Biological and economic performances of an intensified management system for village Ndama cattle in mixed farming systems of West African sub-humid zones.

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Abstract

This study investigated biological effects and the profitability of a management package (INTMS) based on the stabling of village Ndama cows and adult males and that included supplementary feeding, health care and housing. The productivity of 187 animals that benefited from the package was compared with that of 13 1 animals reared on an extensive traditional basis (EXTMS). The package increased the productivity of animals. INTMS cows maintained PCV and LW whereas EXTMS cows suffered decline in PCV and lost 17% of their initial LW. Total milk offtake for human consumption was greater in INTMS cows (7654.4 litres in 80 days) than in EXTMS cows (18±6.4 litres in 37 days). LW growth rates were greater in calves of INTMS cows (153 g/day) than in calves from EXTMS cows (26 g/day). Growth rates were -438 and 139 g/day in EXTMS and INTMS adult males, respectively. An average of 4.8 kg/night/250 kg live weight of manure (faeces + litter + urine) was produced in stables. Stabling operations were financially profitable as net benefits accounted for 45-51% of marginal benefits. However profitability was sensitive to prices of concentrate feed and of milk. Marginal benefits were made up of value of increased LW (43-55%) and value of milk offtake (24-27%) and manure (6%).

Key words: Ndama cattle, intensified management, productivity, profitability

Introduction

The combined effect of population growth, drought and reduced soil productivity has caused a decline in per capita food production in Senegal during the past 2 decades. The need to increase agricultural production to reverse the trend of widening gap between domestic food demand and supply is a great challenge facing the agricultural sector. It is recognised that opportunities to increase agricultural production exist in the subhumid zones and in wetter areas of semi-arid areas of sub-Saharan Africa (Mohamed Saleem et al., 1995). This is because rainfall in these areas is still more reliable and sufficient for major crops (cotton, millet, sorghum, groundnut) and that there is relatively enough land to support expansion of cultivated areas. The potential to increase agricultural production in sub-humid zones lies also on the intrinsic merits of mixed farming systems found in these areas in terms of efficiency of food production. Draught animal power is used for cultivation and transport and crop residues form valuable feed resources during the dry season. Animal manure allows cropping each year of fields around the homesteads where cereals are grown.

Because of their high potential for agricultural production, sub-humid zones are attracting more human and animal populations. As a result more land is being cleared for cropping at the expense of forest resources. Furthermore, livestock production systems in sub-humid zones are operated on an extensive land use basis with minimal extemal inputs. Further intensification of the livestock component is needed to enhance the efficiency of the association between crop and livestock in the mixed farming system, to increase agricultural production and to ease pressure on land in the long run. A mode1 of intensification of livestock production in mixed farming systems in sub-humid zones based on dry season stabling of cattle with supplementary feeding and improved health care, and housing, is being developed in southern Senegal. This was originally designed to address the problem of reduced soil fertility in the area where cotton is produced through increased manure production of a good quality in animal stalls. Stall-feeding of draught cattle during the dry season was also expected to result in more animal power input to cropping because they

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would be in better condition at the start of the cropping season to perform well. Therefore draught cattle were the preferred category of cattlé to be stabled. It was later realised that retums from manure and draught animals power alone could compensate hardly for the investments incurred for the establishment of stables and for their operating costs. As a result, stabling of lactating females was suggested so that revenues generated through milk sales and household milk consumption could make stabling more profitable. This paper reports on findings of a study that investigated the biological effects and the profitability of this intensified management system for village Ndama cattle in the sub-humid zones of Senegal.

Material and methods

The study area and cattle herd management

This study was carried in 1991 and 1992 in the Upper Casamance region of southem Senegal. The climate in this region is of a sudano-guinean type. Rainfall was 787 and 684 mm in 1990 and 1991, respectively. Farmers grow cash crops (cotton and groundnut) as well as food crops (millet, sorghum and maize). Multipurpose Ndama cattle used for meat, milk, power and manure, make up the dominant livestock biomass. Cropping and livestock activities are undertaken by the same household and they are closely interrelated and complementary.

Animals graze on natural pastures which form the main source of food supply. Pastures are abundant and of good quality during the rainy season and early dry season. After harvest of the grain, animals have also access cereal crop residues (millet, sorghum, rice) consumed directly in the fields. Shortage of food supply during the critical months of March, April, may and June is the single most important constraints facing herd owners in this area. Animal are tethered ovemight on cereal crop fields during the dry season and are moved into the forest during the cropping season to avoid damage to crops. Nutrient cycling through direct manure deposition allow cropping each year of fields at the vicinity of the homesteads.

Mating is not controlled and calving occurs all year round. However most of the calvings take place during the second half of the year and peak calving is recorded in July and August. Milking is performed once a day, and it starts one week after calving. The calf is allowed to suckle for few seconds to stimulate milk let-down and thereafter, it is tethered to the leg of the dam during the course of milking. The residual milk is suckled by the calf. Suckling of calves takes places a second time in the evening when adult animals retum from grazing. Calves are tethered over night away from cows to avoid suckling. A main feature of the milking system in the Kolda area is that milk extraction for human consumption is suspended during part of the dry reason and milking is resumed during the next vvet season.

In the present study the intensified management system (INTMS) is referred to as a combination of strategic feed supplementation, better health care and housing during the dry season for a limited number of animals selected from the main herd. Other animals in the herd are managed under extensive management conditions (EXTMS) and therefore do not benefit from these improved management measures.

Experimental design

Research sites, animals and treatments

A total of 3 18 animals distributed into 7 stables in 4 villages were used in this study for regular monitoring of health and production parameters. Animals were divided into 2 groups. Croup 1 was composed of animals in the intensive management system (78 adult females, 79 calves and 30 adult males). In addition to grazing natural pastures, INTMS animals are fed daily a supplement, from February-March to June, l-l.5 kg of cotton seed and 3-4 kg of

groundnut hay. Calves were not given feed supplement, but they benefited from their dam's feed allowance and also fi-om the improved milk production brought about by the supplementary feeding of their dam.

Health measures include vaccination (against anthrax, hemoragic septicaemia), deworming using fenbendazole (PanacurND, Hoechst, A.G.) and trypanocidal treatments of animals using Aceturate Diminazene (BerenilND , at a dose of 3.5 mg/ kg LW).

Animals were housed in stalls built within the homesteads. The floor of the stall is usually a pit where the animals stay ovemight to allow the accumulation of urine and faeces. The litter is formed by bush hay or crop residues that are regularly added into the pit. Many types of stall are found in this area depending on size and whether or not cernent is used. Large stables can accommodate up to 30 adult animals whereas small size stables can house just 2 to 4 animals. The walls of the pit may be cemented or not. Cemented stalls require more capital investment for their establishment, they however have a longer life in comparison to non cemented stalls which tend to deteriorate because of the erosive effect of water runoffs and damages caused by animals.

Group 2, the control group, was formed by animals (66 adult females, 48 calves and 17 adult males) which was selected from the same herd to match as much as possible age categories and physiological status of animals in group 1, but which were managed under traditional extensive conditions (EXTMS). They were grazed on natural pastures without supplementation and they were not subjected to any prophylactic and treatment measures.

Field measurements and laboratory analyses

All animals were weighed at the beginning, midway and at the end of the experiment. Milk offtake for human consumption was measured each week using graduated tubes. Additional data collected during the experiment included herd entries and exit, quantity of food supplement given to animals and inputs (food, drugs, labour) and output prices (live animals, milk, rental of draught animals).

Blood samples were taken fi-om each animal at the start, midway and end of the operation in evacuated tubes containing EDTA to detect the presence of trypanosomes using phase contrast examination of the blood buffy coat (Murray et al., 1983) and for the determination of the packed red cell volume per cent (PCV). Blood smears were also made to detect other blood parasites such as anaplasma spp. and babesia spp. Faecal samples were collected fi-om the rectum of the animals and they were examined for the presence of gastrointestinal parasites and the estimation of worm burden using McMaster egg counting technique, Serological tests were also applied to detect the presence of brucellosis and leptospirosis. At the end of the stall-feeding operation, manure produced in 2 stalls were weighed and samples were taken for the determination of their chemical composition.

Data analysis

Production and health parameters

Live weight (LW) change, milk offtake, PCV % and the prevalence of blood and gastrointestinal parasites were analysed using General Linear Mode1 procedures (SAS, 1989). Sources of variation for the analysis of LW and daily weight gain in different age classes included village, stable within village and treatment eitlher INTMS or EXTMS. Live weight of

each animal was regressed on the number of days of stabling and the slopes of the regression lines were subjected to analysis of variance using initial LW as a covariate. Parity and season of calving were also included as sources of variation in the analysis of milk offtake.

Financial analysis

The partial budgeting approach was used to estimate the profitability of the intensive management system. Therefore only marginal benefits, marginal costs and net benefits brought about by the adoption of the INTMS were considered in the analysis (Harsh et al., 1981). Net returns generated by the INTMS are the difference between marginal benefits gained and marginal costs incurred by shifting from traditional, extensive management systems to the improved management system. Four types of stall were used to evaluate the profitability of the stabling package: type 1: large, cemented stable accommodating 20 adult females and 10 adult males, type 2: large, non-cemented stables with 20 lactating cows and 10 adult males, type 3: cemented stable of medium size with 6 cows and 4 adult males, type 4: non-cemented medium size stable with 6 cows and 4 adult males.

Marginal benefits generated by the INTMS include increased revenues through milk ofttake, LW gains, reduction in losses due to mortality and manure production. Marginal benefits associated with milk production and LW gains were estimated as the production differential between INTMS and EXTMS. Market prices for milk were applied to both marketed and non-marketed milk production. Value of LW gains were set using market prices of live animals at the village level. Stall manure was valued using its chemical fertiliser equivalence. When animal excretions are deposited directly to the fields, nutrient (mainly N) losses estimated at 38% of the nutrient content of fresh excretions (Hamon, 1972). The marginal benefit generated by manure production in stalls was set as the reduction in these nutrient losses. Marginal costs of the INTMS include increased expenses associated with the investment to establish the stall, purchased food supplement and health care supplies. When feed resources used to supplement animals such as groundnut hay were produced on-farm, the opportunity cost of these commodities was applied in the analysis using local market prices. A sensitivity analysis was performed to investigate the effect of changes in input and output prices on the profitability of the INTMS.

Results and discussion

Health characteristics

Prevalence of trypanosome and gastrointestinal parasites is referred to as the number of samples detected parasitaemic over the number of samples. Trypanosome prevalence was low (1.4%). Although animals were treated at the start of the stabling period with Aceturate Diminazene (Berenil^{R}), there were new infections in all age categories. The emergence of new infections raise the question of the relevance of systematic treatment of all INTMS animal with Berenil. Where diagnostic facilities exist, it would be suggested to treat only animals that showed signs of the diseases were detected parasiteamic. In the absence of diagnostic facilities, it is suggested to treat only stall-fed animals planned to be used for work and that treatment could be done at the end of the stabling period. Experiments conducted at Kolda (Seck personnel communication) showed that Ndama oxen infected with new serodemes of trypanosomes performed less work than non-infected animals. Prophylactic interventions using trypamidium may be preferred in areas where the risk of trypanosomiasis is high.

The prevalence of anaplasma was also low (1.2%). However, the impact of this disease on productivity appeared significant. Indeed, of the 10 animals infected with Anaplasma, 2 died,

one disappeared and 3 of them were sold after they suffered severe LW losses of 16% of their initial LW. The treatment of INTMS animals with anthelmintics proved effective as the prevalence of gastrointestinal parasites was lower in these animals compared to EXTMS animals were not drenched (Table 2).

Serological tests performed on 162 blood samples revealed that 3 animals had brucellosis and 39 of them were infected with leptospirosis. Because these affections can cause abortion and therefore lower the reproductive performance of cows and also because of the implication of brucellosis on public health, these diseases deserve further investigation to assess their impact so that appropriate health measures could be devised.

Feed supplementation and health measures had a positive effect on the capacity of animals to resist anaemia. Although there was a trend of PCV to decline during the first phase of the stabling operation (Table 2), supplemented animals were able to increase PCV to starting levels whereas PCV in EXTMS animals remained low due to the combined effect of nutritional and infectious stresses they are subjected to during the dry season.

Productivity

It is assumed that productivity gains observed in INTMS as compared to EXTMS are due to the combined effects of feed supplementation and health care. The severe nutritional stress animals are subjected to during the dry season cause retarded growth in growing animals and pronounced LW losses in adult animals. As nutrient intakes during the dry season do not match nutrient requirements, animals mobilise their body reserves stored as fat. Depletion of body reserves leads to the use of muscular tissues to assure maintenance. This is the main cause of poor productivity observed in traditional extensive livestock production systems where animals experience food shortages during the long dry season. This nutritional deficit translates into reduced milk production, post-partum acyclicity and reduced growth. The main objective of the INTMS package is to minimise the deleterious effect of this nutritional stress by means of feed supplementation of selected animals. In the present study, calves that were stabled benefited from the improved milk production of their dam, they also had the opportunity to share food supplement intended for their dam. Therefore they grew at a much greater rate (153 g/day) than EXTMS calves (26 g/day). The anthelminthic treatment may also have contributed to the better performance of INTMS calves as gastrointestinal parasites cause reduced growth in young animals. Adult males that were not stall-fed lost 438 g per day whereas those that were in INTMS gained 149 g of LW per day. This means that the combined effect of feed supplement and deworming generated a net gain of 438 + 149 = 587 g LW per day in adult males. INTMS cows maintained their LW while those in EXTMS lost LW at a rate of 240 g per day. At the end of the stall-feeding operation EXTMS cows lost LW equivalent to 17% of their initial LW.

In traditional husbandry systems in southern Senegal, milk extraction for human consumption is stopped during the dry season because of food shortages and milking is resumed in the next wet season when natural pastures start growing again. This deprives farmers from a main source of protein in their diet during many months in the year. The present study showed that 68 INTMS cows produced on average 76tr4.4 litres ofmilk in 80 days during the dry season in comparison to EXTMS cows that produced 181T6.4) litres of milk for human consumption in 37 days. Despite the fact feed supplementation was stopped at the end of the dry season, the beneficial effects of supplementing cows during the dry season was carried over the next wet season because INTMS cows produced 8 11-6.7 litres of milk in 90 days during the rainy season in comparison to EXTMS cows that yielded 40±10 litres over 82 days in the rainy

season. Mean values of milk offtake given here are adjusted means and therefore have been corrected with respect to the stage of lactation, parity, village and herd, factors that were included in the analysis of variance. Because most of the cows are not milked during the dry season, the effect of stabling would have been greater if INTMS animals were compared to EXTMS cows that were not milked. Because continuous suckling may inhibit post-partum cyclicity, the beneficial influence of dry season supplementation in terms of increased milk extraction may be offset by reduced reproductive performance. However studies that investigated the effect of intensity of milking on herd productivity in The Gambia showed that the twice daily milking system were superior to the once daily or zero milking systems in terms of overall herd productivity (Agyemang et *al.*, 1991).

The combined effects of feed supplementation and health care appeared to have a significant impact on survival rate. Out of the 120 control animals, 9 died whereas only one animal died out of the 187 INTMS animals.

Manure production was measured in 2 stalls totalling 29 animals with a total LW of 7078 kg which is equivalent to 28 Tropical Livestock Units (TLU, average animal weighing 250 kg LW). Total manure produced (faeces + urines + litter) was 11,03 1 kg with 24% moisture. When Manure production was expressed relative to the animal biomass and the number of nights animals spent in the stables, each TLU produced 4.8 kg of manure per night. Excretions during the day when animals were grazing on natural pastures were not included. The mean chemical composition of the manure on a dry matter basis was: Nitrogen: 11.5 kg / ton, P_2O_5 : 1.4 kg/ton, K_2O kg/ton and Ca + Mg: 8.8 kg/ton of manure. With respect to this chemical composition, 10 adult animals stabled during the dry season for 3 to 4 months would produce about 5 tons of manure which will allow the incorporation of 57, kg of N, 7 kg of P_2O_5 and 45 kg of K_2O. This shows the potential of stall-feeding to substantially contribute to the maintenance and restoration of soil fertility in su-bhumid zones if the manure is actually used.

Financial considerations

Value of increased LW (53-55%) made up the dominant component of marginal benefits and value of milk offtake constituted 24 to 27% of marginal benefits. The lowest contribution to marginal benefits came from manure output (6%). Feed supply is the dominant cost item (66%) in stabling operations followed by cost of building the stable (27%). Farmers had access to credit to establish the stall and payment of the loan was set for 4 years. They also benefited from a one-year loan to buy cotton seed as feed supplement at a subsidised price. Under such circumstances, the operation appeared profitable because the net benefits accounted for 45 to 51 % of the marginal benefits. The type of stall, either cemented or not, did not appear to influence the net benefits. However, the effect of type of stall could have been significant if the analysis was performed over many years. Indeed, non-cemented animal houses will require repair and maintenance each year and therefore will cause additional costs to be incurred by the farmer in comparison to cemented houses. The net benefit gained per stall-fed animal varied between 7829 FCFA to 8958 FCFA. When the average labour wage rate of 500 FCFA per day was applied, the net benefits gained through stabling 6 cows and 4 males were equivalent to 5 to 6 months salary during the dry season. As opportunities for off-farm employment are limited in the area where this study was conducted, the intensive management system during the dry season offers farmers an appreciable means to generate additional revenues. In addition, the extra milk produced contributes substantially to improve farmers diet during the critical dry months when food shortage for human is often experienced.

When the price of the feed supplement was increased and the loans were paid in one year, nets benefits was only equivalent to 14-16% and 30-32% ofmarginal benefits in cemented and non cemented stalls, respectively. Indeed, increases in the price of cotton seed occurred in 1992 and also the payment of the loan to build the stable was reduced from 4 years to 1 year from 1992. This shows that although the intensive management system improves animal productivity, its long term sustainability is greatly dependant upon policy and incentives that determine input and output prices. For instance, the devaluation of the CFA franc in 1994 caused an increase of milk prices in Senegal fi-om 100 in 1992 to 175 CFA per litre at the Kolda area at farm level. Even with increased prices of the feed supplement and the payment of loans in one year, with the price of 175 FCA per litre of milk, there was a significant improvement of the profitability of stabling operations.

In conclusion, the INTMS has a great potential to increase agricultural production, to secure employment in the dry season, to contribute to food security through increased milk and manure production and increased cash revenues by means of milk and live animal sales.

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Table 1 Prevalence' (%) of trypanosome and gastrointestinal parasites in animals under intensive (INTMS) and extensive (EXTMS) management systems at the start (before trypanocidal and anthelmintic treatments), midway and end of the 4-month experiment.

-Animal	Trypanosome (%)		Strongyle (%)		Strongyloides (%)		Ascaris (%)		Coccidia (%)	
category	INTMS	EXTMS	INTMS	EXTMS	INTMS	EXTMS	INTMS	EXTMS	INTMS	EXTMS
Adult females										
Start	2.5	0.0	20.0	22.9	0.0	1.6	0.0	0.0	5.6	1.6
Midway	0.0	1.8	2.7	21.8	0.0	0.0	0.0	0.0	1.3	5.5
End	2.8	0.0	2.8	31.4	0.0	0.0	0.0	0.0	2.8	0.0
Adult males										
Start	3.6	0.0	10.7	17.7	0.0	0.0	0.0	0.0	3.6	0.0
Midway	0.0	0.0	0.0	12.5	0.0	6.3	3.5	0.0	3.5	0.0
End	0.0	0.0	0.0	38.5	0.0	0.0	0.0	0.0	3.9	0.0
Calves										
Star-t	1.3	4.3	21.9	23.4	0.8	0.0	4.9	2.1	19.5	10.6
Midway	2.4	2.4	3.8	19.1	2.4	2.4	1.2	0.0	3.8	9.5
End	0.0	0.0	3.8	26.9	0.0	3.9	0.0	00	13.9	15.4

1: Prevalence = Number of samples detected positive/total number of sample.

Table 2. Mean (± se.) live weight, daily live weight and packed cell volume percent (PCV) at the star-t, midway and end of the experiment and live weight change in animals reared under the intensive management system (INTMS) and extensive management system (EXTMS) during 4 months in the dry season

	Live Weight (kg)			Daily live	PCV (%)		
	Star-t	Midway	End	weight gain (g/day)	Start	Midway	End
Adult females							
INTMS	210±3.1	208±3.2	204±3.2	-1.7 ± 18.9	28.81t0.82	28.5k0.86	30.2±0.86
EXTMS	209±3.5	90±3.6	173±4.1	-240±2 1.4	30.6±0.89	25.5±0.89	25.9±1.00
Adult males							
INTMS	22859.8	248±9.5	241±9.9	149±84.4	34.5±1.07	30.7±1.09	34.4±1.12
EXTMS	1991t12.7	195±13.0	181±14.3	-438±111.8	32.6±1.30	28.2±1.30	29.5±1.41
Calves							
INTMS	60±3.6	72±3.6	83±3.6	153±13.9	29.0±0.82	28.8±0.85	29.9±0.85
EXTMS	621t4.6	27.6±0.90	64±5.2	26±18.04	30.9±0.90		26.5±1.10