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Assessment of Structural Traits and Management Related to Dairy Herds in the Peri-urban Area of Bobo Dioulasso (South West of Burkina Faso)

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Abstract

To define mean herd size, structural traits, animal sourcing and use, management and aspects related to the milk production, 118 dairy herds, involved in a FAO dairy development project were studied. The mean herd size after allocation to clusters: Small (≤ 38 heads), Medium (> 38, ≤ 61 heads) and Large (> 61 heads) was 52.8 ± 25.8, ranging from 7 to 134 heads of cattle. The following genotypes: Cross bred (CR) 58.8%, Zebu (ZB) 23.2% and Taurine cattle (TA) 18.0% which were not uniformly distributed neither across nor within herds were identified. Sex ratio was two thirds of females (70.6%), one third of males (28.1%) and a low proportion (1.3%) of castrated males. No mature TA males compared to 53.3% of the male ZB and 31.4% of the male CR, were indicated as potential sires. Investments in purchase of animals were higher in Small than in Medium and Large herds; of all purchased sires 53.8% were found in Small herds vs. 28.2% and 18.0% in Medium and Large. Herd property was equally distributed between single (56.8%) and multi property (43.2%). There was more manpower available per 100 cows in Small, being almost double and triple than in Medium and Large herds. Although milk extracted, was similar in all clusters averaging 2.4 ± 0.5 litres/day/cow, milk off take rate, due to higher proportion of lactating cows, appeared higher in Small herds.

Keywords: Africa, cattle, dairy herds, structural traits, management, peri-urban

1 Introduction

Milk production in sub Saharan Africa is a sensitive issue. Relevant studies point out that in this part of the continent milk production has continuously increased from the early 1960s until the late 1980s, underlining however that to fulfil the enhancing demand, production should increase by about 4% per year until 2025. By that date, human population in sub Saharan Africa will increase by nearly 800 million, of which 55% will live in towns (Winrock, 1992). Based on this assumption to meet the demand, milk

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production should reach 45 million tons per year, and this growth should be stronger in peri urban areas (Tacher *et al.*, 2000). Unfortunately throughout sub Saharan Africa, although with regional differences, farmers still look at dairying in broad terms (Udo and Cornelissen, 1998). In general cattle are raised with several output objectives: milk production for selling and self consumption, social status, risk diversification, exploitation of manure for fertilization and draught power for cash crop and cereal cultivation (Slingerland and Savadogo, 2001). Since Africa is marked by deep regional differences, a clear understanding of the constraints and opportunities characterising the local production systems (available livestock, management etc.) would help to design and implement, sustainable policies and strategies (Bebe *et al.*, 2002). The study was carried out in the peri urban area of Bobo Dioulasso, sub humid zone of south western Burkina Faso, considered as one the most potential zones to enhance milk production through the integration of crops and livestock farming system (Touré, 1992).

2 Material and Methods

The study area was located at a longitude of 11° 8' N and at a latitude of 4° 11' W with mean minimum and maximum temperature ranging from 17°/23°C to 33°/37°C respectively. Four distinct seasons are acknowledgeable, dry cool, dry hot, wet cool and wet hot. Average annual rainfall is about 1100 mm, falling from June until October. The animals considered in this study were included in a FAO dairy development project (Faso Kossam) and amounted to 4834 heads of cattle. The survey, carried out from May to July 2003, intended to characterise herd distinctive traits through direct data collection on the animals: number of heads, genotype, age, sex, age at first calving, and milk individually produced at the day of the interview. Questions asked to the herdsman referred to age, origin, and the foreseen or actual use of each individual animal at the time of interview. Moreover, social and management aspects were investigated: status of the herdsman (proprietor, non proprietor), nature of ownership (single, multiple), availability of aid herdsman (none, at least one), their salary (none, cash, goods), feed complementation (yes, no, why), watering and estimated distance to water the animals, grazing and milking regimes, transhumance. The herds included in the study were spread in a radius of 50 km around Bobo Dioulasso, commonly considered the peri urban milk production basin of the town. Animals were assigned to specific genotypes according to phenotypic characters: Zebu (ZB), Taurine (TA) and intermediate Crossbred type (CR). Direct observations as well as interviews were carried out by qualified "ingénieurs d'élevage", fluent in both local languages, Fulani and Dioulà. To run statistical analysis on herd structure, the whole lot of herds was split into three clusters scored as Small (≤ 38 heads), Medium (> 38, ≤ 61 heads) and Large ones (> 61 heads) each including about 30% of the animals: 32% (1547) animals were included into Small herds, 33.9% (1642) animals in Medium and the remaining 34.1% (1645) animals in Large herds. The analysis was carried out with SPSS 5.1 ®, by one way ANOVA, non parametric Kruskal Wallis test to compare herds composition for not normally distributed samples and Chi Square test to compare frequencies and proportions. Means are always reported $\pm$ standard deviation.

3 Results

3.1 Herd size and sex ratio

The overall mean herd size was 52.8±25.8 ranging from 7 to 134 heads of cattle. As result of the clustering Small herds (62) averaged 28.2±7.1, Medium (35) 46.5±6.4 and Large ones (21) 82.7±20.5 heads of cattle. Out of 4834 heads the majority of cattle (58.8%; 2840 heads) were scored as CR type whereas ZB represented 23.2 % (1125 heads) and only 18.0 % (869 heads) were classified as TA ($P<0.001$). The distribution of ZB cattle was similar in Small (37.6%) and Medium herds (34.4%), and statistically different from the two other in Large (28.0%) ($P<0.05$). The allocation of TA animals differed between the clusters ($P<0.001$), being 18.4%, 45.2%, and 36.4% in Small, Medium and Large herds. Concerning CR, their proportion across herds did not differ between Small and Large herds (34.1% vs. 35.6%) but was different between Medium (30.3%) and Small ($P<0.05$) and between Medium and Large herds ($P<0.001$). The details of genotypes distribution within each cluster are outlined in Table 1.

Table 1: Genotypes of cattle in 118 dairy herds of the peri-urban area of Bobo Dioulasso, Burkina Faso

	Clusters		
Genotype	*Small (%)*	*Medium (%)*	*Large (%)*
Zebu	27.1 [a]	23.7 [a]	19.2 [a]
Taurine	10.4 [b]	23.9 [a]	19.2 [a]
Crossbred	62.5 [c]	52.4 [b]	61.6 [b]
(n)	(1547)	(1642)	(1645)

(n) = Number of animals; values in the same column, with different superscripts ([a], [b], [c]), differ by $P<0.05$.

The analysis of the overall sex ratio revealed that over two thirds of the animals were females (70.6%, 3411), about one third males (28.1%, 1357) and a very low proportion (1.3%, 66) castrated males. The analysis of the sex ratio by clusters considering only productive animals >3 years (2143) is presented in Table 2. The analysis of the overall sex ratio revealed that over two thirds of the animals were females (70.6%, 3411), about one third males (28.1%, 1357) and a very low proportion (1.3%, 66) castrated males. The analysis of the sex ratio by clusters considering only productive animals >3 years (2143) is presented in Table 2.

As outlined in the table more pubertal ZB females ($P<0.05$) were encountered in Small than in Medium and Large herds, in which conversely the proportion of TA was higher ($P<0.001$). In all herds CR cows represented the majority of females although the fraction they represented differed ($P<0.05$) across clusters of herds. Concerning adult

Table 2: Proportions of productive females and males (>3 years) available in 118 peri-urban dairy herds of Bobo Dioulasso within clusters and according to genotype.

	Clusters					
	Small	*Medium*	*Large*	*Small*	*Medium*	*Large*
Genotype	*F (%)*	*F (%)*	*F (%)*	*M (%)*	*M (%)*	*M (%)*
ZB	23.3 [a]	19.4 [a]	15.4 [b]	44.8 [a]	47.8 [a]	38.0 [a]
TA	12.7 [a]	32.3 [b]	26.8 [c]	6.0 [a]	16.4 [b]	5.0 [a]
CR	64.0 [a]	48.3 [b]	57.8 [c]	49.2 [a]	35.8 [b]	57.0 [c]
(n)	(631)	(624)	(676)	(66)	(67)	(79)

(n) = Number of animals; F = females, M = males; values in the same column, with different superscripts ([a], [b], [c]), differ by $P<0.05$.

males a statistical difference was observed between the three clusters ($P<0.001$) for CR and TA but not for ZB (Table 2).

3.2 Use of the animals

Table 3 summarises the indications of use for males, outlined by genotype. For animals <3 years more ZB ($P<0.001$) were not yet allocated to a specific use compared to TA and CR; whereas a smaller proportion ($P<0.001$) was pointed out for cash earning. The picture radically changed for animals >3 years, statistically more ZB were perceived as suitable for breeding than CR and TA (Table 3).

Particularly TA were clearly indicated as source of cash or traction but not considered appropriate as sires in both <3 and >3 years class of age. Conversely, for ZB and CR very few animals were indicated as potential sires within the class of age <3 years, while their proportion increased tremendously for animals >3 years. Table 3 are also shows that significantly more ZB ($P<0.05$) were designated for breeding than CR, the opposite occurred for draught animals. Females were essentially foreseen for milk production irrespective of the class of age.

3.3 Animal origin, herding, property

The analysis on animals' origin indicated that, up to 86.3% (4170) of the animals were inborn, 4.3% were purchased (210), 9.0% (436) entrusted to the herds, and a very low proportion represented gifts (0,4%). The overall sex ratio of purchased animals was 80.0% females, 18.6% males and 1.4% castrated. Purchasing and entrusting of animals was related to the herd size. Of the purchased animals, 46.7%, were acquired by Small herds, 20.0% by Medium, and 33.3% by Large ones ($P<0.001$), while up to 42.4% (185/436) of entrusted animals were in Large herds, 37.4% (163/436) in Medium and 20.2% (88/436) in Small ones. In Small herds, proportions of purchased and

Table 3: Proportions for entire males available in the 118 peri-urban dairy herds of Bobo Dioulasso by classes of age and genotype according to indication of use

	Classes of age and Genotypes					
	<3 years			*>3 years*		
Indication of use	*ZB*	*TA*	*CR*	*ZB*	*TA*	*CR*
Undecided	58.8 [a]	34.3 [b]	36.8 [b]	2.2 [a]	5.3 [a]	9.8 [c]
Sale	27.8 [a]	43.2 [b]	38.6 [c]	5.4 [a]	26.3 [b]	5.9 [a]
Mating	6.2 [a]	—	3.6 [b]	53.3 [a]	—	31.4 [b]
Traction	7.2 [a]	22.5 [b]	21.0 [b]	39.1 [a]	68.4 [b]	52.9 [c]
(n)	(291)	(102)	(604)	(92)	(19)	(101)

(n) = number of animals; values in the same row for the same class of age with different superscripts ([a], [b], [c]), differ by $P<0.05$

entrusted animals were 48.3% and 43.3% (8.4% gifts); in Medium and Large herds these proportions were 20.4% purchased 79.1% entrusted (0,5% gift) 27.5%, purchased 72.5% entrusted (0% gift) respectively ($P<0.001$). Of the 118 herds involved in the study, 83 were managed by their proprietor, while 35 (29.6%), were run by hired herdsmen. Of the hired herdsmen, 68.6% (24) were remunerated in cash and goods, and 31.4% (11) compensated in kind. The large majority (82.8%) of the salaried herdsmen managed single property herds, while the totality of those compensated managed multi property herds. The proportion of herds belonging to one 56.8% (67) or more owners 43.3% (51) was similar ($P>0.05$), with no difference ($P>0.05$) in the mean herd size, although single property herds were smaller (37.7 ± 21.2) than multi property ones (44.3 ± 22.8). About half of the Medium (51.4%) and Large (47.6%) herds were multi property vs. only 37.1% of the Small herds ($P<0.05$). The availability workers unit per hypothetical 100 cows differed ($P<0.001$) in the three clusters, being 9.7 ± 3.2, 5.0 ± 2.7, 2.9 ± 1.0 in Small, Medium and Large herds.

3.4 Feeding and milking regimes

A high proportion of herds, 83.9% (99), were complemented with no statistical difference ($P>0.05$) in the mean herd size, 37.9 ± 18.1 for complemented herds and 56.5 ± 33.8, for those non complemented; even though the proportion, of complemented herds decreased as the size of the herd increased (Table 4). Table 4 also reports the proportion of herds carrying out transhumance per each cluster; for all herds the reason for transhumance was difficult access to grazing areas due to intense cropping in the rainy season.

The length of transhumance averaging 3.9 ± 1.3 months was not influenced by herds size. Daily grazing was an ordinary practice, 95.8% of the herdsmen guided the herds, and only 4.2% of the farmers owing very small herds, averaging 15.2 ± 3.4 heads, grazed

Table 4: Proportion of complemented 118 dairy herds carrying out transhumance and season of transhumance outlined by clusters

	Complemented	*Transhumant*	*Season of transhumance*	
Cluster (n)	*Yes (%) (n)*	*Yes (%) (n)*	*Dry (%) (n)*	*Rainy (%) (n)*
Small (62)	93.6 [a] (58)	12.9 (8)	0.0 (0)	0.0 (8)
Medium (35)	80.0 [b] (28)	48.5 (17)	0.0 (0)	100.0 (17)
Large (21)	61.9 [c] (13)	80.9 (17)	0.0 (0)	100.0 (17)

(n) = number of herds; figures in the same column with different superscripts ([a], [b], [c]), differ by $P<0.05$

their animals close to the settlement. The average daily grazing time was 9.8±1.2 hours, ranging from 9 to 12 hours, with no statistical difference ($P>0.05$) referring to both mean herds size and clusters. Watering was assured once a day for all herds. During the rainy season 42.4% of the herds walked an average distance of 7.2±2.2 km (back and forth) for watering, the remaining 57.6% got water close to the settlement (< 1 km), this proportion decreased in the dry season to 6.7% whereas 93.3% walked an average daily distance of 12.3±4.2 km. Among females from 3 to 4 years, 35.3% had calved at least once. The analysis by cluster indicated that this proportion was higher ($P<0.05$) in Small 40.1% (67/167) than in Medium 33.4% (84/251) and Large herds 34.0% (84/247). In all herds milk produced was channelled to both selling and home consumption. More herds ($P<0.001$), were milked once a day 75.4% (89) than twice a day 24.6% (29). Although the herds milked once a day appeared larger (44.0±23.4) than those milked twice (30.9±13.5) there was no statistical difference in the mean herd size ($P>0.05$). Of the herds milked twice a day 72.4% (21) were Small, 24.1% (7) Medium and 3.5% (1) Large, the same herds represented 33.8%, 20.0%, and 4.7% of Small, Medium and Large herds ($P<0.001$). Of the 29 herds milked twice 26 (89.6%) were managed by their proprietors and 3 were not. The average daily milk production was 2.4±0.5 litres/cow with no statistical difference between Small (2.5±0.7), Medium (2.3±0.4) and Large (2.1±0.6) herds and cows milked once or twice a day. The proportion of milking cows, on the totality the herd was similar ($P>0.05$) between Medium (22.7%) and Large herds (20.6%) but higher ($P<0.001$) in Small herds (34.1%).

4 Discussion

Herd size presented a great variation ranging from herds with few heads of cattle (< 10) to very large ones (>130). The overall herd composition generally fits with herds of Type A recently described for the area by HAMADOU *et al.* (2003) and other authors (SIDIBE *et al.*, 2004), characterised by the predominance of CR followed by ZB and then TA. This indicates the low degree of specialization of the dairy sub sector. Moreover, within the herds of the FAO project, we could identify productive units similar to the

herds scored as Type B (Hamadou *et al.*, 2003), characterised by specific tropical dairy breeds. Dissimilarly to what is reported in related studies (Sidibe *et al.*, 2004) our data show that Small herds (52.6%) largely above Medium (29.6%) and Large (17.8%). Unfortunately the authors do not report the mean heard size making any comparison impossible, although the difference might be due to a different clustering system. Our results indicate that there is a relationship between the herd size and the proportion of genotypes building up the herd. The presence of ZB cattle decreases as the size of the herd increases, in Small herds their proportion is higher than TA whereas in both Medium and Large herds, ZB and TA are equally represented. More specifically in Small herds ZB females account for 23% of females, 19% and 15% in Medium and Large herds. The proportion of milking cows also varies according to the herd size; it is higher in Small herds (34%) which in line with the findings of Adu *et al.* (1998), than in Medium (24%) and Large herds (16%). This suggests that smaller herds are build up with a more specific milk orientation towards milk production obtained by a high percentage of Zebu females considered better dairy cows (Hamadou and Kamuanga, 2004) whereas the proportion of CR cows is explained by the need to raise trypanotolerant animals (Tano *et al.*, 2001). This relationship between the size of the herd and a more milk oriented output mirror what reported for to the eastern part of the continent (Bebe *et al.*, 2002). Livestock keepers strategy to keep more dairy and/or more trypanotolerant animals (Touré, 1992) also suitable for traction (Kamuanga *et al.*, 2001), is achieved through the use of ZB or CR sires since no TA males are ever indicated as potential breeding bulls, but rather indicated instead as source of cash or had an uncertain destination. It is significant that the overall sex ratio (30% of males) is still in line with studies conducted in West Africa over the last thirty years (Pullan, 1979; Landais and Cissoko, 1986; Njoia *et al.*, 1997), indicating that very little has changed in the management system: still based on plethoric and unspecialised herds. The proportion of animals representing a real investment (purchased) is in general very low, it is just 4.3% of the totality of the animals introduced (14%), and just one out of five is a male, suggesting that no specific importance is attached to genetic upgrading through male outsourcing. This conflicts with what was reported for smallholder dairy system in the Kenya highlands (Bebe *et al.*, 2002) but matches perfectly with the work of Hamadou *et al.* (2003) carried out in the same area, which [defining these herds as "troupeau naisseur"] emphasizes that on a continental basis milk production is dissimilarly perceived and developed. Anyhow within this system, the equivalent proportion between purchased and entrusted animals, points towards a higher level of investment in Small herds compared to Medium and Large herds in which entrusted animals are were the majority. Additionally over 50% of the animals purchased, were found in Small herds, reinforcing the idea of a more focused management. The level of investments in herding appear higher in single property herds where 83.3% of the herdsmen (non proprietors) were remunerated whereas under multi property conditions 100% of hired herdsmen were compensated in goods. In the study area single or multiple property herds were equally distributed conversely to what is reported for The Gambia (Jaitner *et al.*, 2003) where only about 8% of the herds were of single property. The same work indicates that single property herds were larger than those multi property, dissimilarly

to our findings. Although the difference was not statistically significant, single property herds were smaller (37.7±21.2) than multi property ones (44.3±22.8). This is in relation with the widespread tradition to entrust animals of different ownership to one single herdsman constituting large herds (ITTY, 1992). In Small herds the proportion of entrusted livestock remained low (40%) compared to over 70% in Medium and Large ones because of the relatively low percentage (37.1%) of Small herds in multi property. The production of milk as double purpose activity, for self consumption and cash income, was also shown in previous studies conducted in eastern and western Africa (ADU *et al.*, 1998; BEBE *et al.*, 2003) and confirms that in the sub humid zone, in spite of its potential (TOURÉ, 1992; KAMENI *et al.*, 1999; DIEYE *et al.*, 2002) there is still a lack of proper market-oriented milk production sub sector. Although mean daily milk production (2.4±0.5) was similar for the three clusters and comparable to the reported yield (COULIBALY and NYALIBOULY, 1998; BAYEMI *et al.*, 2005), milk off take appeared higher in Small herds than in Medium and Large ones, because of the higher rate of lactating cows in Small herds and the higher proportion of cows that had calved within the fourth year; both likely due to a better feeding regime. Only 6.4% of Small herds were not complemented compared to 20.0% and 38.1% of Medium and Large herds, which in turn played an important role on transhumance since only 12.9% of Small herds, practiced transhumance against respectively 48.5% and 80.9% of Medium and Large ones. It appears evident that under peri urban conditions availability of grazing land during the growing season is a striking problem although less acute for smaller herds which can more easily meet their nutritional requirements. This goes along with the statement that under peri urban conditions smaller units are easier to manage and perform better (BEBE *et al.*, 2002; HAMADOU *et al.*, 2003). Lower complementation rates in Medium and Large herds might be also due both multiple ownerships generating conflicts in the management decision process and owners forced to accept essential expenditures (herdsman charges) but keeping complementation costs at low level. On this matter BENNISON *et al.* (1997) suggested that conflicts arise in the decision process, between the owner/s and the hired managers as well as between different owners on the choice of management procedures.

Concerning the option of milking once or twice a day we couldn't come to a definite conclusion. It is likely a multi factorial choice driven by; (i) the size of the herd: in smaller herds the lower amount of labour required for management and the higher number of available active workers per cow might increase time for milking; (ii) the status of the herdsman: double milking was preponderantly encountered in herds managed by an herdsman-owner with an evident choice to maximise milk off take, (iii) a labour conflict: it is possible that in herds managed by hired, compensated herdsmen, labour conflicts on milking arise on the basis of a non specific contract (JAITNER *et al.*, 2003).

We can conclude that in the study area, the peri urban milk production sub sector suffers from low specialization, and is hindered by several factors: (i) scarce presence of specialized tropical dairy breeds, (ii) insufficient watering facilities and grazing land, forcing farmers into long displacement and transhumance in the rainy season, (iii) low proportion of milking cows, and (iv) multiple property which preclude focused management.

Among the productive units, smaller herds seems to answer better to a sustainable peri urban dairy production. They are characterised by (i) higher and more focused management and investments on dairy animals (ZB), (ii) lower nutritional constraints, (iii) higher proportion of milking cows, and (iv) a lower proportion of herds in multi property management.

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References

Adu, I. F., Aina, A. B. J., Fanimo, A. O., Idowu, A., Okeleye, K. A. and Aromolaran, A. B.; Peri urban dairy production in Ogun State; *Nigerian Journal of Animal Production*; 25:83–87; 1998.

Bayemi, P. H., Bryant, M. J., Perera, B. M. A. O., Mbanya, J. N., Cavestany, D. and Webb, E. C.; Milk production in Cameroon: A review; *Livestock Research for Rural Development*; 17(6):Art.#60; 2005; URL `http://www.cipav.org.co/lrrd/lrrd17/6/baye17060.htm`.

Bebe, B. O., Udo, H. M. J., Rowlands, G. J. and Thorpe, W.; Smallholder dairy systems in the Kenya highlands: breed preferences and breeding practices; *Livestock Production Science*; 82:117– 127; 2003.

Bebe, B. O., Udo, H. M. J. and Thorpe, W.; Development of smallholder dairy systems in the Kenya highlands; *Outlook on Agriculture*; 31:113–120; 2002.

Bennison, J. J., Barton, D. and Jaitner, J.; The production objectives and feeding strategies of ruminant livestock owners in The Gambia: implications for policy makers; *Agricultural Sysems*; 5:425–444; 1997.

Coulibaly, M. and Nyalibouly, O.; Effect of suckling regime on calf growth, milk production and off take of zebu cattle in Mali; *Tropical Animal Health and Production*; 30:179–189; 1998.

Dieye, P. N., Faye, A., Seydi, M. and Cissé, S. A.; Peri urban and increase of the income of small farmers in rural Senegal; *Cahiers Agricultures*; 11:251–257; 2002.

Hamadou, S. and Kamuanga, M.; Farmers perceptions and assessment of cattle traits in periurban dairy system of Bobo Dioulasso (Burkina Faso); *Revue Africaine de Santé et de Productions Animales*; 2:56–61; 2004.

Hamadou, S., Marichatou, H., Kamuanga, M., Kanwé, A. B. and Sidibé, A. G.; Diagnostic of periurban dairy farms: typology of farms in the periphery of Bobo Dioulasso (Burkina Faso); *Journal of Agriculture and Environment for International Development*; 97:69–92; 2003.

Itty, P.; *Economics of village cattle production in tsetse affected area of Africa: a study on trypanosomiasis control using trypanotolerant cattle and chemotherapy in Ethiopia, Kenya, Côte d'Ivoire, The Gambia, Zaire and Togo*; Hartung Gorre Verlag, Konstanz, Germany; 1992.

Jaitner, J., Corr, N. and Dempfle, L.; Ownership Pattern and Management Practices of Cattle Herds in The Gambia: Implications for a Breeding Programme; *Tropical Animal Health and Production*; 35:179–187; 2003.

Kameni, A., Mbanya, N. J., Nfi, A., Vabi, M., Yonkeu, S., Pingpoh, D. and Moussa, C.; Some aspects of the peri urban dairy system in Cameroon; *International Journal of Dairy Technology*; 52:63–67; 1999.

Kamuanga, M., Sigue, H., Swallow, B., Bauer, B. and d'Ieteren, G.; Farmers' Perceptions of the Impacts of Tsetse and Trypanosomosis Control on Livestock Production. Evidence from Southern Burkina Faso; *Tropical Animal Health and Production*; 33:141–153; 2001.

Landais, E. and Cissoko, M.; Bases méthodologiques du contrôle des performances animales pour l'analyse zootechnique et démographique: Collecte des données et choix des variables; In: Actes du séminaire: Méthodes pour la recherche sur les systèmes d'élevage en Afrique intertropicale; Mbour, Sénégal; IEMVT/ISRA; 1986.

Njoia, A., Bouchel, D., Ngo Tama, A. C., Moussa, C., Martrenchar, A. and Letenneur, L.; Systèmes d'élevage et productivitè des bovines en milieu paysan au Nord Cameroun; *World Animal Review*; 89:20–38; 1997.

Pullan, D.; Productivity of Fulani cattle on the Jos Plateau, Nigeria I: Herd structure and Productivity performance; *Tropical Animal Health and Production*; 11:231–238; 1979.

Sidibe, M., Boly, H., Lakouetene, T., Leroy, P. and Bosma, R. H.; Characteristic of Peri urban Dairy Herds of Bobo Dioulasso (Burkina Faso); *Tropical Animal Health and Production*; 36:95–100; 2004.

Slingerland, M. and Savadogo, M.; Livestock production in Sahelian villages; in: *Agro-Silvo-Pastoral Land Use in Sahelian Villages*, edited by Stroosnijder, L. and van Rheenen, T.; Advances in Geoecology 33; chap. 4, 267–274; CATENA Verlag, Reiskirchen, Germany; 2001.

Tacher, G., Letenneur, L. and Camus, E.; A perspective on animal protein production in Sub-Saharan Africa; *Annals of the New York Academy of Sciences*; 916(1):41–49; 2000.

Tano, K., Kamuanga, M., Faminow, M. D. and Swallow, B. M.; Adoption and demand for trypanotolerant cattle in the sub humid zone of West Africa; *Journal of Agriculture and Environment for International Development*; 95:213–236; 2001.

Touré, S. M.; Préservation de l'environnement et intensification de l'élevage dans les zones humides et subhumides de l'Afrique occidentale; in: *Actes de la septième conférence de l'AIMVT, Yamoussoukro; Septembre 1992*; 707–715; CIRAD EMVT Ed.; 1992.

Udo, H. and Cornelissen, T.; Livestock in resource-poor farming systems; *Outlook on Agriculture*; 27:237–242; 1998.

Winrock; *Animal Agriculture in Sub-Saharan Africa*; Winrock International Institute for Agricultural Development, Morrilton, Arkansas, USA; 1992.