Livestock Science 210 (2018) 129–136

Contents lists available at ScienceDirect

Livestock Science

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

Understanding roles and functions of cattle breeds for pastoralists in Benin

Charles Tamou*, Imke J.M. de Boer, Raimon Ripoll-Bosch, Simon J. Oosting

Animal Production Systems group, Wageningen University and Research, P.O Box 338, 6700 AH Wageningen, The Netherlands

ARTICLE INFO

Keywords:
Pastoralists
Traditional knowledge
Indigenous breeds
Cattle traits
AnGR

ABSTRACT

Animal genetic resources (AnGR) are essential for food security and the livelihoods of many pastoralists. However, the AnGR diversity is currently being eroded, as well as the traditional ecological knowledge associated to the use of indigenous breeds and their environment. The objectives of this study were to: i) inventorise indigenous breeds of cattle and their performance in selected traits, ii) analyse pastoralists' preferences for specific breeds and reasons for that, and iii) determine whether the knowledge about breeds and their traits was transmitted across generations and was consistent across agro-ecological zones. Data were collected through focus groups discussions, and individual interviews with 72 pastoralists. Interviewees belonged to three generations and three agro-ecological zones in the periphery of the W Biosphere Reserve in Benin. From the focus groups discussions we identified the most common breeds in the region (i.e. *Keteeji*, *Jaliji*, *Bodeji*, *Tchiwali* and *Gudali*) and the most relevant traits (i.e. milk production, meat production, endurance and tolerance to trypanosomiasis) to assess cattle breeds according to pastoralists. Individual interviewees scored the performance of cattle breeds in the four main traits based on a three-point scale. Finally, we determined the consistency of pastoralists' knowledge across generations and agro-ecological zones. *Keteeji* was valued for its endurance and tolerance to trypanosomiasis, *Bodeeji* was highly valued for endurance and *Gudali* was perceived of high value for meat and milk production, but of low value for endurance. *Keteeji* was the preferred breed by the majority of the pastoralists (nearly 50%), especially for the adaptive trait withstanding hunger. *Gudali* was the least preferred breed (11%). 80% of pastoralists selected a preferred cattle breed based on adaptive traits, i.e. withstanding hunger, intelligence (beyond obedience to herder) or withstanding disease. Pastoralists' knowledge about breed traits did not differ among generations, but some differences appeared among agro-ecological zones. This study suggests that pastoralists prefer adaptive traits of breeds over production traits to deal with the changing and unfavourable conditions of their environment.

1. Introduction

Animal genetic resources (AnGR) are an essential part of the biological basis for world food security, and contribute to the livelihoods of over a billion people (FAO, 2007; Leroy et al., 2016). AnGR provide insurance against current and future challenges, such as emerging diseases, changes in market demands (Meat consumption, 2015) and changing environmental conditions, including climate change (Hoffmann, 2010; Nardone et al., 2010). AnGR also have an important social and cultural role, as they constitute an integral part of traditions in many societies (FAO, 2013). At present, however, AnGR are being eroded as a result of several factors, such as replacement of local breeds by exotic breeds, indiscriminate cross-breeding, changes in production systems (e.g. specialisation with emphasis on a single productive trait) or changes in socio-economic and environmental circumstances (Bruford et al., 2015; FAO, 2015). For instance, from the 8774 livestock breeds documented in 2014 around the world, 9% are extinct and 17% are classified as being at risk (FAO, 2015). Worldwide, cattle are the species with the highest number of breeds (184) reported extinct (FAO, 2015). Animal (and plant) genetic resources are the ultimate non-renewable resource; once gone, they are gone for good (Thornton et al., 2009). Therefore, there is a need to reduce the loss of AnGR and establish programmes for their conservation and sustainable use (FAO, 2007; Bruford et al., 2015; Mwai et al., 2015).

There are two main methods for the conservation of AnGR: *In vitro* conservation and in vivo conservation. *In vitro* conservation refers to the conservation of breeds in an artificial environment, in form of gametes or embryos, whereas in vivo conservation refers to conservation of breeds through the maintenance of life animal populations (FAO, 2013). In developing countries, FAO recommends in vivo, and in situ conservation of breeds through continued use in the production system in which they evolved, are found and bred (FAO, 2013). Moreover, in situ conservation generally implies less financial resources than in vitro conservation (FAO, 2007). *In situ* conservation in Africa builds on

* Corresponding author.
E-mail address: tamouc@gmail.com (C. Tamou).

https://doi.org/10.1016/j.livsci.2018.02.013
Received 29 June 2017; Received in revised form 23 February 2018; Accepted 24 February 2018

pastoralists, which are considered the creators and guardians of African livestock breeds, especially ruminants, such as cattle, sheep, goats and camels (FAO, 2009; Köhler-Rollefson et al., 2009). Across generations pastoralists have developed and transmitted traditional ecological knowledge (TEK), which is a body of knowledge, beliefs, traditions and practices about their indigenous breeds and the interaction with their surrounding environment (Gómez-Baggethun et al., 2013). Within their own production systems, especially where environmental conditions are harsh, indigenous breeds can perform better than exogenous breeds thanks to non-productive traits, such as resistance to trypanosomiasis or adaptation to heat (Köhler-Rollefson et al., 2009; Vordermeier et al., 2012; Kim et al., 2017).

In Sub-Saharan Africa, cattle play an important role for pastoralists and have different roles and functions (Moyo and Swanepoel, 2010). For instance, cattle functions can be economic (source of cash income or in-like payment, mean of savings accumulation and investment, economic status), for household use (food, transportation, fertilizer and animal draught), and sociocultural (social status, paying bride wealth, for communal feasts or sacrifices). Moreover, cattle are important for pastoralists' self-esteem and part of pastoralists' identity. Roles and functions of livestock breeds, however, vary between environments and in time. Livestock breed traits are anatomical, physiological and metabolic characteristics of livestock breeds that determine the roles and functions of the breeds. Breed traits, therefore, are important indicators for getting insight into livestock roles and functions. It is acknowledged that pastoral production is multifunctional and it has multiple objectives, regarding breed traits (Krätli, 2008; Moyo and Swanepoel, 2010). However, information about which traits are valued by pastoralists and how different pastoralists' breeds perform with regard to these traits is generally lacking, implying a poor characterisation of these pastoral breeds (FAO, 2015; Mwai et al., 2015).

At present, pastoralists' traditional culture and lifestyle is threatened, and consequently also their traditional way of herding (Thornton, 2010; Catley et al., 2013) and, eventually, their traditional knowledge. One key challenge for pastoralists is the loss and fragmentation of pastoral lands, watering points and livestock routes, due to increased competition for land by i.e. increased land use for cropping (Ayantunde et al., 2008; Tamou et al., 2017b). Such changes in grazing land are observed also in and around the W Biosphere Reserve in Benin (WBR) (Tamou et al., 2017b). The complex interaction between crop expansion, presence of WBR and the way it is governed, the lack of support to pastoralists, and the increasing shift of pastoralists' lifestyle into one of settled crop farmers is rising competing claims on land among users (i.e. pastoralists, crop farmers and WBR authorities) (Tamou et al., 2017b). The pressures on pastoral production systems can lead to changes in desired traits, which may lead to loss of diversity of indigenous breeds (Hoffmann, 2010). Gaining insight into pastoralists' perception of the indigenous breeds and the associated desired traits is of importance in order to prevent loss of livestock diversity, as well as to understand the roles and functions of the animals and of the overall production system (Van der Zijpp, 2011). So far, it is unknown which indigenous breeds and which traits pastoralists value around the WBR. The objectives of this study were to: i) make an inventory of indigenous breeds of cattle and their performance in selected traits, ii) analyse pastoralists' preferences for specific breeds and reasons, and ii) determine whether the knowledge about breeds and their traits was being transmitted across generations and was consistent across agro-ecological zones. By addressing the two latter objectives, this study is contributing to two aspects of traditional ecological knowledge: a) adaptive traits' preference of livestock breeds and the b) dynamics of knowledge among age categories and within indigenous communities. Gaining insights into these aspects is important for promoting sound and culturally based livestock production development and livestock breeds' conservation in developing countries.

2. Materials and methods

2.1. Study area

This study was carried out in the W Biosphere Reserve (WBR; former National Park of W), in North Benin. The WBR (11°26' to 12°26'N and 2°17' to 3°05'E) comprises about 56% of the W Transboundary Biosphere Reserve located in the countries of Benin, Niger and Burkina Faso, and covers about 5632 km^2. The vegetation of the WBR consists of tree, shrub and woodland savannah, gallery forest and wetland. This vegetation allows the presence of several wildlife species, such as elephants, lions, buffaloes, cheetahs, waterbucks, monkeys, and birds. The regional water supply comes from the Niger River and its tributaries: the Alibori, Mekrou and Sota watercourses. The climate of the WBR is characterised by two main seasons: a rainy season from mid-May to October, with an average minimum daily temperature of 12 °C, an average maximum daily temperature of 25 °C, and precipitation ranging from 700 to 1000 mm, and a dry season from November to mid-May, with an average minimum daily temperature of 30 °C, an average maximum daily temperature of 40 °C and hardly any precipitation (Billand et al., 2005). During the first part of the dry season, from November to February, a dry dusty wind blows through the North of Benin, also referred to as harmattan, which boosts the drying process of natural pasture. The harmattan facilitates burning of dried pasture, either from prescribed early fires used to reduce fuel accumulation or from late bush fires.

In Benin, five districts border the WBR, with a total of 759 300 inhabitants of which 23% are Fulbe (INSAE, 2016), and the main economic activities in these districts are crop farming and livestock production. The WBR and its surrounding land are located in the so-called agro-pastoral contact zone in West Africa (De Haan et al., 1990), indicating that land is suitable for crop farming and livestock farming, enabling competition for land (Tamou et al., 2017b). Crop farmers get their main income from production of cereals (maize, sorghum, millet, rice), roots and tubers (yam, cassava, potato and sweet potato), legumes (groundnut, beans, soybean and *bambara* bean), vegetables (tomato, pepper, okra, pumpkin) and cotton, and possess oxen for ploughing. They belong to the following ethnic groups: *Baatonu*, *Dendi*, *Monkole* and *Goumantche*. In contrast, pastoralists obtain their main income from livestock (living animals) and livestock products (milk), and belong to the *Fulbe* ethnic group. Fulbe pastoralists keep several species of livestock: cattle, goat and sheep, with cattle being the dominant specie. Though Fulbe pastoralists are practicing subsistence crop farming, their main income comes from livestock keeping (Tamou et al., 2017b). The Fulbe pastoralists are dwellers of the districts surrounding the WBR and are known to organise and supply livestock markets where crop farmers buy draught animals and butchers can buy animals to slaughter. Pastoralists from the area usually move their animals on short distance during the wet season and cover long distances southward during the dry season. The area is also frequently visited by pastoralists coming from the bordering countries Burkina Faso, Niger and Nigeria, during the dry season (Convers et al., 2007). Usually, most of these pastoralists go back to their home countries at the beginning of the wet season.

Fulbe are very connected to their grazing lands (through their animals) and they considered TEK about herding as essential (Tamou et al., 2017a). In pastoral production system, TEK is produced and learnt by doing, i.e. by being involved in moving and herding livestock (Gaoue and Ticktin, 2009; Tamou et al., 2017a). At birth, a pastoralist child is endowed with an animal. When growing up, under the authority of the chief of household, the child starts doing small scale herding activities such as tethering and herding calves not far away from the homestead. Gradually, the young pastoralist will accompany senior pastoralists (usually a family member, such as father or older brother) in herding longer distances, up to transhumance. At that stage, learning occur through contacts with other herdsmen, other herds and other landscapes. Since animals are considered God's gifts, young pastoralist

should acquire knowledge and skills in herding to properly take care of animals (Tamou et al., 2017a).

The research was conducted in the periphery of the WBR, comprising three agro-ecological zones: the Sahelo-Sudanian zone in the north, the Sudanian zone in the south and an intermediate zone in between the north and south regions. Average rainfall ranged from 700 mm/year in the north to 1000 mm/year in the south. Selection of the three agro-ecological zones was done to cover possible variation of pastoralists' knowledge about indigenous cattle breeds and their traits. One village and two adjacent hamlets were selected in each agro-ecological zone. Selection of villages was done according to following criteria: i) being representative of the zone (in terms of climatic conditions and land uses), ii) being close to the edge of the WBR Park, and iii) representing ethnic diversity in the area (i.e. co-existence of *Fulbe* community and other ethnic groups). The first author was introduced to *Fulbe* pastoralists' leaders by employees of the livestock service (of the Ministry of Agriculture) in each of the villages and hamlets. Research objectives and methodologies were discussed with these pastoralists' leaders and their permission to conduct the study was obtained.

2.2. Data collection

Data were collected between November 2014 and April 2015. Information was derived from three sources: rapid appraisals, focus group discussions (FGD), and individual interviews (Fig. 1).

2.2.1. Rapid appraisals

Informal interviews about indigenous cattle breeds kept by *Fulbe* pastoralists were held with five employees of the veterinary services working in the periphery of the WBR. The first author also collected information from rapid appraisals (Chambers, 1994) during field visits to the nine communities selected for data collection. On the basis of these rapid appraisals, the first author prepared input for the FGDs.

2.2.2. Focus group discussions

FGDs were held in each of the nine selected communities. The number of participants ranged from 15 to 20 people per FGD. Participants were all men, and most of the time elders, who were members of the village and hamlet council. Participants were all men because herding is an activity exclusively done by men in Fulbe communities (Tamou et al., 2017a). The objective of the FGDs were: to introduce the study, to engage pastoralists' participation in the study design, and to have a FGD (McLafferty, 2004) about the cattle breeds used in herding and the traits they considered relevant. In addition, the FGDs were used to develop a semi-structured questionnaire for the individual interviews and to select relevant age classes to study the generation effect on traditional knowledge of cattle breeds and their traits. The first author facilitated the discussions in French and was translated into the local language (i.e. *Fulfulde*) by a trained interpreter. The FGDs lasted from 1 to 1.5 h and were audio-recorded. The analysis of the FGDs (methodology described in section Data analysis) enabled the selection of the dimensions (described hereunder) and items within dimensions to be further discussed in the individual interviews. Selected dimensions and items were discussed and selected together with pastoralists' representatives.

a) *Relevant age classes for assessing traditional knowledge about herding.* During FGDs, pastoralists agreed that three generations were of relevance (between brackets their *Fulfulde* name) to study the traditional knowledge of pastoralists in herding: the young (*Alwasibey)* generation (18–30 years old), the mid (*Dotibey*) generation (40–60 years old) and the old (*Nahebey*) generation (> 60 years old).
b) *Dimensions and items for the individual interviews*

b1) Inventory of cattle breeds. The participants of the FGDs were asked to make a list of cattle breeds found in their area. We used the names given by pastoralists to the indigenous breeds in their own *Fulfulde* language.
b2) Inventory of traits of cattle breeds. Participants of the FGDs were asked to make a list of relevant traits of cattle breeds. Then, participants were asked to discuss and reach an agreement about the four most relevant traits.
b3) Preference for cattle breed and traits, and herd composition. Participants were asked to list their preferred cattle breeds and the reasons for this preference, as well as their preferred herd type (single breed or multiple breeds) and the reasons for this.

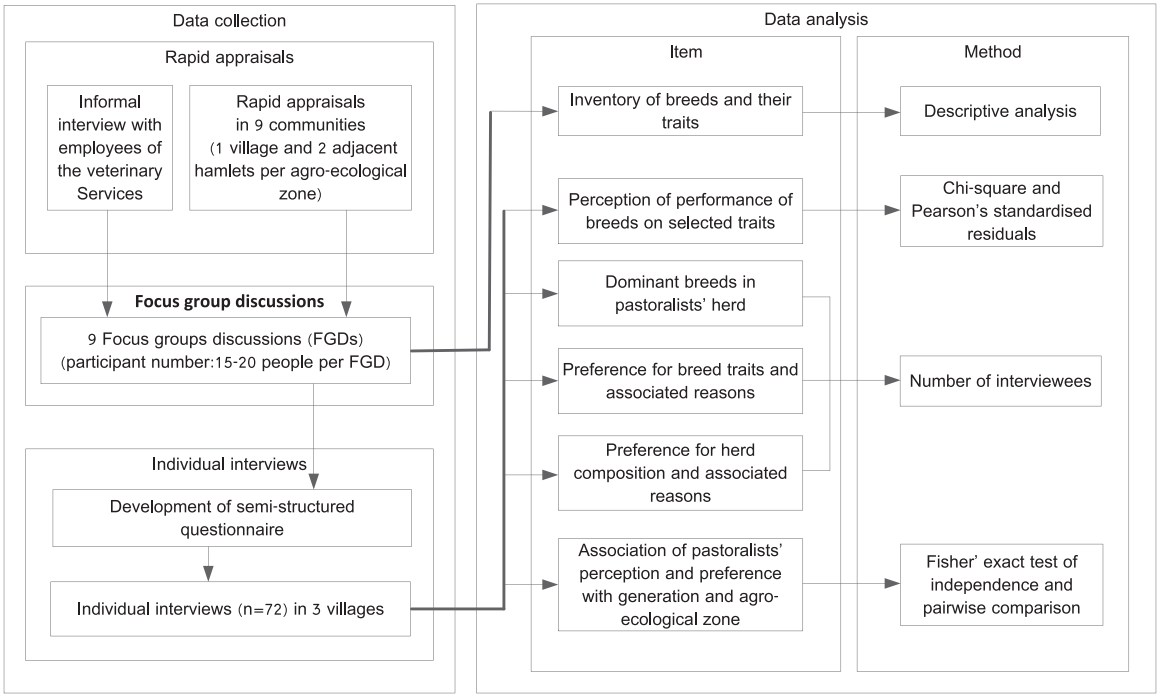

Fig. 1. Framework of data collection and analysis (adapted from Oteros Rozas et al. (2013)).

Table 1
Characteristics of the breeds present in the study area.
Source: (FAO, 2016; Kubkomawa, 2017) and field observations during present study

Characteristics	Indigenous breeds				
	Keteeji	*Jaliji*	*Bodeeji*	*Tchiwali*	*Gudali*
Type of horn	Shorthorn	Shorthorn	Longhorn	Longhorn	Almost hornless
Average weight (male-female, kg)	260–226	300–300	425–275	500–323	525–325
Average daily milk (L)	2.5	2.0	5.5	5.5	7.5
Breed group	Taurine	Zebu	Zebu	Zebu	Zebu
Coat colour	Not specific	Not specific	Red	White	Not specific
Country of dominance (West Africa)	Benin, Nigeria,	Niger, Burkina Faso	Niger, Nigeria	Niger, Nigeria	Niger, Nigeria
Synonym	*Borgu*, *Keteku*	*Jali*, *Jelli*	*M'Bororo*, *Red Fulani*	*White Fulani*, *Daneji*	*Sokoto*, *Godali*

2.2.3. Individual interviews

Based on the outcomes of the FGDs, we developed a semi-structured questionnaire with four sections. The first section addressed the profile of the interviewee (e.g. age or experience in herding) and the dominant cattle breed in the herd owned. A breed was considered dominant in a herd when more than 75% of the herd was composed of this breed. In the second section, interviewees were asked to assess the five most important cattle breeds. Cattle breeds were assessed based on the performance of four most relevant traits using a three-point scale (*low, medium or high)*. In the third section, interviewees were asked to choose their preferred cattle breed and the reasons for this preference, as well their preferred composition of herd (i.e. single breed or multiple breeds herd) and the associated reasons.

Individual interviews were conducted face to face. In total, 72 interviews were conducted, being 24 interviewees (eight per age class) from each agro-ecological zone. The approach to potential individual interviewees started with participants of the FGDs, and followed by using the snowball technique, i.e. each participant suggested two or three new potential participants. The inclusion criterion for the interview was to have experience in herding and hence, be knowledgeable about cattle breeds. Interviewees participated on a voluntary basis and the interview took place in the interviewee's household. Individual interviews lasted between 45 min and one hour. The first author asked the questions in French and the questions were then translated into the local language by a trained interpreter.

2.3. Data analysis

Data analysis consisted of a descriptive analysis of information obtained from FGDs and a statistical analysis of data obtained from the individual interviews (Fig. 1).

2.3.1. Focus group discussions

The FGDs were analysed following content analysis (Stewart and Shamdasani, 2014). The first author summarised the discussions and categorised general patterns (Pope and Mays, 1995) into dimensions and items within dimensions (Elo and Kyngäs, 2008). A mixed inductive and deductive approach (Bernués et al., 2016) was followed to select the dimensions (i.e. cattle breeds, traits and preferences) and items within dimensions (i.e. the particular breeds, traits and reasoning) to be further discussed in the individual interviews.

2.3.2. Analysis of data of individual interviews

We combined Chi-square test and Pearson's standardised residuals to analyse pastoralists' perception of their breeds. Within each trait, we first used the chi-square test to check for significant association between breed (*Keteeji, Jaliji, Bodeeji, Tchiwali and Gudali*) and performance class (high, medium or low) using the number of interviewees. We then calculated Pearson's standardised residual, which is the deviation of the observed number of interviewees for a given score from its expected value (Agresti, 2007). The Pearson's standardised residual was calculated as followed.

$$Residual = (O - E)/\sqrt{E}$$

Where O is the observed number of interviewees, and E is the expected number of interviewees (Agresti, 2007). Pearson's residuals of more than $+3$ and lower than -3 were considered significant (Agresti, 2007), i.e. indicating that there was a high level of agreement among pastoralists.

We used the 72 individual interviews to determine the dominant cattle breeds in the region; the performance of these breeds; the preference and reasoning for a particular breed; and the preferred herd composition (breed dominated or breed mixed herd) and the associated reasons.

We used Fisher's exact test (because of the small sample size) and a post-hoc analysis based on pairwise comparison (Mangiafico, 2016) to test for association between generation and agro-ecological zone with regard to i) preference for cattle breeds, ii) perception of cattle breeds' performance on selected traits, and iii) preference for herd composition.

All statistical analyses were done in R 3.3.2 (R Core Team, 2015).

3. Results

3.1. Inventory of breeds and their traits

Participants of the FGDs mentioned the following cattle breeds to be present in the study area: *Gudali*, *Keteeji*, *Jaliji, Bodeji*, *Tchiwali*, and *Ajawaji*. The *Ajawaji* breed was excluded because pastoralists reported that was scant in their herds. They knew it was well established in Niger republic. Table 1 presents characteristics of selected cattle breeds.

Keteeji is a *Bos taurus* (humpless), whereas the other breeds belong to the *Bos indicus* (zebu, humped) (Felius et al., 2011). *Keteeji* belongs to the group of recently derived breeds, which is now a stabilized crossbred, between a humpless shorthorn with zebu (Felius et al., 2014; Kubkomawa, 2017). Among these breeds, *Gudali* was the (almost) hornless one.

In Table 2, we present the average herd size of livestock across generations and agro-ecological zones of the study area. Cattle herd size matters more to pastoralists than that of sheep and goat, which may be due to the social importance of cattle for Fulbe pastoralists of the study area.

Table 2
Average herd size of cattle, sheep and goat across agro-ecological zones and generations (mean, and standard deviation into brackets).

Herd size	Agro-ecological zones			Generations		
	South	Mid	North	Young	Mid	Old
Cattle (no.)	51(45.0)	64(47.5)	42(26.2)	49(38.9)	49(44.3)	56(41.1)
Sheep (no.)	15(13.7)	19(18.4)	20(19.9)	15(16.2)	20(16.4)	19(19.7)
Goat (no.)	21(25.2)	17(15.5)	25(15.9)	16(14.0)	18(11.3)	30(26.9)

Participants of the FGDs mentioned the following traits to be of importance when valuing a cattle breed: milk production, meat production, withstanding long walk, tolerance to trypanosomiasis, withstanding hunger (capacity to survive with feed shortage), withstanding thirst, intelligence of the breed, obedience to herder, short calving interval, and beauty of the coat (aesthetic trait). From this list, FDGs selected the following traits as being the most relevant for a cattle breed: milk production (hereafter referred to as milk), meat production (hereafter referred to as meat), withstanding long walk (hereafter referred to as endurance) and tolerance to trypanosomiasis (hereafter referred to as trypanotolerance). FGDs mentioned that milk and meat are the main sources of protein and income in their household. Hence, these traits were considered of utmost importance when assessing cattle breeds. Endurance was also considered of importance, because grazing areas are far away from pastoralists' villages and livestock have to walk long distances in search for forages. Trypanotolerance was also considered important because good forages are generally found in humid areas where the tsetse fly is found. Therefore, livestock tolerant to trypanosomiasis is an asset to overcome possible contagion of the herd. Although pastoralists treat their animals against this disease, they do not usually follow the procedure recommended by the veterinary services (informal interview with one of the head of the veterinary services). Acute trypanosomiasis disease is characterised by decreased productivity, weight loss, abortion and possibly death (Yaro et al., 2016). Other symptoms that have been reported for African animal trypanosomiasis include infertility, sleeping disorders, emaciation, pica, splenomegaly, paralysis, neuroendocrine dysfunctions and coma (Steverding, 2008).

3.2. Performance of breeds on selected traits

Table 3 presents the performance of each cattle breed in four traits as perceived by pastoralists. Pastoralists perceived *Keteeji* of low value for milk, of medium value for meat, and of high value for trypanotolerance. *Jaliji* was of medium value for meat and for endurance. Pastoralists had scattered perception of *Tchiwali*. *Bodeeji* was of high value for meat and for endurance. *Gudali* was perceived of high value for milk and for meat, but of low value for endurance.

3.3. Dominant cattle breeds mentioned by pastoralists

Fig. 2 presents the breed dominant in the herds of the pastoralists interviewed. *Keteeji* was the most dominant breed (74%), followed by *Jaliji* (17%), *Tchiwali* (6%) and *Bodeeji* (3%). None of the pastoralist mentioned having a herd with the *Gudali* breed as the dominant breed. During fieldwork, some *Gudali* cattle in the herds of some interviewees was observed, indicating that *Gudali* is indeed kept, but in low numbers.

Table 3
Performance of cattle breeds in four traits as perceived by pastoralists (number of interviewees scoring in performance).

Breed trait[a]	Performance	Breed				
		Keteeji	*Jaliji*	*Bodeeji*	*Tchiwali*	*Gudali*
Milk	High	19^{β}	33	55	31	67^{α}
	Medium	33	29	13	32	5^{β}
	Low	20^{α}	10	4	9	0
Meat	High	21^{β}	21^{β}	62^{α}	42	67^{α}
	Medium	39^{α}	42^{α}	8^{β}	28	5
	Low	12	9	2	2	0
Endurance	High	12	13	66^{α}	28	3^{β}
	Medium	36	41^{α}	4^{β}	38	7^{β}
	Low	24	18	2^{β}	6^{β}	62^{α}
Trypanotolerance	High	35^{α}	9	5	19	9
	Medium	16	19	11	29	12
	Low	21	44	56	24	51

Number with superscript within a row: α indicates Pearson's standardized residuals more than +3 and those with superscript β indicate Pearson's standardized residuals less than −3.

[a] Traits come from step b2), in which the 4 most relevant traits were agreed by pastoralists in a focus group discussion.

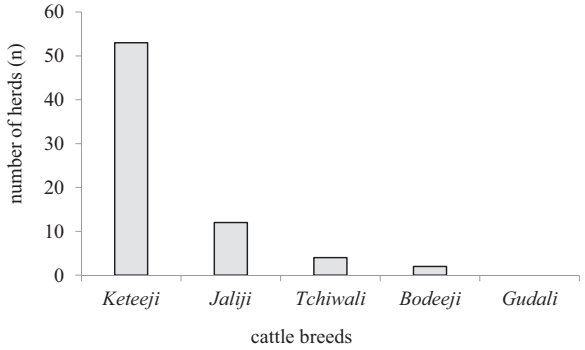

Fig. 2. Number of herds in which the cattle breed is dominant (> 75% of the herd of a particular cattle breed).

Table 4
Pastoralists' stated preference for cattle breeds and the associated reasons (n = 72).

Reasons for breed preference	Breed					Total count per reason
	Keteeji	*Jaliji*	*Bodeeji*	*Tchiwali*	*Gudali*	
Withstanding hunger	29	3	0	4	0	36
Intelligent breed	0	0	8	1	0	9
Productivity (milk and meat)	0	0	2	0	7	9
Experience with breed	4	0	0	0	0	4
Withstanding diseases	2	2	0	3	1	8
Short calving interval	0	0	0	5	0	5
Charm	0	0	0	1	0	1
Total count per breed	35	5	10	14	8	72

3.4. Preference for breed and associated reasons

Table 4 presents the stated preference of pastoralists for a particular cattle breed and the associated reason for this preference. *Keteeji* was the most preferred breed (nearly 50% of the respondents preferred this breed). The most mentioned reason to prefer *Keteeji* was the capability of the breed to withstand hunger (83% of the respondents that preferred *Keteeji* breed). The other breeds were less preferred, Gudali (11%) and Jaliji (7%) being the least mentioned by pastoralists.

Among the reasons to prefer a cattle breed, withstanding hunger was the most mentioned reason (50% of the respondents selected a breed based on this reason). Surprisingly, pastoralists did not mention one of the four traits as main reason for breed preference.

Dominant cattle breeds and preferred cattle breeds were not fully correlated. For instance in Fig. 2, the top 3 dominant breeds were Keteeji, Jaliji and Tchiwali, whereas in Table 4 (stated preference for breed), the top 3 preferred breeds were Keteeji, Tchiwali and Bodeeji.

3.5. Preference for herd type and associated reasons

Keeping one single breed in a herd was the most preferred herd type (61 out of 72 interviewees), because of two reasons: one single breed implies one requirement (35 out of 61 interviewees) in terms of feeding, watering frequency and disease management; and herding one single breed results in better herd behaviour (26 out of 61 interviewees). The latter means that the overall herd is prone to follow the leading-cow, making the herd more compact, facilitating the management and

Table 5
Effect of generation (young, mid and old) on pastoralists' perception of breeds' performance in traits milk, meat, endurance and trypanotolerance.

		Breed				
Breed trait[a]	Performance	*Keteeji*	*Jaliji*	*Bodeeji*	*Tchiwali*	*Gudali*
Milk	High	ns	ns	Mid & old	ns	ns
	Medium			Young		
	Low					
Meat	High	ns	ns	Mid & old	ns	ns
	Medium			Young		
	Low					
Endurance	High	ns	ns	ns	ns	ns
	Medium					
	Low					
Trypanotolerance	High	ns	ns		ns	ns
	Medium			Young		
	Low			Mid & old		

If generation effect is significant, then it is indicated in which performance class the majority of the generation scored.
ns: not significant (P > 0.05), indicates no generation effect.
[a] Traits come from step b2), in which the 4 most relevant traits were agreed by pastoralists in a focus group discussion.

reducing the number of scattered and strayed cows. For pastoralists preferring multiple breeds per herd, the reason was to have breed diversity, which means less risk in the event of disease or drought (resilience), and a diversity in milk taste.

3.6. Perception and preferences across generations and agro-ecological zones

Table 5 presents the generation effect on perception of the performance of the breeds in traits studied. In general, breed traits were perceived similarly across generations. Only the perceived value of *Bodeeji*'s traits differed across generations.

Young pastoralists perceived the breed to score medium for milk, meat and trypanotolerance, whereas the mid and old generations perceived the breed as high in milk and meat production, and low trypanotolerance. Preferences of pastoralists for type of breed and herd composition did not differ across generations (P > 0.05, not in table).

Table 6 presents the effect of agro-ecological zone on perception of

Table 6
Effect of agro-ecological zone (south, mid and north) on pastoralists' perception of breeds performance in traits milk, meat, endurance and trypanotolerance.

		breed				
Breed trait[a]	Performance	*Keteeji*	*Jaliji*	*Bodeeji*	*Tchiwali*	*Gudali*
Milk	High	South	ns	ns	South	ns
	Medium	Mid			Mid	
	Low	North			North	
Meat	High	South	ns	ns	South	ns
	Medium	Mid & north			Mid & north	
	Low					
Endurance	High	ns	ns	ns	South	
	Medium				Mid & north	South
	Low					Mid & North
Trypanotolerance	High	North	ns	ns	ns	ns
	Medium					
	Low	South & mid				

If effect of agro-ecological zone is significant, then it is indicated in which performance class the majority of the generation scored.
ns: not significant (P > 0.05), indicates no generation effect.
[a] Traits come from step b2), in which the 4 most relevant traits were agreed by pastoralists in a focus group discussion.

performance of breeds in traits studied. In general, pastoralists from the different agro-ecological zones perceived the breeds to perform similarly. However, the perceived performances of *Keteeji*'s and *Tchiwali*'s traits differed across agro-ecological zones. In general, for pastoralists living in the south zone the two breeds scored high, whereas for those living in the mid and south zones these breeds scored medium, for the same traits.

The preference of pastoralists for the type of breed differed across agro-ecological zones (P < 0.01, not in table). *Keteeji* was preferred in the south and mid agro-ecological zones whereas *Bodeeji* was preferred in the north. The preference of pastoralists for herd composition did not differ across agro-ecological zones (P > 0.05, not in table).

4. Discussion

This study aims at understanding knowledge of pastoralists about indigenous cattle breeds, their preference for specific breeds and associated reasons, which gives insights into the roles and functions of cattle breeds for pastoralists. We found that pastoralists had a common knowledge (also referred to as TEK) about their cattle breeds, regardless of the generation and the agro-ecological zones (except for some minor differences). The fact that the knowledge was common across generations was surprising to us. Literature describes the loss of traditional knowledge due to direct threats (Tang and Gavin, 2016). In the area of study, Tamou et al. (2017b) identified threats eroding traditional knowledge, such as limited access to or loss of traditional grazing land, change of environment and natural resources, changes in traditional livelihood practices, or lack of institutional support to traditional rights and traditional institutions. In the present study, maintaining TEK across generations could be explained by the absence of other well documented threats, such as loss of pathways of TEK transmission (e.g. loss of traditional language, influence by formal education system, absence of younger generations from the traditional community or influence by dominant societies), change of traditional religion or beliefs, or shift to westernised production systems with reliance to modern products and technologies (Tang and Gavin, 2016). *Fulbe* are a proud traditional community of pastoralists (Bierschenk, 1995). In the area of study, we found a traditional involvement of *Fulbe* pastoralists into herding activities from early ages (Tamou et al., 2017a), low schooling rates of young pastoralists and lack of opportunities outside the herding activities (except cropping). Therefore, young men are taught by their parents and are exposed to TEK about herding, to roles and functions of cattle breeds and to breed traits as their parents are. The bounding and the time families spend for hands-on learning has been identified as a success factor for TEK transmission (Berkes et al., 2000). In contrast to other studies that report a correlation between generation and level of TEK (Boissière et al., 2013; Oteros Rozas et al., 2013; Gaoue et al., 2017), we found a quite homogeneous and robust knowledge about herding and cattle breeds across generations. Hence, we could not observe evident signs of erosion of the transmission of TEK in this area.

Pastoralists' knowledge about indigenous cattle breeds was consistent with scientific literature. For instance, *Gudali* is well known for having a high beef performance (Kubkomawa, 2017); *Bodeeji* is described to perform well in endurance and to be intelligent (Ayantunde et al., 2007); and *Keteeji* is tolerant to trypanosomiasis (Kubkomawa, 2017) and it endures under harsh environmental conditions (Shabtay, 2015) with shortage of forage. We also found that pastoralists generally agreed on *Bodeeji* performing well in milk production, which is similar to pastoralists' perception about this breed in southern Niger (Ayantunde et al., 2007). This reflects that pastoralists had a perception of the breeds and their performances, based on traditional knowledge, and this in line with that reported in scientific literature.

Our findings demonstrate that pastoralists consider productive traits and especially non-productive traits as important. First, during the FGDs, 2 productive (i.e. meat and milk) and 2 non-productive traits (i.e. endurance and trypanotolerance) were selected as the most relevant

traits in cattle breeds. Second, when exploring preferences for a breed and the reasoning for this preference, 80% of pastoralists selected a breed based on a non-productive trait. In this case, traits that enable adaptation to the environment prevailed, such as withstanding hunger for *Keteeji*, intelligence for *Bodeeji* or withstanding disease for several breeds. The preference for adaptive traits can possibly be attributed to the changes in the pastoral environment occurring in the area of study (Tamou et al., 2017b). In the periphery of the WBR, the encroachment of arable land at the expense of natural and semi-natural areas is resulting in a loss and fragmentation of grazing areas and watering points (Avakoudjo et al., 2014; Tamou et al., 2017b). Hence, preference for breeds that withstand hunger or with high endurance to walk in search for forage may reflect strategies to cope with shortage of grazing land and watering points (Liao et al., 2016). The scarce grazing lands has also pushed pastoralists to graze illegally inside the WBR (Tamou et al., 2017b) or to look for grazing land where trypanosomiasis may be a risk. Pastoralists in the north zone preferred *Bodeelji* because of its intelligence to the herder, which is important when grazing illegally inside the WBR. According to those pastoralists, *Bodeeji* herds can be instructed to run away when discovered by patrollers of the WBR authority and then meet at their compound, avoiding the herder to be arrested and fined. Preferences for adaptive traits among pastoralists is in line with Dossa et al. (2007) for goat keeping in southern Benin, with Ayantunde et al. (2007) for cattle in southern Niger, and with Shabtay (2015) for the Baladi cattle of the Mediterranean basin. This finding suggests that pastoralists might change their preference for the adaptive traits in case of change of their environment. In the current situation of conversion of grazing land into crop land in the study area, adaptive traits for endurance are preferred. However, the incipient shift in lifestyle suggested by Tamou et al. (2017b), in which pastoralists have initiated crop farming, and the claim for more land (to graze and cultivate) may lead to change in the preferred breeds and traits, as well as in the roles and functions of the livestock.

Besides preference for breeds based on non-production traits, our findings show that the majority of pastoralists preferred keeping a single breed in their herd. The diversity of breeds was not perceived as an asset of resilience in this changing environment. In contrast, herds with diverse breeds were perceived as more demanding in terms of feeding and disease management. Therefore, from a pastoralists' perspective, cattle diversity within a herd was less desirable. This finding contradicts the fact that while oriented towards minimizing risk, pastoralists are prompt for conserving diversity (Köhler-Rollefson et al., 2009). Conserving diversity by pastoralists is adopted only when it is in line with their livestock keeping objectives.

5. Implications for policy on management of livestock diversity

In this study, we found that pastoralists are knowledgeable about traits of their reared breeds. Traditional knowledge is a reservoir of knowledge that can guide scientists. Pastoralists valued the adaptive traits of their livestock more than productive traits. This suggests that improvement of indigenous breeds by targeting high productivity might not be aligned with pastoralists' preferences and needs. Moreover, maintaining and improving indigenous breeds of cattle should be accompanied with a range of actions supported by governmental institutions, such as ensuring access to grazing lands and hence, access to feed resources, supporting traditional livelihoods practices and recognizing traditional rights and institutions. Therefore, policies should set appropriate objectives compatible with the production system, rather than ambitious performance objectives incompatible with prevailing conditions (FAO, 2015).

The continued loss of pastoral land and resources, and the pressure on pastoral communities, may be steering the preferences of pastoralists into cattle with high adaptive traits. Preferences for particular breeds and keeping a single breed herd are potential threats to cattle diversity in the area under study. This implies that national policies should also consider conserving less desired breeds. Conservation of a variety of local breeds in pastoral communities could assist in addressing the high projected demand for animal food products (FAO, 2015) in and around the studied area, as well as challenges of emerging diseases and new consumers' preference. To this end, in vivo conservation should be encouraged as framed in the community-based conservation of AnGR (Köhler-Rollefson et al., 2009; Shabtay, 2015). In addition, *ex situ* conservation or cryopreservation could also be implemented at international level as the investigated breeds are transboundary.

6. Conclusion

This study aims at understanding pastoralists' knowledge about indigenous cattle breeds (inventory of breeds and performance in selected traits), the preference for specific breeds and the associated reasons, and the potential variation of knowledge across generations and agro-ecological zones. We found that pastoralists had common knowledge about indigenous cattle breeds and their performance in selected traits. Pastoralists acknowledged production traits (i.e. meat and milk production) and also adaptive traits (endurance and tolerance to trypanosomiasis) in cattle breeds, which are important for gaining insight into roles and functions of cattle breeds. Nevertheless, large majority of pastoralist expressed preference for adaptive traits, as a coping strategy function, over the production role of cattle. For instance, the breed preferred by the majority of pastoralists stands out by its adaptive capabilities (i.e. *Keteeji*), in contrast to the most productive one (*Gudali*), which is one of the least preferred. The adaptive traits become of utmost importance in the study area as a strategy to cope with the shortage of grazing land. Programs and initiatives directed towards maintenance and improvement of indigenous breeds should be aware of pastoralists' needs and preferences. In the current situation, however, with an unfavourable environment for pastoralists, preference for such breeds and preference for keeping a single breed in the herd might be a potential threat for indigenous cattle diversity. This can compromise future improvement of breeds or adaptation of the farming systems in a region under change.

Acknowledgements

The research was funded by the Netherlands Organisation for International Cooperation in Higher Education (NUFFIC) under the grant NFP-PhD 322/2012 and the Animal Production Systems group of Wageningen University & Research. The first author would like to thank Fokje Steenstra for assistance with the statistical analyses and Akke Kok for providing comments on an early version of this manuscript, as well as the anonymous reviewers for their comments.

Conflict of interest statement

The research was funded by the Netherlands organisation for international cooperation in higher education (NUFFIC) under the grant NFP-PhD 322/2012 and the Animal Production Systems group of Wageningen University & Research. The funding organisations had no involvement in study design, in the collection, analysis and interpretation of data; in the writing of the report; and in the decision to submit the manuscript for publication. This manuscript has not been published elsewhere and is not under consideration for publication elsewhere. We, therefore, have no conflicts of interest to disclose.

References

Agresti, A., 2007. Residuals for cells in a contingency table. In: Agresti, A. (Ed.), An Introduction to Categorical Data Analysis. JohnWiley & Sons Inc., Hoboken, NJ, USA, pp. 38–39.

Avakoudjo, J., Mama, A., Toko, I., Kindomihou, V., Sinsin, B., 2014. Dynamics of land use in the W National Park and its surrounding northwest of Benin. Int. J. Biol. Chem. Sci. 8, 2608–2625.

Ayantunde, A.A., Fernández-Rivera, S., Hiernaux, P.H., Tabo, R., 2008. Implications of restricted access to grazing by cattle in wet season in the Sahel. J. Arid Environ. 72, 523–533.
Ayantunde, A.A., Kango, M., Hiernaux, P., Udo, H.M., Tabo, R., 2007. Herders' perceptions on ruminant livestock breeds and breeding management in southwestern Niger. Hum. Ecol. 35, 139–149.
Berkes, F., Colding, J., Folke, C., 2000. Rediscovery of traditional ecological knowledge as adaptive management. Ecol. Appl. 10, 1251–1262.
Bernués, A., Tello-García, E., Rodríguez-Ortega, T., Ripoll-Bosch, R., Casasús, I., 2016. Agricultural practices, ecosystem services and sustainability in High Nature Value farmland: unraveling the perceptions of farmers and nonfarmers. Land Use Policy 59, 130–142.
Bierschenk, T., 1995. Rituels politiques et construction de l'identité ethnique des Peuls au Bénin. Cah. Des. Sci. Hum. 31, 457–484.
Billand, A., De Visscher, M.N., Kidjo, F.C., Compaore, A., Boureima, A., Morel, A., Camara, L., Czesnik, F., Ahoyo Adjovi, N.R., 2005. Plan d'Aménagement et de Gestion (2006–2010) de la Réserve de Biosphère Transfrontalière W - Etat des lieux. Ecosystèmes Protégés en Afrique Sahélienne (ECOPAS), Ouagadougou, Burkina Faso.
Boissière, M., Locatelli, B., Sheil, D., Padmanaba, M., Sadjudin, E., 2013. Local perceptions of climate variability and change in tropical forests of Papua, Indonesia. Ecol. Soc. 18, 13. http://dx.doi.org/10.5751/ES-05822-180413.
Bruford, M.W., Ginja, C., Hoffmann, I., Joost, S., Orozco-terWengel, P., Alberto, F.J., Amaral, A.J., Barbato, M., Biscarini, F., Colli, L., Costa, M., Curik, I., Duruz, S., Ferenčaković, M., Fischer, D., Fitak, R., Groeneveld, L.F., Hall, S.J.G., Hanotte, O., Hassan, F.-u., Helsen, P., Iacolina, L., Kantanen, J., Leempoel, K., Lenstra, J.A., Ajmone-Marsan, P., Masembe, C., Megens, H.-J., Miele, M., Neuditschko, M., Nicolazzi, E.L., Pompanon, F., Roosen, J., Sevane, N., Smetko, A., Štambuk, A., Streeter, I., Stucki, S., Supakorn, C., Telo Da Gama, L., Tixier-Boichard, M., Wegmann, D., Zhan, X., 2015. Prospects and challenges for the conservation of farm animal genomic resources, 2015–2025. Front. Genet. 6. http://dx.doi.org/10.3389/fgene.2015.00314.
Catley, A., Lind, J., Scoones, I., 2013. Pastoralism and Development in Africa: Dynamic Change at the Margins. Routledge, London, UK.
Chambers, R., 1994. Participatory rural appraisal (PRA): challenges, potentials and paradigm. World Dev. 22, 1437–1454.
Convers, A., Chaibou, I., Binot, A., Dulieu, D., 2007. La gestion de la transhumance dans la zone d'influence du parc régional du W par le programme Ecopas. une «approche projet» pour l'aménagement de la périphérie du parc. VertigO-la revue électronique en sciences de l'environnement [En ligne], Hors-série 4 | novembre 2007, mis en ligne le 27 mai 2008. Accessed on January 15th, 2017. 〈http://vertigo.revues.org/761〉.
De Haan, L., van Driel, A., Kruithof, A., 1990. From symbiosis to polarization? Peasants and pastoralists in northern Benin. Indian Geogr. J. 65, 51–65.
Dossa, L.H., Wollny, C., Gauly, M., 2007. Smallholders' perceptions of goat farming in southern Benin and opportunities for improvement. Trop. Anim. Health Prod. 39, 49–57.
Elo, S., Kyngäs, H., 2008. The qualitative content analysis process. J. Adv. Nurs. 62, 107–115.
FAO, 2007. Global Plan of Action for Animal Genetic Resources and the Intertaken Declaration. FAO's Commission on genetic resources for food and agriculture, Rome, Italy.
FAO, 2009. Livestock Keepers-guardians of Biodiversity (Paper. No. 167). Animal Production and Health, Rome, Italy.
FAO, 2013. In Vivo Conservation of Animal Genetic Resources (No. 14). FAO Animal Production and Health Guidelines, Rome.
FAO, 2015. The Second Report on the State of the World's Animal Genetic Resources for Food and Agriculture. FAO Commission on Genetic Resources for Food and Agriculture Assessments, Rome, Italy.
FAO, 2016. Domesticated Animal Diversity Information System. DAD-is. 〈http://dad.fao.org/〉 Accessed on December 2016.
Felius, M., Beerling, M.-L., Buchanan, D., Theunissen, B., Koolmees, P., Lenstra, J., 2014. On the history of cattle genetic resources. Diversity 6, 705.
Felius, M., Koolmees, P.A., Theunissen, B., Lenstra, J.A., Consortium, E.C.G.D., 2011. On the breeds of cattle—historic and current classifications. Diversity 3, 660–692.
Gaoue, O.G., Coe, M.A., Bond, M., Hart, G., Seyler, B.C., McMillen, H., 2017. Theories and major hypotheses in ethnobotany. Econ. Bot. 71, 269–287.
Gaoue, O.G., Ticktin, T., 2009. Fulani knowledge of the ecological impacts of Khaya senegalensis (Meliaceae) foliage harvest in Benin and its implications for sustainable harvest. Econ. Bot. 63, 256–270.
Gómez-Baggethun, E., Corbera, E., Reyes-García, V., 2013. Traditional ecological knowledge and global environmental change: research findings and policy implications. Ecol. Soc. 18, 72. http://dx.doi.org/10.5751/ES-06288-180472.
Hoffmann, I., 2010. Climate change and the characterisation, breeding and conservation of animal genetic resources. Anim. Genet. 41, 32–46.
INSAE, 2016. Principaux indicateurs socio-démographiques et économiques du département de l'Alibori (RGPH-4, 2013).
Kim, J., Hanotte, O., Mwai, O.A., Dessie, T., Bashir, S., Diallo, B., Agaba, M., Kim, K., Kwak, W., Sung, S., Seo, M., Jeong, H., Kwon, T., Taye, M., Song, K.-D., Lim, D., Cho, S., Lee, H.-J., Yoon, D., Oh, S.J., Kemp, S., Lee, H.-K., Kim, H., 2017. The genome landscape of indigenous African cattle. Genome Biol. 18, 34. http://dx.doi.org/10.1186/s13059-017-1153-y.
Köhler-Rollefson, I., Rathore, H.S., Mathias, E., 2009. Local breeds, livelihoods and livestock keepers' rights in South Asia. Trop. Anim. Health Prod. 41, 1061–1070.
Krätli, S., 2008. Cattle breeding, complexity and mobility in a structurally unpredictable environment: the WoDaaBe herders of Niger. Nomad-. Peoples 12, 11–41.
Kubkomawa, H.I., 2017. Indigenous breeds of cattle, their productivity, economic and cultural values in sub-Saharan. Afr.: A Rev. Int. J. Res. Stud. Agric. Sci. 3, 27–43.
Leroy, G., Besbes, B., Boettcher, P., Hoffmann, I., Pilling, D., Baumung, R., Scherf, B., 2016. Factors and determinants of animal genetic resources management activities across the world. Livest. Sci. 189, 70–77.
Liao, C., Ruelle, M.L., Kassam, K.-A.S., 2016. Indigenous ecological knowledge as the basis for adaptive environmental management: evidence from pastoralist communities in the Horn of Africa. J. Environ. Manag. 182, 70–79.
Mangiafico, S.S., 2016. Association tests for nominal variables. In: Mangiafico, S.S. (Ed.), Summary and Analysis of Extension Program Evaluation in R, version 1.5.0. Rutgers Cooperative Extension, New Brunswick, NJ, USA, pp. 393–401.
McLafferty, I., 2004. Focus group interviews as a data collecting strategy. J. Adv. Nurs. 48, 187–194.
Moyo, S., Swanepoel, F., 2010. Multifunctionality of livestock in developing communities. In: Swanepoel, F., Stroebel, A., Moyo, S. (Eds.), The Role of Livestock in Developing Communities: Enhancing Multifunctionality. UFS and CTA, Bloemfontein, South Africa, pp. 1–11.
Mwai, O., Hanotte, O., Kwon, Y.-J., Cho, S., 2015. African indigenous cattle: unique genetic resources in a rapidly changing world. Asian-Australas. J. Anim. Sci. 28, 911–921.
Nardone, A., Ronchi, B., Lacetera, N., Ranieri, M.S., Bernabucci, U., 2010. Effects of climate changes on animal production and sustainability of livestock systems. Livest. Sci. 130, 57–69.
Oteros Rozas, E., Ontillera-Sánchez, R., Sanosa, P., Gómez-Baggethun, E., Reyes-García, V., González, J.A., 2013. Traditional Ecological Knowledge among transhumant pastoralists in Mediterranean Spain: learning for adaptation to global change. Ecol. Soc. 18, 33. http://dx.doi.org/10.5751/ES-05597-180333.
Pope, C., Mays, N., 1995. Reaching the parts other methods cannot reach: an introduction to qualitative methods in health and health services research. Br. Med. J. 311, 42–45.
R Core Team, 2015. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria.
Shabtay, A., 2015. Adaptive traits of indigenous cattle breeds: the Mediterranean Baladi as a case study. Meat Sci. 109, 27–39.
Steverding, D., 2008. The history of African trypanosomiasis. Parasites Vectors 1, 3. 〈http://www.parasitesandvectors.com/content/1/1/1〉.
Stewart, D.W., Shamdasani, P.N., 2014. Analysing focus group data. In: Stewart, D.W., Shamdasani, P.N. (Eds.), Focus Groups: Theory and Practice. Sage publications, Los angeles, USA.
Tamou, C., de Boer, I.J.M., Ripoll-Bosch, R., Oosting, S.J., 2017a. Traditional ecological knowledge underlying herding decisions of pastoralists. Animal 1–13.
Tamou, C., Ripoll-Bosch, R., de Boer, I.J.M., Oosting, S.J., 2017b. Pastoralists in a changing environment: the competition for grazing land in and around the W Biosphere Reserve, Benin Republic. Ambio. http://dx.doi.org/10.1007/s13280-017-0942-6.
Tang, R., Gavin, M.C., 2016. A classification of threats to traditional ecological knowledge and conservation responses. Conserv. Soc. 14, 57–70.
Thornton, P., Van de Steeg, J., Notenbaert, A., Herrero, M., 2009. The impacts of climate change on livestock and livestock systems in developing countries: a review of what we know and what we need to know. Agric. Syst. 101, 113–127.
Thornton, P.K., 2010. Livestock production: recent trends, future prospects. Philos. Trans. R. Soc. B: Biol. Sci. 365, 2853–2867.
Van der Zijpp, A.J., 2011. Special Issue: assessment for sustainable development of animal production systems. Livest. Sci. 139, 1–2.
Vordermeier, M., Ameni, G., Berg, S., Bishop, R., Robertson, B.D., Aseffa, A., Hewinson, R.G., Young, D.B., 2012. The influence of cattle breed on susceptibility to bovine tuberculosis in Ethiopia. Comp. Immunol., Microbiol. Infect. Dis. 35, 227–232.
Yaro, M., Munyard, K.A., Stear, M.J., Groth, D.M., 2016. Combatting African Animal Trypanosomiasis (AAT) in livestock: the potential role of trypanotolerance. Vet. Parasitol. 225, 43–52.