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Contribution of cattle of different breeds to household food security in southern Mali

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Contribution of cattle of different breeds to household food security

Abstract

Cattle husbandry plays an important role in the livelihoods of many households in southern Mali where the endemic N'Dama and Fulani Zebu breeds and their crosses are raised by farmers. This study examines food security, its determinants and the coping strategies used among 258 households in southern Mali, with particular emphasis on the contributions of cattle keeping and different breed groups, i.e. N'Dama, Zebu, crossbreds and mixed herds, to food security. The main aim was to investigate whether the replacement of the endemic N'Dama breed threatens or improves household food security. A linear mixed model was used to analyze the effects of household characteristics on food security using the household dietary diversity score (HDDS), food consumption score (FCS), and a modified household food insecurity access scale (mHFIAS) as indicators. Results revealed that cattle ownership and breed group were important determinants of all household food security indicators. Households keeping Zebu and mixed herds had the highest FCS. HDDS and FCS were positively correlated with crop diversity and household wealth, while negatively correlated with cotton cultivation. During the period of food shortage, households raising Zebu were better off and had significantly lower mHFIAS than those keeping N'Dama, crossbreds or mixed herds. In times of food shortage, selling livestock was the main coping strategy for households with a cattle herd, while households without cattle relied mostly on borrowing cash. In conclusion, the ongoing displacement of native N'Dama cattle by Zebu cattle and their crosses is contributing to improved household food security in Mali.

Keywords N'Dama · Fulani Zebu · Dietary diversity · Food security · Coping strategies · Mali

Contribution of cattle of different breeds to household food security

1 Introduction

Livestock husbandry can contribute directly to household food security through the home consumption of livestock products, and indirectly through the provision of cash income, manure and draft power (Smith et al. 2013). Animal source food (ASF) is known for its high nutritional value due to its high energy density, high quality protein and diverse essential micronutrients, such as vitamin A, vitamin B-12, riboflavin, calcium, iron and zinc. However, a considerable share of poor farmers in sub-Saharan Africa does not have adequate access to ASFs, and they depend on starchy and plant protein based diets, which, alone, hardly fulfill their nutrient requirements (Kidoido and Korir 2015; Murphy and Allen 2003). While the potential role of livestock in contributing to better nutrition for households keeping livestock is often stressed, few studies reveal this link and show the conditions under which it occurs (Azzari et al. 2015). Moreover, the relative contribution of different livestock breeds to household food and nutrition security in developing countries has hardly been studied, even though such research is particularly relevant under changing environmental conditions and when comparing exotic with local breeds in the tropics (Marshall 2014). On the one hand, the replacement of locally adapted breeds by exotics or crossbreds might affect farmers' food security through livestock losses in the event of drought or disease outbreak (König et al. 2016). On the other, the adoption of more productive breeds may be advantageous for food security as it can lead to more food and cash availability in comparison with the lower output but more adapted breeds (Marshall 2014).

The Sikasso region in southern Mali is the country's poorest region and most affected by malnutrition (Eozenou et al. 2013), although this region is regarded as the country's cereal basket and known for cotton production, its most important export commodity. Cattle production plays an important role in the livelihoods of many farmers in this region, where about 90% of the households own at least an ox and 60% have a cattle herd (Poccard-Chapuis et al. 2007). The endemic N’Dama breed (Fig. 1) and the more productive Fulani Zebu breed (Fig. 2), as well as their crosses, are raised by farmers mainly for draught power, as a saving and a source of income (Traoré et al. 2017). The N’Dama cattle are well known for their trypanotolerance and resilience to helminthes and tick-borne diseases as well as their low nutritional requirements (Murray et al. 1991; Grace 2005). Zebu and Zebu-N’Dama crosses are valued by many farmers for their high market price, large size and high milk yield (Jabbar and Diedhiou 2003; Traoré et al. 2017). There has been an increasing trend of crossbreeding between N’Dama cattle, as well as other West African Shorthorn trypanotolerant breeds and the larger trypano-susceptible Zebu breed in West Africa (Agyemang 2005), putting N'Dama cattle under risk of genetic erosion. However, the shift towards crossbreds and Zebu might benefit farmers in terms of food security, even though implying the loss of farm animal genetic diversity.

The multidimensional character of food security makes its measurement challenging. Nevertheless, it is well recognized that food security is built on four pillars: availability, access, utilization and stability (FAO 2011a). The household dietary diversity score (HDDS), food consumption score (FCS) and household food insecurity access scale (HFIAS) have been often utilized to measure different aspects of food security (Becquey et al. 2010; Kennedy et al. 2010; Regassa and Stoecker 2012) and were found to be suitable in estimating diet adequacy and assessing household food security (Arimond and Ruel 2004; Becquey et al. 2010). Our study examines household food security using HDDS, FCS and HFIAS, its determinants and coping strategies used in response to food shortages in southern Mali, with an emphasis on the contribution of cattle and specifically of different breed groups. The main aim was to investigate whether the displacement of the endemic N’Dama breed is a threat or an opportunity to food security for farm households.

2 Materials and methods

2.1 Study area

The study was conducted in the communes of Sibirila and Garalo in the district of Bougouni within the Sikasso region of southern Mali from October to December 2012. The region has a sub-humid climate, with an annual rainfall of between 1,000 and 1,200 mm. The rainy season extends from May to October. Crop farming and livestock husbandry make the main contributions to the livelihood of households in the study area. The major crops cultivated are maize, sorghum, millet, rice, groundnut, beans and yam. The main cash crops are cotton and cashew nut. Food shortages generally occur from July to September (the lean period, reaching a peak in August). The harvest period usually starts in October and ends in December.

2.2 Sampling

The communes, Sibirila and Garalo, and four villages in each of the communes were purposively selected based on the presence of N'Dama, Zebu and crossbred cattle. A stratified random sampling based on cattle and breed ownership was applied for the selection of 258 households. Households with a herd were grouped into four herd categories based on breed composition. The first three categories were comprised of herds with more than 75% of N'Dama, Zebu or crossbred cattle, respectively. Herds with less than 75% cattle from a single breed were designated as mixed herds, forming the fourth category. Households with only oxen and those without cattle represented two additional herd categories. Farmers of the Zebu herd category were mainly settled transhumant farmers from the Fulani ethnic group whose culture, livelihood and diet are centered on cattle (Glew et al. 2010). Farmers of all other herd categories were mainly local farmers affiliated to the Bambara ethnic group who rely mainly on crop farming as their source of livelihood.

2.3 Data collection and definition of food security indicators

Interviews with sets of semi-structured questionnaires were used to collect socio-economic data on households, livestock holding, cropping, household assets, and inputs and outputs of animal and crop production for the previous 12 months. Household heads and their wives were interviewed once during the harvest period between October and December in order to list, qualitatively describe and quantify food items prepared at home and consumed by household members during previous periods. These data were used to calculate HDDS and FSC. HDDS is the number of food groups consumed by household members during the previous day based on 12 food groups according to the FAO guidelines for measuring household and individual dietary diversity (FAO 2011b). These food groups include cereals, white roots and tubers, vegetables, fruits, legumes, meat, eggs, fish, dairy, oils and fats, sweets and condiments. FCS data were generated from household food consumption patterns (i.e. dietary diversity and food frequency information) over the past seven days. All food items consumed during the past seven days were grouped into eight specific food groups and a weighting system designed by the World Food Programme was applied to the different food groups based on their energy, protein and micronutrient densities (WFP 2008). This makes FCS a blended score of dietary diversity, consumption frequency and relative nutritional value of different food groups.

Additionally, to compute the modified household food insecurity access scale (mHFIAS), household food insecurity situations were retrospectively assessed for two periods: 1) the past 30 days before the interviews carried out from October to December and corresponding to the harvest period and 2) for the month of August, which is considered to be the most critical period for food security (lean period) in the study. mHFIAS was derived from a guideline proposed by Coates et al. (2007). The six food insecurity-related conditions used were whether or not household members had to do any of the following because of a lack of resources or food: 1) eat a kind of food they did not like; 2) eat a smaller meal; 3) eat fewer meals in a day; 4) stay a whole day without eating anything; 5) borrow food; or 6) purchase food on credit. If the response was yes to a condition, the frequency was asked to determine whether the condition occurred rarely (1 = once or twice), sometimes (2 = three to 10 times), or often (more than 10 times) during a four week time span. The mHFIAS score is the sum of the frequency of occurrence during the four weeks for the six food insecurity-related conditions. Finally, a household food insecurity access prevalence (HFIAP) status, which categorizes households into four levels of household food insecurity, i.e. food secure, and mildly, moderately and severely food insecure, was also computed. Households were categorized as increasingly food insecure as they experienced more severe conditions and/or suffered those conditions more frequently. In this study, the mHFIAS and HFIAP were based on only four of the nine questions suggested by Coates et al. (2007), since some of these conditions were considered as redundant and not relevant. Furthermore, household heads were asked which months their household members experienced food shortages and which coping strategies they used.

2.4 Data analyses

Data analysis was performed using SAS 9.3 (SAS Institute Inc. 2012). Descriptive statistics were used to characterize households, their food consumption, food insecurity indicators and coping strategies. T-test, $\chi 2$-test and Fischer's exact test were applied to identify significant differences between herd categories. HDDS, FCS, mHFIAS and food shortage length were used as dependent variables and analyzed using linear mixed model procedures with commune and village (nested within commune) as random effects. Higher values of HDDS and FCS indicate a better household food security status, while higher values for mHFIAS and the food shortage length reveal a situation of food insecurity. Continuous explanatory variables included in the models were: 1) food crop species' diversity as defined by the number of species cultivated by the household; 2) the wealth index, which was computed using a Principal Component Analysis (PCA) based on the number of motorcycles, phones, radios, ploughs, total livestock units and total revenue of the household; and 3) the dependency ratio, which is defined as the ratio of household members with an age of between 0 and 14 and above 65 years, to the productive age group (15–65 years). The herd category was a categorical variable with the six levels defined above. The cultivation of cotton, education of the household head and off-farm income were all dichotomous variables. The effects of socioeconomic factors on food security indicators (HDDS, FCS, mHFIAS and food shortage length) were modeled as follows:

$$y_{ijklxya}=\mu + F_i + \beta_1 n_z + \beta_2 w_z + \beta_3 d_z + C_j + E_k + O_l + u_x + v_{xy} + e_{ijklxya}$$

where

$y_{ijklxya}$ = observation of the ath household; μ = overall mean; F_i = herd categories (i = 6; N'Dama herd, crossbred herd, Zebu herd, mixed herd, only oxen, without cattle); β_1-β_3 = regression coefficients; n_z = number of crops cultivated as covariate; w_z = wealth index as covariate; d_z = dependency ratio as covariate; C_j = cultivation of cotton (j = 2; cultivation, no cultivation); E_k = education of the household head (k = 2; no formal education, primary school), O_l = off-farm income (l = 2; no off-farm income, off-farm income); u_x is the random effect of the commune (x = 2; Sibirila, Garalo); v_{xy} is the random effect of the village (y = 8; 1, 2, …, 8) nested within commune, and $e_{ijklxya}$ is the residual error, assumed to be normally distributed.

Before data analyses, multi-collinearity of the explanatory variables was checked; normal distribution and homogeneity of the variances of the residuals were tested. Non-significant effects were removed by backward elimination, and only variables found to satisfy a $P<0.1$ significance level were retained in the final model. The strength of the correlation between the food security indicators was examined using Pearson correlations.

3 Results

3.1 Household characteristics

Table 1 summarizes household characteristics stratified by herd category. Zebu and mixed herds were significantly larger than N'Dama herds. Farm size was lowest for households with Zebu cattle and no cattle and similar between households with mixed, crossbred and N'Dama herds. The diversity of food crop species was significantly lower for Zebu herds compared to mixed and crossbred herds. The wealth index was highest for households with mixed herds, followed by those with Zebu, crossbred and N'Dama herds. Households without cattle had the lowest wealth index after households with only oxen. The household dependency ratio was similar between herd categories, with more dependent members than active ones in all herd categories. The share of households involved in cotton cultivation and those whose household head had an off-farm income was lower for Zebu compared to the other herd categories.

3.2 Dietary patterns

All households consumed cereals, and most of them also had meals with vegetables during the past 24 hours (Fig. 3). Households differed mostly in their milk consumption and to a lesser extent in their legumes, meat and fruit consumption, depending on the herd categories. Milk consumption clearly depended on herd category: the majority of the households with a Zebu (97.1%) and mixed herd (80.0%) and half of the households with N'Dama (58.8%) and crossbred herd (54.8%) consumed milk. However, only 35.6% and 24.5% of the households with only oxen and without cattle consumed milk, respectively. Average daily per capita milk consumption was 222, 140, 84, 115, 56 and 57 ml, for Zebu, mixed, crossbred, N'Dama, only oxen and no cattle herd categories, respectively. Households without cattle also had the lowest consumption of legumes and fruits. Approximately 80% of the households in all herd groups consumed fish, which was mainly consumed as dried fish. Meat and legume consumption followed the same pattern between herd categories, except for N'Dama. Both were highest for households with mixed herds, and were lowest and similar for households with Zebu, with only oxen and without cattle. Except for the mixed herd category, the consumption of fruits, which are a good source of vitamins, was low, particularly for households without cattle. Eggs were not consumed by almost all of the households.

The frequency of consumed ASF for the past seven days is presented in Fig. 4. Herd categories differed mostly in the consumption frequency of milk, fresh fish, beef, meat from small ruminants and poultry. Households without cattle had the lowest consumption frequency of all these three food groups, which are known to have a high protein content and to be rich in vitamins A and B12, calcium, iron and zinc. All milk consumed during the week before interview by households with Zebu herds originated from their own herds, while 76.5, 73.7 and 78.3% of the households with mixed, crossbred and N'Dama herds which consumed milk, sourced it from their own herd, respectively. Households with only oxen and without cattle consumed milk on average once a week and had to purchase it. Dry fish was consumed more often than fresh fish by all herd categories, and the frequency of consumption of fresh fish differed between herd categories. Of the households that consumed beef, goat and sheep meat in the week before the interview, 96.9, 97.7 and 100% purchased it, respectively. In contrast, consumed poultry originated mainly from own production (88.5%).

3.3 Estimates and determinants of FCS and HDDS

Study households had a mean HDDS of 7.7 (±1.6) and FCS of 75.7 (±19.4), indicating intakes of good dietary diversity and a high food consumption score (FCS). Estimates of factors influencing the two indicators of food security, FCS and HDDS, are presented in Table 2. Herd category was a key determinant of FCS, while it was a weak determinant of HDDS. The FCS of the Zebu herd category was 11 scores higher compared to the N'Dama herd and 21 scores higher compared to households without cattle. For HDDS, only households without cattle were significantly different from those with Zebu herds, consuming on average 0.9 food groups less. Both indicators of food security were significantly and positively associated with the diversity of food crop species cultivated. FCS was significantly associated with the wealth index, while HDDS only had a weak link to wealth. Surprisingly, cultivation of cotton was negatively correlated with HDDS and FCS.

Table 3 presents least square means of FCS and HDDS by herd categories, showing how herd categories differ from each other for these two indicators. HDDS was less differentiated among households with a herd, compared to FCS. Households keeping Zebu cattle had a higher FCS than those of other herd categories, except for those with mixed herds. Households keeping Zebu and mixed herds had a significantly higher FCS compared to households keeping N'Dama herds, only oxen and without cattle. Considering HDDS among households with a herd, only households with a mixed herd had a significantly higher score than households keeping an N'Dama herd. The non-cattle keepers had the lowest FCS and HDDS.

3.4 Household food insecurity access scale (mHFIAS) and food shortage period

During the lean period (August), a higher proportion of households were affected by different conditions of food insecurity compared to the harvest period (October to November). During the lean period, a large proportion (43.5%) of households had to eat a type of food they did not like because of a lack of resources or other food; 36.9% had to reduce the size of their meals; and 20.9% had to reduce the number of meals they had per day. Some households (9.4%) reported going a whole day without food, indicating hunger. Many households either borrowed food (23.5%) or had to take credit to buy food (27.5%), which might put them in permanent indebtedness. Households without cattle purchased food on credit the most during the lean period (41.5%), putting them at greater risk of indebtedness. Households without cattle and those with only oxen were most affected by food insecurity conditions compared to households with a herd (Table 4).

During the lean period of August, 50.6% of the study households were food secure, while of those that were food insecure, 7.6% were mildly, 25.4% were moderately and 16.3% were severely food insecure (Table 5). Households without cattle had the highest proportion of severe food insecurity (30.2%), followed by households with only oxen (26.7%). Among the households with a cattle herd, those with an N'Dama herd had the highest proportion of severe food insecurity (14.7%).

An analysis of household food insecurity indicators showed that an increase in the wealth index was significantly associated with a decrease of the mHFIAS score for the harvest period (P=0.0085) as well as the lean period (P=0.0008). An increase of a household's wealth index was also significantly (P=0.0001) associated with a reduced period of food shortage. Furthermore, the herd category had a significant effect on all food insecurity indicators (Table 6). In the harvest period, only households without cattle were significantly more food insecure compared to the other herd categories. Households keeping a Zebu herd were significantly less food insecure in the lean period and had a significantly shorter food shortage length compared to the other herd categories. The N'Dama herd category had the highest values for mHFIAS for the lean period and food shortage length among households with a cattle herd. These two indicators were significantly higher for N'Dama and the crossbred compared to the Zebu herd category.

3.5 Coping strategies during lean period

Fifty-four percent of the households experienced food shortage for at least one month (range 1 to 4 months), of which most (66.4%) experienced one month of food shortage. August was the month in which the largest number of households (51.6%) experienced a food shortage followed by September (12.8%) and July (10.5%). Household coping strategies during the lean period were found to vary among different herd categories as shown in Table 7. Households without cattle were the most affected by food shortage (84.9%), followed by households with only oxen (73.3%). As a result, borrowing cash was found to be the main coping strategy of these two groups, followed by working on other farms as daily labor. For farmers with a cattle herd, selling livestock was the major strategy to ensure food for their families during a period of food shortage. Farmers with a Zebu herd sold mostly only their cattle, while farmers in other herd categories used more coping strategies besides selling cattle.

3.6 Relationship of the indicators

Table 8 gives an overview of the Pearson's correlation coefficients between the food security indicators, and also shows which correlations are significant and at which level. HDDS and FCS are negatively correlated with the mHFIAS score and length of food shortage. This is expected since a higher HDDS and FCS indicate a better food security status, while a higher HFIAS score and longer food shortage length means the household is more food insecure. All the correlations between the indicators were significant at the p=0.01 level, except between HDDS and mHFIAS during the harvest period, which was weak and only approaching significance at the 0.1 level.

4 Discussion

This study provides findings on the role of cattle production and the keeping of different breeds of cattle in ensuring a good dietary intake and household food security in southern Mali where the endemic N'Dama cattle is gradually being replaced by Fulani Zebu and their crosses (Traoré et al. 2017).

Cattle production was shown to be an important source of livelihoods for most farmers in the study area and contributed significantly to improved dietary intake and household food security. A positive association between cattle ownership and food security has also been found in other studies across Africa (Desiere et al. 2015; Rawlins et al. 2014). The revealed higher FCS among Zebu cattle and mixed herd keepers compared to N'Dama keepers was mainly explained by their higher milk consumption (Fig. 3). This also coincides with our previous observation (Traoré et al. 2018) in which the values of milk consumed and sold, as well as milk offtake per cow, were higher for households keeping Zebu and mixed herds compared to N'Dama and crossbred herds. In addition to the direct contribution of milk for own consumption (Yigrem et al. 2015), higher milk off-take in Zebu and mixed herds might have contributed indirectly to improve food security through the increased daily cash income, which allows households to access a more diversified diet as also reported by Kidoido and Korir (2015). More milk for home consumption and increased income through the sale of animals and milk also resulted in better nutrition in households that upgraded their indigenous goats to crossbreds in the frame of the FARM Africa Goat Improvement Project (Peacock 2008). Moreover, owing to the larger body size of their Zebu and crossbred cattle fetching higher market prices (Traoré et al. 2018), Zebu and mixed herd owners would see their purchasing power and food access enhanced compared to households with N'Dama cattle. In addition to milk, the households keeping mixed herds had a higher quality diet through an increased intake of meat (Fig. 3). However, none of the cattle keepers slaughtered cattle at home and, thus, all beef consumed was purchased, suggesting that cattle ownership did not directly increase home consumption of beef, but could improve their access to meat. Regarding the comparison of animal species with respect to their contribution to food security, Romeo et al. (2016) found evidence that poultry had the strongest correlation with household diet diversity followed by goats and sheep, while keeping cattle did not affect diet diversity although associated with more milk consumption. A reason given by the authors was that poultry and small ruminants did not only lead to more meat consumption, but were also more likely to be sold in order to buy more diverse food items. In our study, however, we found cattle keeping to be associated with both milk consumption and dietary diversity, suggesting that cattle ownership could contribute to increased home consumption of milk and dietary diversity. During the food shortage period, the higher proportion of severely food insecure households was observed in the N'Dama herd category compared to households with Zebu and crossbred herds (Table 5), suggesting that cattle breed had an impact on the food security status of a household. The mHFIAS were more differentiated between the different herd categories during the lean period than during the harvest period (Table 6), indicating the seasonal patterns of food insecurity and suggesting a difference in the coping ability of farmers in the different herd categories. As also observed in their coping strategy, the Zebu cattle keepers mainly used animal selling as the major mechanism to ensure household consumption during the lean period (Table 7). The fact that households are increasingly interested in raising Zebu cattle and their crosses (Traoré et al. 2017) could be due to economic reasons and the greater role Zebu cattle plays in ensuring household food security, although endemic N'Dama cattle are more adapted to the local environment through their disease tolerance and hardiness (Grace 2005; Kim et al., 2017). This shows that the non-endemic Zebu cattle and its crosses with the endemic N'Dama breed are the most suitable breed groups to improve food security. For food security, the keeping and thus conservation of the endemic breed is not justifiable unless large investments from governmental or non-governmental bodies would enable the genetic improvement of milk yield and growth performance of the N'Dama cattle as proposed by Traoré et al. (2017).

Cereals and vegetables were the common food groups consumed by the majority of the surveyed households, as also shown by other studies in this region of Mali (Hatløy et al. 2000; Torheim et al. 2004). Dried fish was a frequently used source of animal protein since it was cheap and easy to store; indeed, dried fish was by far the main source of ASF protein for households without cattle, households that were also the poorest (Table 1). Although dried fish contributed to increasing food security indicators, i.e. HDDS and FCS, in this study, the small quantity consumed (1 kg/week/household) might not alone provide household members with the adequate amount of protein and micronutrients. However, this could not be determined in the frame of our study. In our study, ethnicity is likely to have affected household diet as dietary patterns often follow well-established local cultural codes (Sougou and Boëtsch 2016). On the one hand, Zebu-keeping households − who were mainly Fulani − consumed milk on a daily basis (Fig. 4); households with a mixed herd of similar size − who were mainly Bambara − consumed milk on average five days a week. On the other hand, the diet of Zebu-keeping households included less legumes, meat and fruit (Fig. 3) compared to households keeping a mixed herd. The almost non-existing egg consumption observed was due to the low egg production of local hens, which were reserved for brooding, as also found in a study in central Mali by Kuit et al. (1986). We observed a higher average HDDS (7.7) compared to a previous report of 5.9 food groups from the same study area (Dury and Bocoum 2012). The higher HDDS in our study could be attributed to the interview period that took place during the harvest season, during which households' diet diversity may be above the annual average. In particular, the diversity of plant-source foods consumed from their own farms, such as cereals, pulses, vegetables and fruits, would be expected to increase in this season.

In our study, HDDS and FCS were positively associated with the diversity of food crop species cultivated. Similarly, a wider variety of crops planted were also found to be associated with higher food diversity in Malawi (Jones et al. 2014) and in a study based on household-level data from Indonesia, Kenya, Ethiopia, and Malawi (Sibhatu and Qaim 2018). In general, increasing crop diversity grown on their own farms is the most feasible strategy to improving dietary diversity and nutrient intake for the majority of rural households that consume legumes, vegetables and fruits. Homestead production of fruits and vegetables thus provides the households with important nutrients that may not be readily available otherwise or within their economic reach. Cotton cultivation, despite being an important source of income that could be expended on food items, was found to disfavour the food security status of households in our study. This is in line with the result of a study carried out by DNSI (2007), which showed that cotton producers had the highest poverty rate (77.8%) in the Sikasso region compared to 47.4% for other farmers. It supports the so-called “Sikasso paradoxe” situation in which poverty rates are unexpectedly high in a fertile region dominated by cash crop production (Eozenou et al. 2013). Indeed, Delarue et al. (2009) noted that cotton generates a low profit, especially for the smallest producers, and that the main reason for continuing cotton cultivation was access to credit and inputs as a member of the cotton cooperative. Anderman et al. (2014) and Tankari (2017) also found a negative relationship between the extent of cash crop farming and food security in Ghana and Senegal respectively. mHFIAS and food shortage length (Table 6) were not affected by crop diversity or cotton cultivation unlike the other food security indicators (FCS and HDDS). This might be explained because mHFIAS and food shortage length reflect to a greater extent a situation of insufficient access to food during an extended time period than diet diversity, which gives a snapshot of consumption information. In fact, mHFIAS and food shortage length were more affected by household wealth than HDDS. Like herd category, household wealth was found to be associated with all the indicators of food security. The wealth index had a significant and positive effect on FCS, but the effect was insignificant on HDDS (Table 2). The most probable explanation is that higher FCS mirrors consumption of more nutrient-dense food such as meat and milk, which are also more affordable for richer households if they are not produced on the farm. Therefore, FCS better reflects the monetary value of the food consumed by a household compared to HDDS.

In our study, no significant associations were found between the indicators of food security and the household dependency ratio, as well as the education level of the household head. This is unlike the findings of Eozenou et al. (2013) for Mali and De Cock et al. (2013) for South Africa, which showed that food insecure households had a higher dependency ratio and were more likely to have a household head with no primary education. The reason may lie in the low variation of education level of household heads and the dependency ratio, in spite of considerable variation in household sizes found in our study. In addition, Torheim et al. (2004) did not find any significant relationship between the dependency ratio and HDDS in rural Mali. Households without cattle and with only oxen had detrimental coping strategies, such as borrowing cash and working on other farms. Working on other farms decreases labor available for their own farm and may weaken their ability to produce enough food, while taking credit increases the risk of poor households being trapped in permanent indebtedness, which might result in a vicious cycle of food insecurity (Maxwell 1996). Cattle ownership seems to have a stabilizing effect on household food security status.

The strong correlation (0.74) between FCS and HDDS found in this study was similar to the value (0.73) found by Kennedy et al. (2010) in Burkina Faso. We found also that FCS displayed higher correlation coefficients with other food security indicators (mHFIAS; length of food shortage) compared to HDDS, which was in line with Kennedy et al. (2010). The high correlation coefficients between HDDS and FCS and between mHFIAS for the lean period and the food shortage length (Table 8) showed good agreement between these indicators and thus validates their use as food security (HDDS and FCS) and insecurity (mHFIAS for the lean period and the food shortage length) measurements. The lower correlations between indicators of diet diversity (HDDS and FCS) and indicators of food access and availability (mHFIAS and the food shortage length) may indicate complementarity of these different indicators, thus enriching information on food security.

FCS was a better indicator than HDDS when assessing the special contribution of livestock, since it is not only based on dietary diversity but also takes into account consumption frequency and the relative nutritional value of different food groups, for which animal-source food has the highest weight (World Food Programme 2008). Thus, FCS is more sensitive to dietary quality such as the intake of animal source foods compared to HDDS, which is a better measure of household access to food and dietary diversity. Measuring FCS is, however, slightly more time demanding as it poses a recall burden on the respondents during data collection due to its longer reference period and integration of consumption frequency (Kennedy et al. 2010).

5 Conclusion

Cattle ownership, breed group, diversity of food crops cultivated and household wealth were important determinants of food security in the Sikasso region of southern Mali. Households keeping Zebu cattle and mixed herds had the highest diet diversity. Cattle ownership and breed group seemed to directly influence milk consumption whereas no association with beef consumption was found. Ownership of Zebu cattle had the strongest impact on food access, reducing household food insecurity, especially during the lean period. FCS provides a more fair representation of households' food consumption than HDDS, especially when assessing the contribution of livestock to dietary quality. In general, our results show that the ongoing replacement of native N'Dama cattle by Zebu cattle and their crosses is contributing to improve household food security in southern Mali. However, since cause-effect relationships could not be established, our results may also reflect the fact that only the more food-secure households shift and profit from higher yielding Zebu and crossbred cattle.

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Conflict of interest

The authors declare that they have no conflict of interest.

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Table 1 Means and (standard deviation) of socioeconomic characteristics of surveyed households by cattle herd category in Mali

Socioeconomic characteristic	Herd category					
	Zebu N=34	Mixed N=61	Crossbred N=31	N'Dama N=34	Only oxen N=45	No cattle N=53
Cattle (head)	44.2^{a}	39.2^{a}	36.4^{ab}	$26{,}0^{b}$	2.4^{na}	0.0^{na}
	(22.2)	(27.2)	(35.3)	(24.5)	(1.1)	(0.0)
Farm size (hectare)	5.2^{c}	13.5^{a}	13.1^{a}	13.2^{a}	9.6^{b}	6.5^{c}
	(4.1)	(10.3)	(8.2)	(6.6)	(5.6)	(4.8)
Food crop species diversity (n)	2.9^{b}	3.6^{a}	3.6^{a}	3.3^{ab}	3.6^{a}	3.4^{ab}
	(1.4)	(1.5)	(1.7)	(1.3)	(1.5)	(1.4)
Wealth index[1]	0.2^{b}	0.7^{a}	0.3^{b}	0.3^{b}	-0.4^{c}	-0.9^{d}
	(0.8)	(1.2)	(0.9)	(0.8)	(0.5)	(0.4)
Household size (number members)	12.4^{bc}	16.6^{a}	15.3^{ab}	15.9^{a}	12.3^{bc}	9.5^{c}
	(7.4)	(9.1)	(7.3)	(6.7)	(4.4)	(3.5)
Dependency ratio[2]	1.1^{a}	1.3^{a}	1.4^{a}	1.4^{a}	1.1^{a}	1.4^{a}
	(0.7)	(0.7)	(0.7)	(0.8)	(0.7)	(1.3)
Cultivation of cotton [+ #]	0.2	0.5	0.7	0.6	0.7	0.4
	(0.4)	(0.5)	(0.4)	(0.5)	(0.5)	(0.5)
Education of household head [+ #]	0.0	0.2	0.1	0.1	0.2	0.1
	(0.2)	(0.4)	(0.3)	(0.4)	(0.4)	(0.2)
Off-farm income [+ #]	0.3	0.5	0.6	0.5	0.5	0.7
	(0.5)	(0.5)	(0.5)	(0.5)	(0.5)	(0.5)

[+]Indicates dummy variables (yes = 1, no = 0).

[1]Based on number of motorcycles, phones, radios, ploughs, total livestock units and total revenue.

[2]Ratio of household members who are aged 0–14 and above 65 years to the productive age group (15–65 years).

[a,b,c,d] Means within a row with different superscripts differ significantly at $P < 0.05$. (Lsd t-test).

[#]Statistically significant relationship with herd category at $P < 0.05$, ($\chi 2$/Fischer's exact test for dummy variables).

Contribution of cattle of different breeds to household food security

Table 2 Regression analysis of determinants of food consumption score (FCS) and household dietary diversity score (HDDS) in Mali

	FCS			HDDS		
Effect	Estimate	SE	P-value	Estimate	SE	P-value
Herd category (ref. = Zebu herd)						
Mixed herd	-3.05	3.70	0.4114	0.52	0.32	0.1002
Crossbred herd	-8.52	4.36	0.0517	0.01	0.37	0.985
N'Dama herd	-11.17	4.17	0.008	-0.11	0.36	0.7505
Only oxen	-18.01	4.13	<.0001	-0.53	0.35	0.1348
No cattle	-20.89	4.06	<.0001	-0.91	0.35	0.0089
Food crop species diversity	1.47	0.73	0.0420	0.29	0.06	<.0001
Wealth index[1]	3.06	1.33	0.0223	0.19	0.11	0.0868
Cultivation of cotton (1: yes)	- 5.13	2.28	0.0256	- 0.52	0.19	0.0086

Estimates were presented only for household characteristics found to satisfy a $P<0.1$ significance level.

[1]Based on the number of motorcycles, phones, radios, ploughs, total livestock units and total revenue.

Contribution of cattle of different breeds to household food security

Table 3 Least square means (LSM) and standard errors of food consumption score (FCS) and household dietary diversity score (HDDS) by cattle herd category

Indicator		Herd category					
		Zebu N=34	Mixed N=61	Crossbred N=31	N'Dama N=34	Only oxen N=45	No cattle N=53
FCS	LSM	86.5^{a}	83.5^{ab}	78.0^{bc}	75.3^{cd}	68.5^{de}	65.6^{e}
	SE	3.5	2.9	3.5	3.4	3.1	3.1
HDDS	LSM	7.9^{ab}	8.4^{a}	7.9^{ab}	7.8^{b}	7.3^{bc}	7.0^{c}
	SE	0.3	0.2	0.3	0.2	0.2	0.2

^{abcde}Least square means with different superscripts within variable levels in a row vary significantly ($p < 0.05$).

Contribution of cattle of different breeds to household food security

Table 4 Summary of modified household food insecurity access scale (mHFIAS) related conditions for the lean period by cattle herd categories in Mali

Condition (%)	Herd category					
	Zebu N=34	Mixed N=61	Crossbred N=31	N'Dama N=34	Only oxen N=45	No cattle N=53
Eat a kind of food they do not like	15.2	23.0	41.4	38.2	64.4	71.7
Smaller amount of food per meal	12.1	21.3	37.9	32.4	51.1	60.4
Reduced number of meals per day	0.0	9.8	3.5	14.7	33.3	47.2
Spending the whole day without eating any food	3.0	4.9	0.0	2.9	13.3	24.5
Borrowing food	3.0	11.5	27.6	14.7	35.6	43.4
Purchasing food on credit	3.0	24.6	31.0	23.5	33.3	41.5

Values are given in percentages of households affected

Contribution of cattle of different breeds to household food security

Table 5 Household food insecurity access prevalence (HFIAP) categories by cattle herd category in the lean period of August in Mali

	Herd category						
HFIAP category (%)	Zebu N=34	Mixed N=61	Crossbred N=31	N'Dama N=34	Only oxen N=45	No cattle N=53	All groups N=258
Food secure	81.8	68.9	51.7	52.9	31.1	24.5	50.6
Mildly food insecure	6.1	4.9	10.3	14.7	4.4	3.8	6.7
Moderately food insecure	6.1	16.4	34.5	17.7	37.8	41.5	26.3
Severely food insecure	6.1	9.8	3.5	14.7	26.7	30.2	16.5

Statistically significant relationship between HFIAP categories and herd category; P<.0001 (Fisher's exact test).

Contribution of cattle of different breeds to household food security

Table 6 Least square means (LSMs) and standard errors of modified household food insecurity access scale (mHFIAS) and food shortage length by cattle herd category

Food insecurity indicators		Herd category					
		Zebu N=34	Mixed N=61	Crossbred N=31	N'Dama N=34	Only oxen N=45	No cattle N=53
mHFIAS for harvest period[1]	LSM	0.42[a]	0.66[a]	0.75[a]	0.58[a]	0.73[a]	2.27[b]
	SE	0.38	0.3	0.39	0.38	0.33	0.33
mHFIAS for lean period	LSM	0.68[a]	2.04[b]	2.44[b]	2.59[bc]	3.68[cd]	4.23[d]
	SE	0.58	0.47	0.6	0.57	0.51	0.51
Food shortage length[2]	LSM	0.30[a]	0.60[ab]	0.74[bc]	0.84[bc]	1.07[cd]	1.26[d]
	SE	0.17	0.15	0.18	0.17	0.16	0.16

[1]Modified food insecurity access scale (mHFIAS) ranging from 0 to 18 (i.e. the larger the scale, the higher the food insecurity).

[2]Food shortage length in months per year.

[3]Weighted mHFIAS ranging from 0 to 24 based on the severity of indicators.

Least square means with different superscripts within variable levels in a row vary significantly ($p < 0.05$).

Table 7 Households' coping strategies by cattle herd category in Mali

Coping strategies (%)	Zebu N=7	Mixed N=21	Crossbred N=16	N'Dama N=17	Only oxen N=33	No cattle N=45	All groups N=139
Borrowing cash	14.3	28.6	31.3	11.8	45.5	33.3	31.6
Selling livestock	85.7	38.1	37.5	58.8	9.1	8.9	26.6
Working on others farms	0.0	0.0	0.0	5.9	12.1	26.7	12.2
Borrowing food	0.0	0.0	18.8	17.7	15.1	4.4	9.4
Off farm activity	0.0	9.5	0.0	0.0	9.1	8.9	6.5
Remittances	0.0	4.8	6.3	0.0	6.1	11.1	6.5
Early growing of crops	0.0	19.0	6.3	5.9	3.0	6.7	7.2
Food shortage[1]	20.6	34.4	54.8	50.0	73.3	84.9	54.3

Herd category: Zebu, Mixed, Crossbred, N'Dama, Only oxen, No cattle, All groups.

[1]Proportion of households experiencing a food shortage for at least one month in each herd group.
Statistically significant relationship between coping strategies and herd category; P<.0001 (Fisher's exact test).

Contribution of cattle of different breeds to household food security

Table 8 Pearson's correlation coefficients for food security indicators

	HDDS	FCS	mHFIAS for lean period	mHFIAS for harvest period	Food shortage length
HDDS	1.00				
FCS	0.76***	1.00			
mHFIAS for lean period	-0.27***	-0.37***	1.00		
mHFIAS for harvest period	-0.12*	-0.19***	0.51***	1.00	
Food shortage length	-0.29***	-0.37***	0.86***	0.37***	1.00

*10 % significance level, **5 % significance level, ***1 % significance level

Contribution of cattle of different breeds to household food security

Fig. 1 N'Dama cow

Fig. 1 Fulani Zebu cow and calf

Contribution of cattle of different breeds to household food security

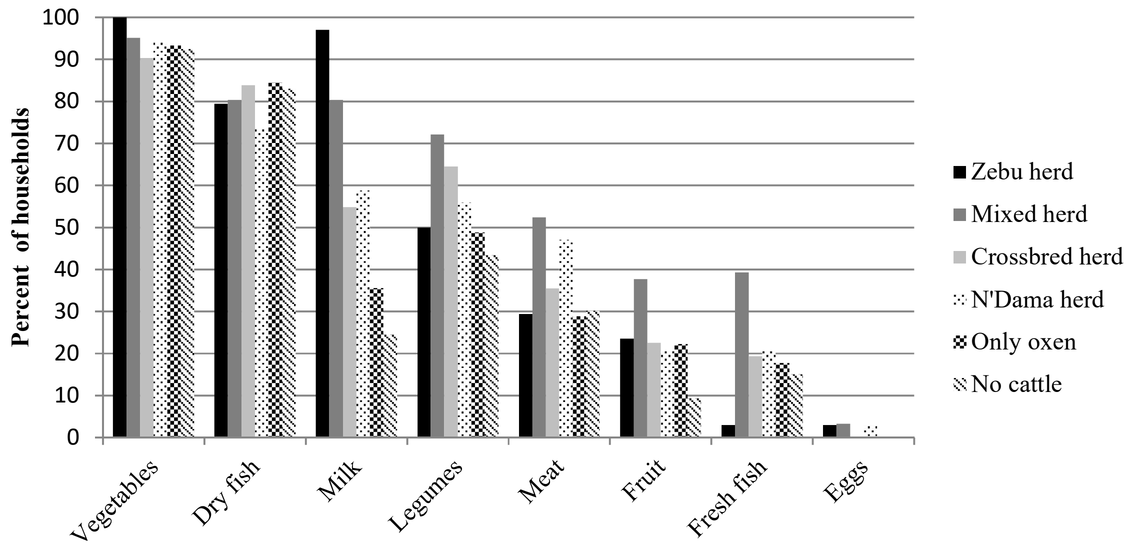

Fig. 3 Proportion of households that consumed micronutrient rich food groups in the past 24h by cattle herd category in Mali

Contribution of cattle of different breeds to household food security

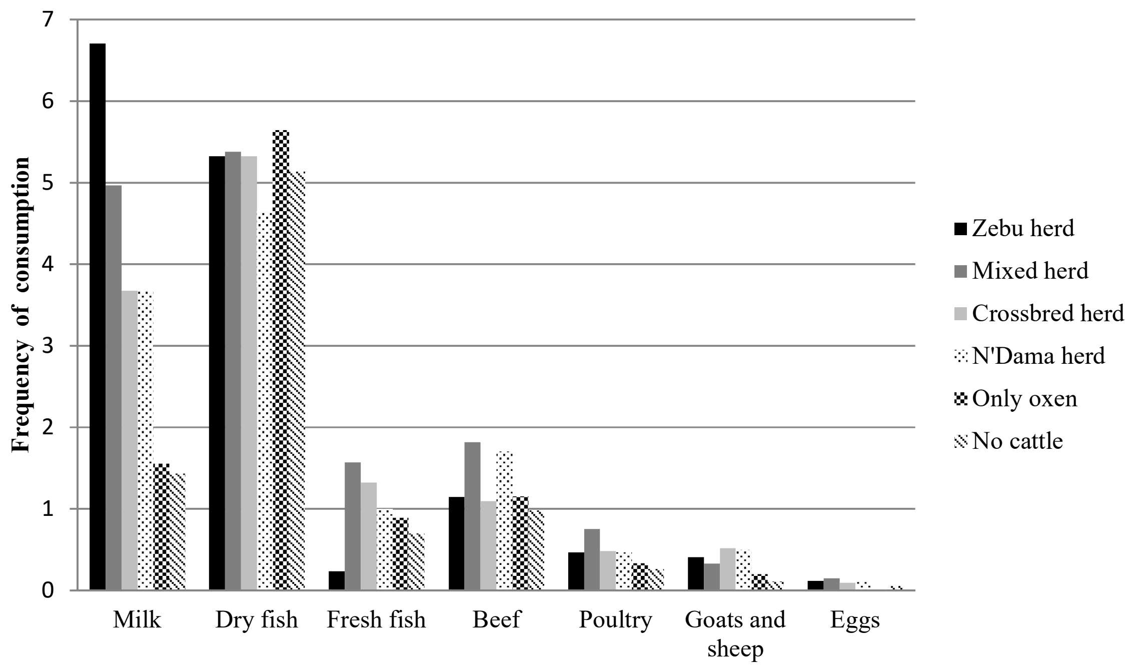

Fig. 4 Frequency of consumed animal source food in the past seven days by cattle herd category in Mali