability and exploit seasonal availability of grazing and water resources (Brottem *et al.*, 2014). This breeding system gives herders the opportunity to exploit weight gain and milk production in the wet season and limit weight loss in the dry season (Krätli and Schareika, 2010). Furthermore, it allows minimizing possible impacts of climate change and variability on livestock production (Zampaligré *et al.*, 2013).

Due to their geographical position and relative abundance of pastoral resources, the central and northern regions of Benin are among the most preferred destinations for transhumant herders from Niger, Burkina Faso, Nigeria and Mali (FAO, 2012). Cross-border transhumance into Benin from neighboring Sahelian countries takes place from November to June each year, even though the officially proclaimed transhumance period is from January to May (Convers *et al.*, 2007). The latter period corresponds to the dry season in Sahelian countries, when scarcity of feed and water resources is acute. The immediate consequence of cross-border cattle influxes into Benin is an increasing pressure on already fragile rangeland ecosystems (Oloukoi, 2013).

Cross-border transhumance has been traditionally associated with *FulBe* people also known as *Fulani* or *Peulh* (Bassett and Turner, 2007; Ayantunde *et al.*, 2014). Although they keep various breeds of zebus (humped cattle), the *FulBe* pastoralists are strongly attached to longhorn zebu (Boutrais, 2007). Hence, in addition to contributing to growing competition for grazing resources, seasonal southward movements of *FulBe* herders from the Sahel represent an intrusion of various zebu breeds into the natural habitat of shorthorn taurine (humpless) cattle breeds. The increased proximity of the two cattle subspecies has encouraged their crossbreeding. While crossbreeding might represent a good opportunity for resident herders to improve the productivity of their herds, it is its poor planning and indiscriminate practice which potentially puts indigenous breeds at risk because of dilution of the local gene pool (Ayantunde *et al.*, 2014; Roschinsky *et al.*, 2015; Leroy *et al.*, 2016). This risk of genetic erosion is further exacerbated by the mere replacement of locally adapted taurine breeds by zebus in some locations. Indeed, several studies have proven the inferior adaptability of zebus to the environment prevailing in the southern regions of West Africa that are characterized by a hot-humid climate and high pathogen challenge (Beckley *et al.*, 2016).

There is a growing body of literature analyzing host-client and host-stranger relationships in West African agro-pastoral systems, whereby most studies (Ange *et al.*, 2014; Afouda *et al.*, 2016; Cabot, 2017; Dary *et al.*, 2017; Soeters *et al.*, 2017) adopted the latter perspective and primarily analyzed conflicts between herders and crop farmers. Host-client and the potential of mutually beneficial relations between transhumant and resident herders have been rarely studied in Benin. Consequently, little is known about the kinds of

relationships, including social networks, that exist between the two groups. In northern Benin, a direct exchange of zebu for taurine cattle, and vice versa, between transhumant pastoralists from Niger and Nigeria and resident herders around various cattle camps has been previously reported (Quarles Van Ufford, 1999). Similar patterns of acquisition of animals of special attributes or socio-cultural values were observed among the *FulBe* pastoralists in Cameroun (Boutrais, 2007). Yet, little is known about how transhumant herders and resident herders manage different genotypes, including the newly acquired, within their herds in Benin.

In addition to animal breeds and people's ethnicity, differences exist between transhumant and resident herders in terms of cattle production objectives, herd size, herd structure and cattle husbandry practices (Azalou *et al.*, 2017). Yet, whether and how the seasonal presence of transhumant herders and the social networks they develop with resident herders influence the herd management strategies of both groups has not yet been explicitly investigated. This study aims to identify the non-conflicting relationships developed between cross-border transhumant and resident herders and to assess to what extent these affect cattle husbandry practices along the transhumance corridors in Benin.

Material and methods

Study area

The study was carried out in the municipalities of Savalou and Gogounou (Figure 1) in the Guinea-Sudanian (GSZ) and Sudanian (SZ) vegetation zones, respectively (Akoègninou *et al.*, 2006). According to INSAE (2016), *Bariba* and related (49.4%) and *FulBe* (43.5%) are the major socio-cultural groups in Gogounou (SZ), whereas *Fon* and related (48.1%) and *Yoruba* and related (38.2%) predominate in Savalou (GSZ). In the latter location, only 5.2% of the population are from the *FulBe* socio-cultural group.

Both municipalities are considered as highly preferred destinations of transboundary transhumant herders from Niger, Burkina-Faso and Nigeria (DE-Bénin, 2010). Likewise, transhumance is dominantly practiced by local herders in the two areas (Alkoiret *et al.*, 2009; Houessou *et al.*, 2019). The GSZ zone is characterized by a climate in transition between the bimodal sub-equatorial climate and the unimodal tropical climate. The annual rainfall ranges from 1100 to 1300 mm. The natural vegetation consists of a patchwork of gallery forest, dense semi-deciduous and open forest, moist wooded savannas and shrubby and saxicolous vegetation (Akoègninou *et al.*, 2006). The natural pastures are dominated by *Schizachyrium sanguineum* (Retz.) Alston, *Sorghastrum bipennatum* (Hack.) Pilg, *Andropogon schirensis* Hochst., *Andropogon chinensis* (Nees) Merr. and *Andropogon gayanus* Kunth (Sinsin and Kampmann, 2010).

The SZ zone is characterized by a sub-humid tropical climate and an average annual rainfall of 1050 mm distributed over a single rainy season from May to October. The vegetation is largely dominated by wooded savannas with *Monotes*

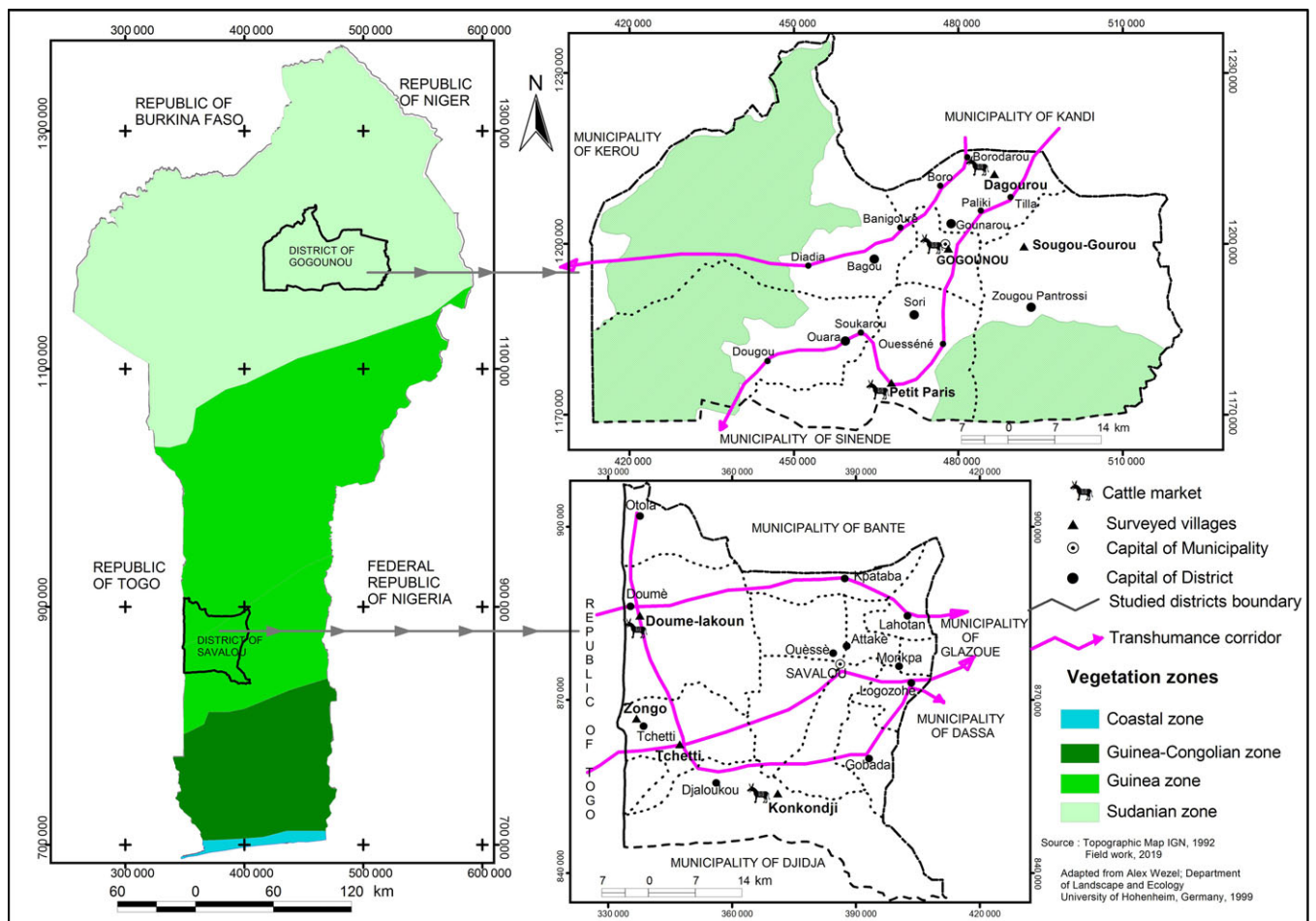


Figure 1 (colour online) Map of study locations showing the main cattle transhumance routes and markets.

kerstingii Gilg, shrubby savannas with *Burkea africana* Hook. and *Combretum spp.*, and grassy savannas with *Vetiveria nigritana* (Benth.) Stapf, *Oryza longistaminata* A. Chev. & Roehr., *Loudetia simplex* (Nees) C. E. Hubb., *Elymandra androphila* (Stapf) Stapf and *Loxodera ledermannii* (Pilg.) Clayton (Sinsin and Kampmann, 2010).

Data collection

Using a stratified simple random sampling approach, eight villages were selected for the study (four in each of the two vegetation zones). The main criteria for village selection were the importance of cattle farming as local livelihood activity and the presence of a transhumance corridor. A village located less than 25 km from a transhumance corridor was considered close to the latter. Due to lack of data on cattle farm households in surveyed municipalities, no random selection could be accomplished. Hence, selection of livestock owners for interviews was based on the list of cattle camps obtained from the livestock extension services and from other key resource persons during focus-group discussions. 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 determine the adequate time for

conducting interviews. A convenience sampling based on herd size (at least 10 heads) was used to select resident herders (herders who reside in the municipality for at least 5 years). Given the difficulties in arranging a reliable interview program with cross-border transhumant herders, most of them were interviewed without prior appointment. A total of 142 cattle keepers including 104 resident herders and 38 cross-border transhumant herders (Table 1) participated in questionnaire-based face-to-face interviews that were conducted from September to November 2016 and from April to May 2017. The questionnaire covered the socio-economic characteristics of the respondent (socio-cultural origin, age and education), his/her cattle herd characteristics (size, age and sex structure, breeds) and management practices (herding, feeding and health care), the nature and intensity of relationships he/she has established with resident herders or with cross-border transhumant herders. Bukari *et al.* (2018) broadly distinguished three types of cooperative relationships as follows: social relations or interpersonal relations such as friendships; trade relationships characterized by mutual economic benefits in which both groups of actors barter, sell and buy from each other and resource-oriented relations in which both groups cooperate in the use of pastoral resources, namely water points and pastures. In this

Table 1 Distribution of sampled cattle keepers per vegetation zone

Vegetation zone (VZ)	Municipality	Villages	Village's position with respect to transhumance corridors ¹	Resident herders (n)	Cross-border transhumant herders (n)
Guineo-Sudanian (GSZ)	Savalou	Doumè-lakou	Close	13	17
		Tchetti	Close	13	
		Konkondji	Far	13	
		Zongo	Far	13	
		Gogounou	Close	13	
Sudanian (SZ)	Gogounou	Petit Paris	Close	13	21
		Dagourou	Far	13	
		Sougou-gourou	Far	13	
Total				104	38

¹Distances less than or equal to 25 km were considered close to transhumance corridors as perceived by local populations in both locations.

study, we built on this typology to predefine two categories of relationships as follows: (i) resource-oriented relationships which include encampment/manuring contracts as well as sharing pastures and water resources and (ii) economic relationships, further subdivided into cattle purchase relationships, cattle sale relationships, and cattle purchase and barter relationships.

Data processing and analysis

To determine the effects of cross-border transhumance on local livestock husbandry practices, the non-parametric Mann–Whitney *U* test and the χ^2 test of independence were used to compare – within and between vegetation zones – herd size, feeding, breeding and health management practices between resident herders living in villages close to transhumance corridors and those far away.

The relative proportions (frequencies of occurrence) of each identified type of relationship between resident herders and cross-border transhumant herders were calculated. The Mann–Whitney *U* test was used to compare these proportions between villages close to and far from transhumance corridors within and between vegetation zones. Furthermore, herd characteristics and husbandry practices were compared between resident herders with and without a relationship with transhumant herders, respectively.

All statistical analyses were performed using SPSS software version 22.0 (IBM Corp., Armonk, NY, USA) and differences between groups were considered significant at 5% level.

Results

Herd characteristics and husbandry practices among resident herders

Irrespective of the vegetation zone and a farm's closeness to a transhumance corridor, the majority of surveyed resident cattle herds were kept and supervised by skilled *FulBe* (Peulh) herders (71.2%). With no significant differences between the two surveyed locations, *FulBe* herders represented 63.5% and 78.8% of interviewed herders in GSZ

and SZ, respectively. In contrast, the indigenous populations were poorly represented with 25.0% of *Yoruba* and 11.5% of *Fon* surveyed in GSZ and 21.2% of *Bariba* surveyed in SZ.

The average herd size (46.8 ± 24.88) was significantly ($P < 0.01$) larger in SZ than in GSZ (Table 2). Moreover, it was significantly ($P < 0.01$) related to the proximity of a transhumance corridor in the latter vegetation zone, whereby resident herders in villages close to transhumance corridors had larger herds than those located farther away. Five main cattle types were found in the resident herds. The West African Shorthorn (**WAS**) taurine cattle type locally called *Bobodji* represented 21.5% of animals in GSZ herds, while 90% of the respondents identified this breed as the most widely encountered cattle type in this zone more than 20 years ago. The *Borgou* type, a crossbreed between WAS taurine and zebu represented 87.4% of the animals present in SZ herds and was considered by respondents as the local and predominant cattle type in SZ. Other breeds encountered in the herds included Sahelian zebu breeds (*Goudali*, *M'bororo* and *White Fulani*) and their crosses with *Borgou* or other unnamed crossbreeds. Herds in GSZ had a significantly ($P < 0.01$) higher proportion of undescribed crossbreeds than those in SZ. However, irrespective of vegetation zone, this proportion was not affected by the distance to a transhumance corridor.

There was a significant ($P < 0.05$) relationship between the location of the farm with respect to a transhumance corridor and the resident herders' adoption of improved cattle husbandry practices, whereby a higher proportion of resident herders located close to a transhumance corridor provided feed supplementation ($P < 0.05$) and modern preventive health care ($P < 0.001$) to their animals than those located farther away (Table 2). Furthermore, the proportion of resident herders supplementing their animals was significantly ($P < 0.001$) higher in SZ than in GSZ.

Effects of host-client relationships

A range of relationships with cross-border transhumant herders were reported by the resident herders (61.5% in GSZ and 55.7% in SZ). Irrespective of vegetation zone, 68.9% of the

Table 2 Resident cattle herds' composition and management practices as affected by their proximity to transhumance corridors in the Guinea-Sudanian zone (GSZ; Savalou) and Sudanian zone (SZ; Gogounou) in Benin

Parameter	GSZ (Savalou)			SZ (Gogounou)			Overall (n = 104)
	Distance to corridors ¹			Distance to corridors ¹			
	Close (n = 26)	Far (n = 26)	Total (n = 52)	Close (n = 26)	Far (n = 26)	Total (n = 52)	
Herd size (n; mean ± SD)	57.6 ^a ± 27.18	36.7 ^b ± 20.78	47.1 ^B ± 6.17	60.1 ± 22.43	49.1 ± 28.49	54.6 ^A ± 25.9	50.9 ± 26.22
Proportion of West African shorthorn (WAS) taurine cattle type in the herds (%; means ± SD)	14.9 ± 3.37	28.5 ± 6.77	21.5 ± 3.82	0.0 ± 0.00	0.0 ± 0.00	0.0 ± 0.00	10.7 ± 2.16
Proportion of Borgou (crossbreed WAS x Zebu) cattle in the herds (%; means ± SD)	0.0 ± 0.00	0.0 ± 0.00	0.0 ± 0.00	85.6 ± 3.90	89.2 ± 3.04	87.4 ± 2.46	44.1 ± 4.50
Proportion of <i>Goudali</i> in the herds (%)	5.3 ± 1.95	3.0 ± 1.36	4.2 ± 1.19	0.0 ± 0.00	0.0 ± 0.00	0.0 ± 0.00	2.1 ± 0.62
Proportion of <i>M'bororo</i> in the herds (%)	0.0 ± 0.00	0.0 ± 0.00	0.0 ± 0.00	5.2 ± 2.32	6.8 ± 2.41	6.0 ± 1.66	3.0 ± 0.88
Proportion of undescriptive crossbreed and White Fulani cattle in the herds (%; mean ± SD)	79.9 ± 4.00	65.7 ± 7.24	72.8 ^A ± 4.21	9.2 ± 2.31	4.0 ± 1.90	6.6 ^B ± 1.53	39.7 ± 3.95
Practice of transhumance (% yes)	26.9	19.2	23.1 ^B	46.1	30.8	38.5 ^A	30.8
Feed supplementation (% yes)	53.8 ^a	26.9 ^b	40.4 ^B	73.1 ^a	61.5 ^b	67.3 ^A	53.8
Disease prevention measures (% yes)	76.9 ^a	42.3 ^b	59.6	80.7 ^a	38.5 ^b	59.6	59.6

¹Distances less than or equal to 25 km were considered close to livestock corridors.

^{a,b,cA,B,C}Different small and capital letters within a row denote significant differences within and between municipalities, respectively ($P \leq 0.05$). Where no small and capital letters appear, the respective differences are not significant, non-parametric Mann-Whitney *U* test.

Table 3 Types of non-conflicting relationships between cross-border transhumant and resident cattle herders as affected by their proximity to transhumance corridors in the Guinea-Sudanian zone (GSZ; Savalou) and Sudanian zone (SZ; Gogounou) in Benin. Values denote share (%) of respondents¹

Type of relationship	GSZ (Savalou)			SZ (Gogounou)			Overall (n = 104)
	Distance to corridors [#]			Distance to corridors [#]			
	Close (n = 26)	Far (n = 26)	Total (n = 52)	Close (n = 26)	Far (n = 26)	Total (n = 52)	
Resource-oriented							
Encampment/manuring contracts, facilitation of access to pastures and water points	30.8 ^a	11.5 ^b	21.2	38.7 ^a	11.5 ^b	25.0	22.1
Economic							
Cattle purchase	42.3	30.7	36.5 ^A	26.9	15.4	21.2 ^B	28.8
Cattle sale	19.2 ^a	7.6 ^b	13.5 ^A	11.5 ^a	3.8 ^b	7.7 ^B	10.6
Cattle purchase and barter	7.7	0.0	3.8 ^B	23.1	0.0	11.5 ^A	7.6

¹Only residents.

²Distances less than or equal to 25 km were considered close to livestock corridors.

^{a,b,cA,B,C}Different small and capital letters within a row denote, respectively, significant differences within and between vegetation zones ($P \leq 0.05$). Where no small and capital letters appear, the respective differences are not significant, non-parametric Mann-Whitney *U* test.

resident herders having a relationship with cross-border transhumant herders were from the *FulBe* socio-cultural group.

The majority (85%) of the resident herders mentioned that their relationships with cross-border transhumant herders were lineage-based and spontaneous (social and interpersonal relationships). These relationships were further based on a variety of common interests which included resource-oriented relationships such as encampment/manuring contracts and access to grazing lands and watering points, as well as trade relationships such as the exploration of livestock markets and

bartering opportunities. However, irrespective of vegetation zone, and with the exception of cattle purchase relationships (acquisition of a new breed or an animal perceived as of high reproductive and/or productive qualities), the likelihood of a resident herder to develop a relationship with a transhumant herder was positively and significantly ($P < 0.001$) associated with his/her proximity to a transhumance corridor (Table 3). The occurrence of relationships of cattle sale and cattle purchase as well as those of cattle purchase combined with bull barter differed significantly ($P < 0.001$) between the two vegetation zones. In the relationships of purchase combined with

barter, a transhumant herder commonly exchanged a zebu bull against three *Borgou* bulls in SZ. In GSZ, a zebu *Goudali* bull was exchanged for two heads of WAS taurine cattle and for either food or money. The animal purchase and barter relationships, in contrast to the two previous relationships, were more frequent in SZ than in GSZ. The average number of cattle purchased from cross-border transhumant herders per resident herder and season was 3.5 ± 1.85 and 2.0 ± 0.71 heads in GSZ and SZ, respectively. Likewise, the average number of animals sold by transhumant herders was 3.0 ± 1.00 heads and 2.0 ± 0.82 heads in GSZ and SZ, respectively. In addition to those relationships, conflicts between cross-border transhumant and resident herders were reported with no significant difference concerning the distance to transhumance corridors and vegetation zone (43.8% in GSZ and 29.7% in SZ).

Irrespective of vegetation zone, the breed composition of the resident herds varied significantly ($P < 0.01$) depending on whether or not the farmers had developed relationships with transhumant herders. The presence of Sahelian cattle breeds was more frequently observed in herds whose owners had developed relationships with transhumant herders.

Discussion

Limitations of the study

The study investigates how cross-border transhumance influences resident herders' cattle husbandry practices and use of genetic resources along transhumance corridors. Its major limitation is the use of 'proximity of a village to livestock corridor' as a main explanatory variable. An arguable weakness is the arbitrariness, although based on the perceptions of the resident herders, in the definition of this variable. Although it is well established that transhumance corridors consist of well-defined resting points (Turner *et al.*, 2016), the development of relationships between resident and transhumant herders may be influenced by the length of stay of transhumant herds at a resting point, which is determined by many factors including the existing local institutions regulating the presence of transhumant herds, the availability of grazing resources and watering points (Brottem *et al.*, 2014; Kitchell *et al.*, 2014). The aforementioned factors might also differ between locations, which may limit the generalizability of the findings.

Despite these limitations, the study contributes to a better understanding of the non-conflicting relationships that exist between cross-border transhumant and resident herders and of the implications of these relationships for cattle husbandry practices and use of genetic resources in resident herds.

Cross-border transhumant herders' migration into agro-pastoral areas

The larger cattle herd sizes in SZ than in GSZ are in accordance with the distribution of the cattle population across the country's different vegetation zones (DE-Bénin, 2010). Gogounou in SZ is known for its efficient organization of cattle marketing as it hosts one of the largest cattle markets in

the West African region. Nevertheless, the considerable herd size (average 47 heads) recorded in GSZ reveals an expansion of cattle husbandry in this zone where many transhumant *FulBe* herders from Niger, Nigeria and Burkina Faso have migrated to and settled in relatively recent times (Azalou *et al.*, 2017). This settlement of formerly transhumant herders explains the recorded predominance of *FulBe* people among the surveyed resident herders in this vegetation zone previously known to be dominated by local ethnic groups, namely the *Fon* and *Yoruba*. Similar patterns of migration and settlement of *FulBe* herders have also been reported for the municipality of Tchaourou, another destination point of foreign transhumant herders in the same zone (Orékan, 2007). According to the latter report, the first migrants settled close to villages whereas recent settlements occur more along larger transregional roads. In consequence, and also with respect to the current increase of urbanization and human pressure in pastoral zones (Holechek *et al.*, 2017), it seems plausible that many resident herders located close to transhumance corridors are the most recent settlers.

The relatively high presence of zebu cattle breeds (*White Fulani*, *Goudali* and *M'bororo*) and their crosses with *Borgou* cattle in the surveyed sedentary agro-pastoral herds is consistent with previous findings by Azalou *et al.* (2017). They also conform to reports from Ivory Coast (Bassett and Turner, 2007) that Sahelian herders who settle in a new region adjust the genetic composition of their zebu-dominated herds by crossbreeding their animals sensitive to trypanosomiasis, an insect-borne parasitic and endemic disease, with trypanotolerant taurine breeds as an adaptive strategy to the new environment.

Unfortunately, poorly planned breed replacement and indiscriminate crossbreeding result in the erosion of local genetic resources and increase the risk of losing valuable traits such as adaptability to marginal environments and tolerance of or resistance to certain diseases (Jabbar and Diedhiou, 2003; Tisdell, 2003). The settling down of former cross-border transhumant herders has therefore a detrimental effect on the sustainable use of local cattle genetic resources which merits a more detailed investigation.

Relationships between resident and cross-border transhumant herders

First settlements constitute springboards for later and recent movements of herds across the country, since the presence of *FulBe* families in a host community facilitates the access and integration of new herders (Bassett and Turner, 2007). This may explain why most of the relationships developed by cross-border transhumant herders with resident *FulBe* were spontaneous. Schöneegg *et al.* (2006) reported that the already settled *FulBe* herders often serve as intermediaries between transhumant herders and local communities (farmers, village leaders, etc.) in agro-pastoral areas. These relationships are particularly important for transhumant herders with no or only little experience in cross-border transhumance whose first series of movements are exploratory and serve to adjust their spatial knowledge, social contacts

and also the composition of their herd (Bassett and Turner, 2007). For resident herders, the exchange of cattle breeds with transhumant herders represents an opportunity to improve the productivity of their (taurine) herds through the acquisition of new genotypes with larger frame and thus higher milk and meat production potential. This might explain the high presence of Sahelian cattle breeds and cross-breed animals in herds of resident herders that established a relationship with transhumant herders. The increasing tendency of resident herders to upgrade their local breeds with zebu cattle, acquired through bartering with transhumant herders, is in accordance with previous observations in Northern Benin (Quarles Van Ufford, 1999) as well as in other regions of West Africa, for instance, in Southwest Nigeria (Jabbar and Diedhiou, 2003). Nevertheless, the acquisition of new genotypes is not always sustainable and profitable for resident herders. Leroy *et al.* (2016) and Roschinsky *et al.* (2015) provided evidence that the low genetic adaptation of foreign breeds and crossbreeds to the local environment does not improve smallholder resident herders' income as they increase labor requirements, production costs, risk of disease outbreak and early depletion of pasture. It is therefore important to create awareness among resident herders and help them identify and raise those (appropriate and adapted) genotypes that fit their socio-economic conditions and cope with environmental challenges (Mirkena *et al.*, 2010).

The encampment/manuring contracts established between transhumant herders and resident herders are coherent with the pecuniary and manuring contracts between transhumant herders and farmers reported from northern Benin (Djohy *et al.*, 2013). Similar encampment contracts have been described in the Sahel (Mali and Niger) by Turner *et al.* (2014). According to these authors, transhumant herders tend to set up their camps near villages where both natural vegetation and crop residues are abundant. These observations explain the relatively higher proportion of crossbreed animals in herds close to transhumance corridors. We thus conclude that short-term passage as well as longer-term stay of cross-boundary herders in the northern part of Benin affect to a considerable extent the breed composition of resident herders' cattle herds.

Impact of cross-border transhumance on herd management practices in hosting areas

Although cattle feeding is mainly based on natural grazing, feed supplementation was provided by 54% of the surveyed resident herders, mainly those located close to transhumance corridors. Feed supplementation by resident herders is an adaptive strategy to feed shortage, given the continuous shrinkage of grazing lands (Zampaligré *et al.*, 2013). Hence, the more frequent practice of feed supplementation by resident herders located close to transhumance corridors suggests that these herders experience more feed shortage, probably due to higher competition for grazing land with cross-border transhumant herders along the transhumance routes. These findings corroborate the already mentioned increasing competition for and the pressure on pasture land


due to transhumance (Schöneegg *et al.*, 2006; Convers *et al.*, 2007; Brottem *et al.*, 2014).

Furthermore, the more frequent use of prophylactic measures against diseases in resident herds close to transhumance corridors in both vegetation zones suggests that disease outbreaks are more common in these areas than in areas located far from transhumance corridors. Indeed, exposure of resident herds to infectious diseases conveyed by cross-border movements of foreign herds has been described by several authors (Abiola *et al.*, 2005; Dean *et al.*, 2013; Apolloni *et al.*, 2018). Dean *et al.* (2013) provided evidence of anthrax outbreaks along transhumance routes from the Sahel to Togo. Further, cross-border transhumance, by facilitating rapid spread of pathogens and diseases, can cause significant economic losses for livestock producers at national and regional levels (Abiola *et al.*, 2005). These observations point to inefficient epidemiological surveillance by veterinary services at the borders of countries hosting transhumant herders (Couacy-Hymann *et al.*, 2006). Improvement of the existing regional management policies of cross-border transhumance in West Africa and effective collaboration between countries could promote the establishment of sustainable management strategies that reinforce animal health and nutrition and sensitize and support pastoralists to avoid indiscriminate and poorly planned crossbreeding.

Our case study confirms that cross-border transhumant herders develop a variety of non-conflicting relationships with resident herders along their transhumant routes. These relationships are facilitated by earlier settlements of some transhumant herders in the hosting pastoral areas. As part of these relationships, transhumant herders often exchange cattle breeds with resident herders, thus contributing to the increasing practice of crossbreeding in local herds. Our results also suggest that the increasing adaptation of feed supplementation and prophylactic measures against contagious animal diseases by resident herders near transhumance corridors are responses to increasing competition for forage resources and a high risk of disease transmission. These findings are relevant for the establishment of policies governing cross-border cattle transhumance and management strategies for local cattle genetic resources in hosting communities along the transhumance routes.

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Declaration of interest

The authors declare that they have no conflict of interest.

Ethics statement

None.

Software and data repository resources

None of the data were deposited in an official repository.

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