Effect of the level of supplementation of bran concentrate on the demographic performance of Djelli (*Bos indicus*) cattle in Niger

Guéro Chékaraou Issoufou[1*], Adamou Karimou Ibrahim [2], Gréma Moustapha[3] and Issa Moumouni[3]

[1]Abdou Moumouni University of Niamey, Faculty of Agronomy, Department of Animal Production, Niger
[2]University of Tahoua, Faculty of Agronomic Sciences, Department of Animal Production and Food Technology, Niger
[3]Abdou Moumouni University of Niamey, Faculty of Science and Technology, Department of Animal Biology, Niger

**Corresponding author email:* issoufouguero44@gmail.com

The aim of this study was to evaluate the demographic performance of Djelli cattle herds as a function of the level of bran concentrate supplementation in three localities in western Niger. The 12 MO method was used to record the demographic parameters of 68 herds (1114 head) divided into three supplementation categories: those supplemented with 2.5 kg of bran per day per head (Category 1), those supplemented with 3.75 kg of bran per day per head (Category 2) and those supplemented with 5 kg of bran per day per head (Category 3). The results showed that the proportions of males were significantly lower than those of females for all categories of supplementation in the herds. There were more juveniles in the more highly supplemented herds (15.6% in Category 3 versus 7.2% in Category 1 and 6.5% in Category 2 for females, and 3.9% in Category 3 versus 1.3% in Category 1 and 2 for males). The results showed a significant difference in parturition rates between the categories (P = 0.027); these were higher among most supplemented (56.7% in Category 3 versus 38.4% in Category 2 and 36.4% in Category 1). There was a significant difference in abortion rates (P = 0.020) (4.8% in Category 3 versus 12.2% in Category 2 and 9.6% in Category 1) and a very signifcant difference in stillbirth rates (P < 0.001) (13.5% in Category 3 versus 30.2% in Category 2 and 46.7% in Category 1). With regard to herd exploitation, no significant differences were detected in terms of imports (P = 0.947) or exploits (P = 0.781) for all three supplementation categories. In conclusion, the higher the level of concentrate supplementation, the better the zootechnical performance of the females, with better exploitation of the males.

Keywords: Supplementation categories, bran concentrate, abortion rate, parturition rate, Djelli cattle herds, demographic performance, Niger

In Niger, notwithstanding its strong dependence on environmental and climatic conditions that affect the dynamics of pastoral systems, livestock farming contributes over 15% to household budgets, ensuring that 25% of food needs are met (Adamou et al. 2021). It contributes 11% to national GDP and 35% to agricultural GDP, and is the main export product along with agriculture, uranium and oil (Andres et al. 2014). Among local animal genetic resources, cattle play an important role in the national economy. They are the most widely used (98%) animal power in Niger, contributing to the development of agricultural activities in the country (Arifa et al. 2022).

Like the Azawak zebu and the Bororo zebu from Niger, the Djelli zebu (7% of the cattle in Niger) represents a highly valued animal genetic resource for breeders, due to its adaptation to different climatic hazards, its fattening capacity, its carcass yield, which can reach 48 - 50%, and its market value (Zakari et al. 2019).

Despite the growing role of Djelli cattle breeding in Niger, the demographic characteristics of village herds have been little studied. Yet increasing the productivity of traditional Djelli cattle herds is an important way of meeting the growing demand for livestock products in sub-Saharan Africa. Faced with this challenge, and in order to facilitate decision-making, it is necessary to

0041–3216/2024/040445–453

have good indicators and tools to be able to estimate the effects of zootechnical interventions on the productivity of Djelli cattle herds in village settings (Ba et al. 2012). Among the survey methods commonly used to estimate demographic rates, the retrospective method known as 12 MO is well suited. This method attempts to record all events in the calendar leading up to the day of interview. Retrospective surveys are cross-sectional, meaning that herds are surveyed only once and all at the same time of year (ideally the same month of the year so that information between herds is comparable) (Lesnoff 2013). The 12 MO tool has been used in several African countries to make a preliminary diagnosis of the productivity of endemic West African livestock. During interviews with herders, an exhaustive listing of the animals present in the herd at the time made as well as a record of all the events that occurred during the interview.

These correspond to functional herds capable of self-renewal through births and ranging in size from 8 to 54 head (including juveniles) with at least five females of breeding age per herd. This method offers a complete chain from field protocol to calculation of demographic parameters (Lesnoff 2013).

Studies of Djelli herds have been limited to assessing the demographic rates without taking into account their nutritional status (Zakari et al. 2019). Assessing the nutritional status of herds is important for adjusting their feed and assessing their production capacity (Vall and Bayala 2004). The demographic rate of local Djelli cattle on a nutritional basis therefore should be determined to better standardise the breeding environment conducive to their productivity. The aim of this study was to assess the effect of the level of rice bran concentrate supplementation on the demographic events of Djelli herds on traditional farms in the peri-urban area of Tillaberi. The site was chosen because of the high concentration of Djelli cattle on farms in this area, where rice cultivation is predominant.

Materials and methods

Study area

The survey was conducted in the localities of Yelwani, Daikaina and Diadia (Figure 1), located in the peri-urban area of Tillaberi. These localities are part of the Djelli zebu breeding area par excellence in the Niger River region. The region is located in the extreme west of Niger between latitudes 11°50 and 15°45 north and longitudes 0°10 and 4°20 east. It has a surface area of 97,251 km² (around 7.7% of the national territory) with a population in 2018 estimated at 3,280,333 (49.6% men and 50.4% women), i.e. 15.9% of the Niger population (Zakari 2020).

Data collection

In the localities of Yelwani, Daikaina and Diadia 12 MO surveys identified a total of 1114 head of cattle from 68 different herds (Table 1). These herds all met the standard of functional herds capable of self-renewal through births and ranging in size from 8 to 54 head (including juveniles) with a minimum of five breeding females and belonging to only one household. The 12 MO questionnaires were administered to the farmer in the presence of all the animals in the herd.

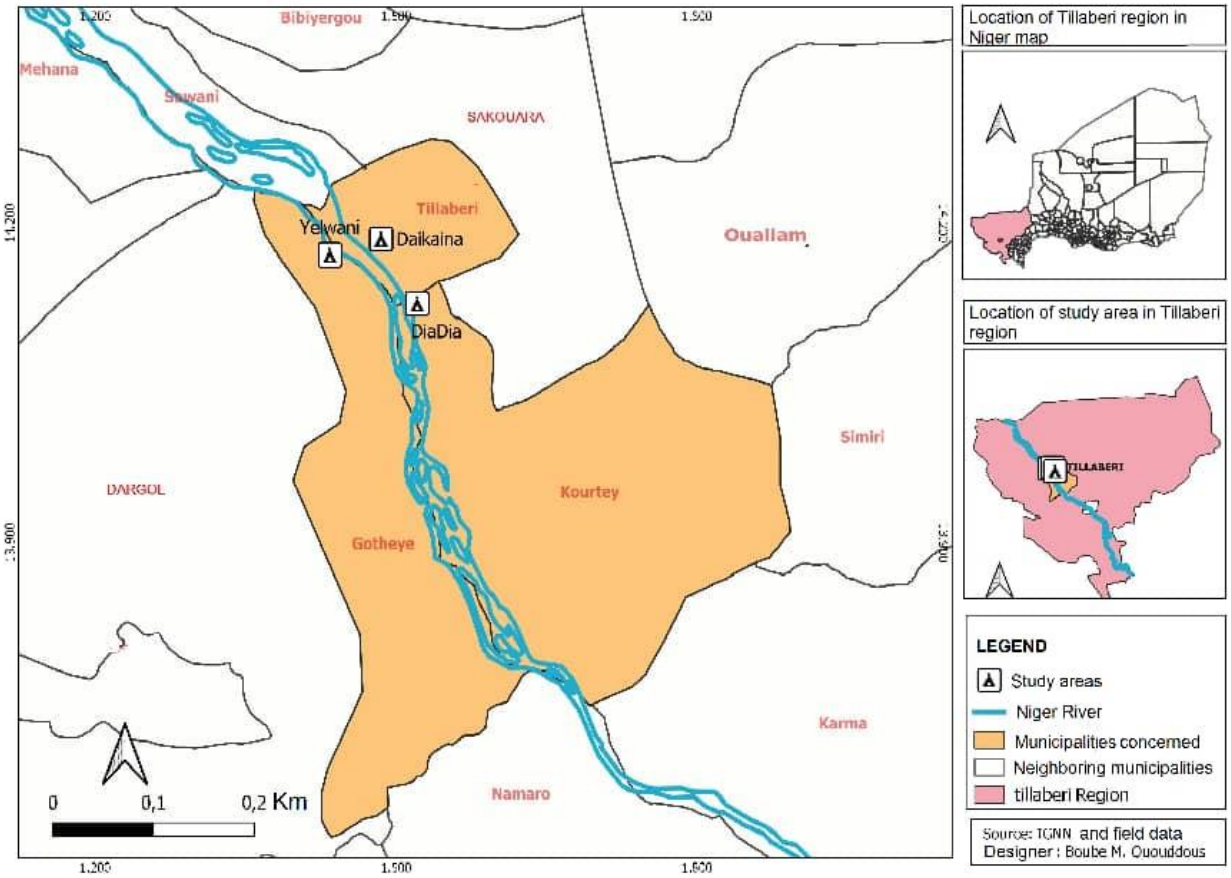

Figure 1: Location of Djelli herd demography survey sites.

Table 1: Composition of herds categorised by age group

Sex	Age class	Category 1 Head count	Category 2 Head count	Category 3 Head count	Total head count
Female	Juvenile < 1 year old	38	19	46	103
	Sub-adult 1-4 years old	106	46	42	194
	Adult ≥ 4 years old	280	143	115	538
Total females		**424**	**208**	**203**	**835**
Male	Juvenile < 1 year old	7	7	10	24
	Sub-adult 1-4 years old	52	44	58	154
	Adult ≥4 years old	45	32	24	101
Total males		**104**	**83**	**92**	**279**
Overall total (males and females)		**528**	**291**	**295**	**1114**

Category 1 = Herd with breeding females supplemented with 2.5 kg of rice bran per head per day.
Category 2 = Herd with breeding females supplemented at 3.75 kg rice bran per head per day.
Category 3 = Herd with breeding females supplemented with 5 kg rice bran per head per day

During the interviews an inventory of the animals present in the herd at the time of the survey was taken with estimates of their ages. All demographic events (calving, abortion, stillbirths, exploitation and importation) occurring by sex and age class in the herd over the last 12 months were recalled. In addition, to assess the effect of supplementation level on herd demographic performance, the quantities of rice bran concentrate distributed to breeding-age females in each herd were recorded for each household. Rice bran has a feed value of 0.63 forage units and 68 g/kg digestible nitrogen material.

Three categories of supplemented herds were identified on the basis of the daily quantities of rice bran concentrate received. These were Category 1 (herd receiving 2.5 kg of bran per day per female of breeding age), Category 2 (herd receiving 3.75 kg of bran per day per female of breeding age) and Category 3 (herd receiving 5 kg of bran per day per female of breeding age) (Table 1)

Calculating demographic rates

The demographic parameters provided by the 12 MO method are instantaneous risk rates. Each rate is estimated as the number of cases of the demographic event occurring in the last 12 months, divided by the total time "under risk". Annual cow calving or abortion rates and stillbirth rate were calculated for the herd for each age class by the following formulae:

Calving or abortion rate = Number of calving or abortions/Number of cows bred
Stillbirth rate = Number of stillbirths/Number of calvings

Exploitation rates (slaughterings, sales, gifts, etc.) and import rates (purchases, inheritances, etc.) were calculated to study the behavior of breeders with regard to the management of their herds. The demographic rates of exploitation and importation were estimated as the ratio between the number of demographic events observed in the monitoring year (12 months preceding the survey) and the average herd size:

Exploit rate = Exploit number/Average herd size
Import rate = Import number/Average herd size

Statistical analysis

R software was used. The data collected were entered into the Access 12 MO database and saved. The various parameters were then calculated using the t12mo package. Data on demographic rates for age groups (1 to 11 years) were used for the analysis of variance of these rates according to herd category (1, 2 and 3). Where the differences observed were significant, Tukey's test was used for multiple, pairwise comparison of means at the 5% significance level.

Results

Overall herd demographics by age class

The overall average (Table 2) shows a very high proportion of females to males: 9.8% juvenile females to 2.0% juvenile males, 16.7% sub-adult females to 14.9% sub-adult males, 47.1% adult females to 9.2% adult males. Table 2 also shows that there are more young females in the most supplemented herds (15.6% in Category 3 versus 7.2% in Category 1 and 6.5% in Category 2). It also shows that there are more young males in the most supplemented herds (3.4% in Category 3 versus 1.3% in Category 1 and 1.3% in Category 2). However, it shows that there are fewer adult females in the most complemented group (39.0% in Category 3 versus 53.0% in Category 1 and 49.1% in Category 2). There are also fewer adult males in the most complemented group (8.1% in Category 3 versus 8.5% in Category 1 and 11.0% in Category 2).

Table 2: Overall percentages of Djelli herds by age group

	Juvenile females < 1 year old	Sub-adult females 1-4 years old	Adult females ≥ 4 years old	Juvenile males < 1 year old	Sub-adult males 1-4 years old	Adult males ≥4 years old	Total
Category 1	7.2	20.1	53.0	1.3	9.8	8.5	100.0
Category 2	6.5	15.8	49.1	1.3	15.1	11.0	100.0
Category 3	15.6	14.2	39.0	3.4	19.7	8.1	100.0
Mean	**9**.8	**16.7**	**47.1**	**2.0**	**14.9**	**9.2**	**100.0**

Category 1 = Herd with breeding females supplemented with 2.5 kg of rice bran per head per day. Category 2 = Herd with breeding females supplemented at 3.75 kg rice bran per head per day. Category 3 = Herd with breeding females supplemented with 5 kg rice bran per head per day

Comparative performance of zootechnical parameters

Table 3 indicates a significant difference in calving rate among the categories (P = 0.027) (56.7% in Category 3, 38.4% in Category 2 and 36.4% in Category 1) a significant difference in abortion rates (P = 0.020) (4.8% in Category 3, 12.2% in Category 2 and 9.6% in Category 1) and a very significant difference in stillbirth rates (P < 0.001) (13.5% in Category 3, 30.2% in Category 2 and 46.7% in Category 1).

Table 3: Overall herd demographic percentages

	Category 1	Category 2	Category 3	P-value
Calving rate	36.4a	38.4ab	56.7b	0.027
Abortion rate	9.6a	12.2a	4.8b	0.020
Stillbirth rate	46.7a	30.2a	13.5b	<0.001

Row values with at least one letter in common are not significantly different (P = 0.05)
Category 1 = Herd with breeding females supplemented with 2.5 kg of rice bran per head per day. Category 2 = Herd with breeding females supplemented at 3.75 kg rice bran per head per day. Category 3 = Herd with breeding females supplemented with 5 kg rice bran per head per day.

Herd exploitation and importation

An exploit rate (out of herd) of 14% and an import rate (into herd) of 15% were recorded for Category 1, an exploit rate of 12% and import rate of 15% were recorded for Category 2, and an exploit rate of 18% and an import rate of 14% were recorded for Category 3. No significant difference was found in imports (P = 0.947) or exploits (P = 0.781) across all three levels of supplementation (Table 4).

Table 4: Herd import and exploit rates by supplemented category (%)

	Category 1	Category 2	Category 3	P-value
Import	15 ± 0.0a	15 ± 0.0a	14 ± 0.0a	0.947
Exploit	14 ± 0.0a	12 ± 0.0a	18 ± 0.0a	0.781

Row values with at least one letter in common are not significantly different (P = 0.05)
Category 1 = Herd with breeding females supplemented with 2.5 kg of rice bran per head per day. Category 2 = Herd with breeding females supplemented at 3.75 kg rice bran per head per day. Category 3 = Herd with breeding females supplemented with 5 kg rice bran per head per day.

Discussion

Overall herd demographics by age class

The results revealed a female:male ratio of 3:1; this result is similar to those of Azalou and Youssouf (2018), and Ira et al. (2019). This demonstrates the strong exploitation of males in village cattle herds. Males are generally fattened and sold, or used for various customary ceremonies (feasts, religious ceremonies, weddings, baptisms). The high proportion of juvenile females (15.6%) in Category 3 herds compared with 7.2% in Category 1 herds and 6.5% in Category 2 herds shows that there are more births in the best supplemented herds.

According to Brisson (2003), feed supplementation is certainly a major factor in the success or failure of bovine reproduction. Improved performance and productivity can be achieved not only through a feeding strategy, but also through better disease control (Manuel 2010).

The lowest percentage of adult females was in Category 3 herds (39.0%) versus 53.0% obtained in Category 1 and 49.1% in Category 2; the lowest percentage of adult males was also in Category 3 herds (8.1%) versus 8.5% obtained in Category 1 and 11.0% obtained in Category 2. These results are thought to be linked to the systematic culling of the oldest animals in the best-fed herds. This corroborates the observation of Mobio (2009) on the need for adequate feed supplementation, which, in addition to survival, determines the prosperity of any farm.

Herd exploitation and importation

The annual exploit rates recorded in this study (14% for Category 1, 12% for Category 2, and 18% for Category 3) are considerably lower than the overall exploit rate of 50% obtained by Ira et al. (2019) in Guinea-Bissau cattle populations. However, the exploit rate of the Category 3 herds in this study is higher than the overall exploit rate of 13% obtained by Thibault (2011), and 15% obtained by Zakari (2020). In this study the best complemented herds (Category 3) are also the most exploited. The annual import rates for all categories in this study (14% –15%) are higher than the import rate of 12% obtained by Thibault (2011).

Comparative performance of zootechnical parameters

The highest calving rate in this study was for Category 3 herds, 56.7%; this is slightly lower than the estimated overall calving rate of 58.0% obtained by Thibault (2011). The higher calving rate of the best-supplemented cows shows that the greater the quantity of feed supplemented, the higher the birth rate in the herd. Vinsoun et al. (2019) stated that, with proper management and feeding, there will be no negative impact on reproduction. The 56.7% calving rate of the Djelli cattle in Category 3 is lower than the 70.0% calving rate obtained among zebu cows in cotton-growing areas (Ba et al. 2012). This difference could be due to the nutritional richness of cattle feed in the cotton zone and it may also be linked to differences in genetic performance between cattle breeds.

According to APESS (2015), in females undernourishment results in sexual changes characterised by reduced secretions (mucus) and hormones. However, these disturbances can be reversed once a suitable diet is re-established. Sanogo et al (2019) found that animals with the most supplement performed better than the controls.

Sounon et al. (2019) found that improved female nutrition, in addition to increasing the rate of parturition, has the effect of increasing precocity and boosting reproductive performance.

The stillbirth rate obtained in Category 3 (13.5%) was the lowest of the three categories, but is higher than the stillbirth rate of 4.1% observed by Thibault (2011). This difference may be due to the genetic difference between the two breeds of cattle.

The low stillbirth rate in the best supplemented calves demonstrates the importance of the mother's good nutritional status for calf survival. Supplementation not only increases productivity, but also calf weight after calving, and significantly reduced calving intervals (Vinsoun et al. 2019). The combination of feed supplementation and internal deworming has a definite impact on the zootechnical performance of local cattle, and offers the best economic and financial results (Diao et al. 2006). Several studies have demonstrated the influence of supplementation on cattle productivity. It has been shown that a diet adapted to the reduction in pastoral mobility and its corollaries would be sufficient to cover the animals' needs, ensuring better milk production and good calf growth (Sènouwa et al. 2021). The production of high-quality beef animals (cows, heifers and steers) cannot be achieved without improved feed efficiency (Bithionol 2020). Hamidou et al. (2021) stated that to ensure good rationing of their cows, farmers must provide them with the quality and quantity of feed required to cover their maintenance and production needs (milk production, pregnancy requirements). Providing cattle with the right supplements is not only essential in times of crisis, it is also a necessity for improving productivity and enhancing the economic value of the herd (Maroobe 2004).

Improving reproductive performance, mainly through better feeding conditions for females, seems to be an avenue to be recommended (Ba et al. 2012). The performances obtained in breeding on farms are better than those in village settings (Paul 2006). According to Azalou and Youssouf (2018), environmental conditions undoubtedly play a decisive role in the success of any breeding operation.

Conclusion

This study shows a high exploitation rate of Djelli males compared with females per herd for all supplementation categories. It should be noted that the higher the concentrate supplementation, the better the zootechnical parameters, with a fairly high calving rate, a fairly low abortion rate and a low stillbirth rate. It would be advisable to carry out a comparative study on a station where the feed components and sanitary practices would be the same, with different levels of supplementation, to gain a better understanding of all the zootechnical performances of the Djelli zebu in Niger.

Acknowledgement

The authors would like to express their gratitude to the Centre d'Excellence Régionale sur les Productions Pastorales (CERPP) for facilitating the funding of this study. They would also like to thank all the herders in Diadia, Dayikaina and Yelwani for their availability and frank collaboration during the study.

Conflict of interest

The authors declare that they have no conflicts of interest.

References

Adamou K.I., H. Abdou, A. Alhassane, and S.D. Hapizou. 2021. "A Simple Retrospective Demographic Survey Tool Adapted to Traditional Livestock Systems: Application to Cattle Herds in Sahelian Zone in Niger." *Journal of Agriculture and Veterinary Science* **13:**24−37 DOI: 10.9790/2380-1310032437.

Andres, L., S. Bodé, J. Faux, A. Laouali, B. Yamba, and P. Lebailly. 2014. "A Proposal for a Vulnerability Index in the Pastoral Food System in the Republic of Niger: The Case of the Abalak Department." *Agriculture and Forestry* **60:**35−42.

Arifa, W., C. Mahamadou, and S. Laouali. 2022. "Agricultural Mechanization in Niger: What Role do Animals Play?" *American Journal of Applied Sciences* **19:**34−42. https://doi.org/10.3844/ajassp.2022.34.42.

APESS (Association pour la Promotion de l'Elevage au Sahel et en Savane). 2015. "Les Aliments pour Bétail. Programme de Formation de l'APESS, Niveau 2, Version 1. (Livestock Feed. APESS Training Programme, Level 2, Version 1)." 1−67. https://www.apess.org › uploads › 2018/02 ›

Azalou, M., and T. Youssouf. 2018. "Paramètres Démographiques des Troupeaux Bovins Transhumants dans la Commune de Djidja au Sud du Bénin. (Demographic Parameters of Transhumant Cattle Herds in the Commune of Djidja in Southern Benin)." *Annales de l'Université de Parakou Serie Sciences Naturelles et Agronomie* **7:**10−18.

Ba, A., M. Lesnoff, D. Coulibaly, R. Chapuis-Poccard and C. Moulin. 2012. "Un Outil Simple de Projection Démographique pour l'estimation de la Productivité des Troupeaux: Application à un Troupeau Bovin de la Zone Cotonnière du Sud-Mali. (A Simple Demographic Projection Tool for Estimating Herd Productivity: Application to a Cattle Herd in the Cotton Zone of South Mali)." Actes du séminaire ASAP, Bobo-Dioulasso, Burkina Faso.

Diao, M., A.A. Fall, C. Sall, and O.T. Diaw. 2006. "Influence de la Complémentation Alimentaire et de la Vermifugation Interne sur la Valorisation Économique de la Production Laitière des Vaches Gobra en Zone Sahélienne du Sénégal. (Influence of Feed Supplementation and Internal Deworming on the Economic Valorisation of Milk Production of Gobra Cows in the Sahelian Zone of Senegal)." *Tropicultura* **24:**51−57.

Bithionol, N. 2020. "L'engraissement des Gros Bovins Améliore L'alimentation. (Fattening Large Cattle Improves Nutrition)." Report: Agriculture et Territoire, Chamber d'agriculture, Pyrenées-Atlantiques Landes. 4p.

Brisson, J. 2003. "Nutrition, Alimentation et Reproduction." *Symposium sur les Bovins Laitiers. (Nutrition, Feeding and Reproduction. Symposium on Dairy Cattle)*. Une Initiative du Comité Bovins Laitiers, Question de Reproduction 66p. https://www.agrireseau.net› Brisson_Jean

Hamidou, K., D. Michel, T. Ibrahima, S. Ahmadou, and F. Abdou. 2021. Recueil de Paquets Technologiques Intégrés du Bétail Ruminant Domestique au Mali. (Compendium of Integrated Technology Packages for Domestic Ruminant Livestock in Mali). Institut International de Recherche sur l'élevage (ILRI) Manuel 61p.

Ira, M., K.D. Guiguigbaza, S. Mamadou, D. Bacar, G. Joao, C. Bernado, T. Aboubacar, V. Chia, G. Yapi-gnaore, and O. Anicet. 2019. "Paramètres démographiques et productivité du cheptel bovin bissau-guinéen. (Demographic parameters and productivity of the Guinea-Bissau cattle herd)." *International Journal of Biological and Chemical Sciences* **13:**704−719.

Lesnoff, M. 2013. "Méthodes d'enquêtes pour l'estimation des Taux Démographiques des Troupeaux de Ruminants Domestiques Tropicaux. Synthèse, Limites et Perspectives. (Survey Methods for Estimating Demographic Rates of Tropical Domestic Ruminant Herds. Synthesis, Limits and Perspectives)." *Revue d'Elévage et de Medécine Vetérinaire des Pays Tropicaux* **66:2** https://doi.org/ 10.19182/remvt.10142.

Manuel, H. 2010. "Estimation des Paramètres Démographiques des Systèmes D'élevage Bovin et Analyse de la Filière Bovine, dans le Southeast Lowveld (Zimbabwe). (Estimation of Demographic Parameters of Cattle Farming Systems and Analysis of the Cattle Value Chain, in the Southeast Lowveld (Zimbabwe)." *Rapport de Stage de Seconde Année* 6−10. https://agritrop.cirad.fr › document_561482

Mobio, S.A. 2009. "Evaluation of the Zootechnical Performance of Pregnant Cows and their Offspring after Artificial Insemination in the Thiès Region. (Evaluation of the Zootechnical Performance of Pregnant Cows and their Offspring after Artificial Insemination in the Thiès Region)." *Thèse de Médecine Vétérinaire*: Université Cheikh Anta Diop Dakar, Senegal. 76p.

Paul, F.A. 2006. "Évaluation des Performances Zootechniques. (Evaluation of Zootechnical Performance)." Thèse de Médecine Vétérinaire: Université Cheikh Anta Diop Dakar, Senegal. 124p.

Sanogo, O.M., D. Salif, and D. Katrien. 2019. "Supplémentation des Bovins Laitiers pour l'amélioration de la Production Laitière et de la Manipulation en Milieu Paysan dans le Cercle de Koutiala. (Supplementation of Dairy Cattle to Improve Milk Production and Handling in the Farming Environment in the Circle of Koutiala)." *Revue Malienne de Science et de Technologie Série A: Sciences Naturelles, Agronomie, Techniques et Sciences de l'Ingénieur* **22:** 43−134.

Sènouwa, L., H. Guidimê, S. Imorou, J. André, B. Djènontin, K. Orou, and B. Sévérin. 2021. "Effets d'une Complémentation à Base de Vitanimal sur les Performances Laitières et Économiques des Vaches Borgou au Bénin. (Effects of Vitamin-Based Supplementation on the Dairy and Economic Performance of Borgou Cows in Benin)." *Revue d'Elévage et de Medécine Vetérinaire des Pays Tropicaux* **74:**43−48. https://doi.org/10.19182/remvt.36322

Sounon, K.L.S., A. Edouard, P. Lesse, I. Alexandre, M. Samir, M. Lesnof, and R.B.H. Marcel. 2019. "Évaluation de la Valeur Économique Directe de l'élevage Bovin dans le Nord du Bénin. (Assessment of the Direct Economic Value of Cattle Farming in Northern Benin)." *International Journal of Biological and Chemical Sciences* **13:**8−17. https://dx.doi.org/10.4314/ijbcs.v13i1.2

Thibault, J. 2011. "Les Bovins Après une Sécheresse au Sahel Selon les Types D'exploitation Pastorale: Cas du Ferlo au Sénégal. (Cattle after Drought in the Sahel According to Types of Pastoral Exploitation: The Case of the Ferlo in Senegal)." Mémoire de Master 2: Université de Montpellier 2. 60p.

Vall, E., and I. Bayala. 2004. "Note d ' Etat Corporel Des Zébus Soudaniens. (Body Condition Score for Sudanese Zebu Cattle)." CIRDES-CIRAD: Production Animale en Afrique de l'Ouest, Fiche N°12. 8p. https://agritrop.cirad.fr › document_531084.

Vinsoun M., M. Sissao, A.A.G. Sidibe, T.O. Amoussou, and G.A. Ouedraogo. 2019. "Effet d'une Supplémentation Valorisant les Ressources Localement Disponibles sur les Performances de Production Laitière des Vaches pour Réduire L'intervalle Vêlage-Vêlage dans la Zone Périurbaine de Bobo-Dioulasso au Burkina Faso. (Effect of Supplementation Enhancing Locally available resources on milk production performance of cows to reduce the calving Interval in the Peri-Urban Area of Bobo-Dioulasso, Burkina Faso)." *Journal of Applied Biosciences* **142:**14529−14539. https://dx.doi.org/10.4314/jab.v142i1.11.

Zakari, I.Y., G. Dayo, M. Maman, M. Issa, and H. Marichatou. 2019. "Caractérisation Morphobiométrique du Zébu Djelli du Niger. (Morphobiometric Characterization of the Djelli Zebu from Niger)." *International Journal of Biological and Chemical Sciences* **13 (2)**: 727. https://doi.org/10.4314/ijbcs.v13i2.13

Zakari, I.Y. 2020. "Caractérisation de la race zébu Peul (Djelli) au Niger, (Characterisation of the Peul (Djelli) zebu breed in Niger)." Thèse de Doctorat en Production Animale: Université Abdou Moumouni de Niamey 129p.