THE EFFECT OF SUPPLEMENTATION STRATEGIES ON REPRODUCTIVE AND PRODUCTIVE PERFORMANCE OF COWS KEPT UNDER DIFFERENT HUSBANDRY SYSTEMS IN SUDAN

Y.H. ELMANSOURY
Department of Radioisotopes,
Central Veterinary Research Laboratories,
Animal Resources Research Corporation,
Khartoum

M.M.M. MAHAGOUB
Institute of Environmental Studies,
University of Khartoum

K.A. EL RABEEA
Department of Animal Production,
El Fashir University,
El Fashir

A.O. IDRIS,
Department of Animal Production,
University of West Kordofan,
ElNuhud

I.B. MOHAMMED
Faculty of Agricultural Science,
Department of Animal Production,
University of Dulling

A. A. MAJID
Department of Radioisotopes,
Central Veterinary Research laboratories,
Animal Resources Research Corporation,
Khartoum

Sudan

Abstract

THE EFFECT OF SUPPLEMENTATION STRATEGIES ON REPRODUCTIVE AND PRODUCTIVE PERFORMANCE OF COWS KEPT UNDER DIFFERENT HUSBANDRY SYSTEMS IN SUDAN.

Three extensive systems of husbandry practices were chosen in the semi-arid rainfed area of Western Sudan (Latitude 11°15' and 16°30' N, Longitude 27° and 32° E). Cattle production in sedentary, transhumance and migratory systems were closely monitored through a period of 365 days (June 1999–June 2000). Cattle herders were randomly selected from those who were willing to participate in the project and implementation of supplementary feeding with poultry manure/molasses or molasses alone. Selection was based on different geographical sites around El Obeid city (600 km west to Khartoum capital). In the sedentary system seven groups of cattle herders were selected and were designated as farms SA, SB, SC, SD, SE, SF, and SG. In the transhumance system the cattle herders were desinated as TA, TB, and TC and in the migratory system, MA, MB, MC, MD, and ME.

In each system the recently calved cows were monitored for post-partum ovarian activity using milk progesterone radioimmunoassy. Days to conception were taken as non-return to oestrus. Regression analyses were done for fertility parameters against body weight (BW) and body condition score (BCS) at calving, 30, 60, and 90 days from calving, as well as milk yield (MY) at 30, 60, and 90 days from calving. Poultry manure/molasses mixture was used to replace farmer's concentrate diet in farm SB (supplementation) of the sedentary system while in others the concentrate ration usually used by the farmer was partially susbstituted by molasses. In the migratory system the poultry manure/molasses mixture partially supplemented the farmer's concentrate diet (substitution) of all animals. In the farms belonging to transhiumance system molasses alone was used as a substitution diet. The results revealed that there was a wide variation in both days to first ovulation and days to conception in all systems of production. The majority of cows showed delayed post-partum activity and days to conception, especially in the transhumance system. Cows in both sedentary and migratory systems showed gradual increase in BW and MY from calving up to 90 days, while those of the transhumance showed a steady decrease in both these parameters. BCS was found to decrease from calving to 60 days in all systems. Regression analyses showed significant negative correlation between BW and BCS (at calving, 30, 60, and 90 days from calving) and days to ovulation and conception. Dry season showed an adverse effect on fertility compared with the rainy season. Poultry manure/molasses diet as supplementation showed the best increase in milk yield in the sedentary system, but when used as a substituted diet in the migratory system milk yield increased only slightly. Diets substituted with molasses alone increased milk yield remarkably in both sedentary and transhumance systems. Also recently calved cows that received any of the above diets in the sedentary system were found to resume post-partum activity earlier than before supplementation. Cross breds, had shorter days to ovulation and conception than the local ones, but showed lower pregnancy rates. It could be concluded that, poor reproductive performance in cows kept under extensive traditional system was due to poor management practices, which ignored high-energy supplementation during late pregnancy and early lactation, especially during the dry season when rangeland pastures deteriorate drastically. Suckling further exacerbated the effect of poor nutrition resulting in extended post-partum anoestrus and low conception rates. Controlled mating and suckling together with good feeding strategies may greatly enhance reproductive performance of cows kept under extensive systems of management.

1. INTRODUCTION

Sudan has a livestock population of 103 million; approximately 33 million are cattle. The bulk of the cattle population is of the local beef type, living under the pastoral system of management. Sudan has the largest extent of permanent pasture and the largest number of pastoralists compared to any other African country. Three main categories of pastoralists can be recognized.

The migratory pastoralists are those that are on constant move with their animals in pursuance of forage and water. During the rainy season (July to August) they settle in camps near a city and graze their animals in the nearby fields. With the advancement of the season they move out in search of pasture and water, covering long distances. As the dry season approaches the herders settle around sorghum fields to make use of sorghum residues as the main diet of the animals. Once the grain has been harvested cattle graze the standing stover and ungrazed stover is stored in sacks for feeding during the winter. Cows produce 2–3 litres of milk/day during the wet season. However, by the end of the dry season, there is no surplus milk over and above the needs of calves. Dry season feeding is mainly dependent on stored pasture and sorghum stovers. Concentrates are given only to milking cows at the rate of 2 kg/cow/day.

Migratory people as well as their animals, suffer from heat stress, lack of water and food. By the time next rains arrive, adult animals may have lost over 30% of their body weight and young animals would be weak and vulnerable to diseases [1]. Many tribes rare

cattle, sheep, camels and goats together in their herds as a means of harnessing the marginal and constantly changing resources to support their existence [2].

In the transhumance system, pastoralists with their animals move from a home-base located at the centre of the migratory route, between wet and dry season camping areas. It is an adaptive system whereby rangeland use is inseparable from the livelihood of the people. Movement is across several ecological zones [3]. The transhumance are conservative to their environment and provide meat, milk and milk products to the sedentary people. It is the demand for these products that has kept the pastoral system expanding [4].

In the sedentary system of cattle management, there are two production systems, the traditional and the improved. The traditional system is subsistence-oriented and is characterized by low inputs with a resultant low productivity. The improved system consists of intensive crop-livestock smallholders, peri-urban production and semi-intensive management. Output from this system is generally several times more compared to the traditional system. Production from all systems has remained comparatively lower than those from other areas of the world due to inadequate feed, both in quality and quantity, poor management of the available feed resources and the reproductive wastage due to low conception and calving rates, delayed age at puberty and first calving, high mortality due to diseases and inadequate health care.

The general constraints to all pastoralist systems include (a) an erratic rainy season from July to October, (b) the domination of rangelands by annual grass species offering neither an optimum carrying capacity nor adequate nutrition around the year, (c) scarcity of water towards the middle and end of dry season (d) expanding cultivation, (e) unperscribed burning of rangelands, and (f) restriction of mobility due to the closing of many migration corridors by farmers and ranchers [5]. Due to such pressures, transhumance have become more dependent on farming to avoid purchase of grain [5]. Sorghum and groundnut are cultivated when the opportunity arises; however, crop residue utilization is not strictly adopted.

The present study was undertaken to investigate the influence of various supplementation strategies on production and reproductive performance of cattle under the three management systems.

2. MATERIALS AND METHODS

2.1. Study area

The present investigation focused around the cattle herders of El Obeid city, about 600 km from the capital Khartoum. This is the semi-arid rainfed area in Western Sudan (Latitude 11^{o} 15' and 16^{o} 30'N, Longitude 27^{o} and 32^{o}E) with temperatures ranging between 30–35^{o}C during most of the year and over 40^{o}C during the dry season (April to June). The rainy season extends from July to October. The dominant vegetation is a varying mixture of grasses and shrubs. [6]. The cattle farms comprising of 15–50 animals are concentrated around urban centers and are the main suppliers of milk to the inhabitants. Millet is the main food grown for human consumption with sorghum, watermelon, groundnut, sesame and roselle (kerkade) grown as cash crops.

2.2. Husbandry practices

2.2.1. Sedentary pastoralists

Seven cattle owners were randomly selected from different geographical sites around El Obeid city for studies on the sedentary system of production. They were designated as

farms SA, SB, SC, SD, SE, SF, and SG. Each farm had an area of 10–15 ha, which was being cultivated with sorghum for local consumption. During the rainy season farmers settle in drier areas avoiding the flooded areas, which are usually uninhabitable because of unpleasant smell and biting flies. Cattle spend around 6–9 h grazing during the day, moving over small (3–4 km) distances. Surface water from natural ponds and catchment areas is their source of drinking water. During the dry season, more time is spent grazing (8–10 h) moving over longer distances (7–8 km) in search of good quality forage. They come back to the farms and then move another 1–2 km to find drinking water from deep wells in the city. Crop residues and concentrates are offered before the afternoon milking. Approximate 1–2 kg of a concentrate ration is offered to each milking cow. Mature animals are kept in open enclosures made from local materials or barbed wires. Calves are kept in separate sheds with a roof for protection against the sun.

2.2.2. Migratory pastoralists

Five farmers MA, MB, MC, MD and ME, from the migratory system of production, each having between 5–20 cows were selected. In this system cattle owners were on constant move with their animals in pursuance of forage and water. They have homelands in which they settle during certain times of the year. During the rainy season (July to August), cattle herders settle in camps. Mature animals are kept lose; calves are kept in sheds. With the advancement of the rainy season and as the pasture becomes dry, cattle herders move in an eastward direction away from the city in search of pasture and water. They cover long distances before settling around the sorghum fields. During the dry season the herders return to the villages moving in a southward direction and covering a distance of about 20 km. Animals are allowed to drink from deep-water wells located about 2 km from their settlements. Dry summer feeding depends mainly on stored pasture and sorghum stover. Concentrates are given only to milking cows at a rate of 2 kg/cow/day.

2.2.3. Transhumance pastoralists

The transhumance system was represented by three cattle herders who were willing to participate in molasses supplementation. They were chosen during their settlement around El Obeid city in the summer of July 1999. They were designated as TA, TB, and TC herds. Due to controlled breeding, all cows calved during the rainy season. Recently calved cows in each herd were of the same number and parity. Concentrate feed (2 kg/animal/day) was given to milking cows during the dry season. Milking cows generally do not move with the rest of the herd in the southward migratory route in the dry season, but those that become dry during this period are allowed to join the migratory herd.

The transhumance cattle herders move from north to south and backwards along rainfed rangelands located in western Sudan. Mobility is a principle defense against the fluctuating climate, the periodic droughts and the uneven rainfall. During the rainy season they settle in the north. The trek back south is undertaken once the rain stops. The scarcity of water dictates their fast return. Pre-weaned calves of less than one year are kept indoors within the camp and sometimes tied to a common rope. One year old calves are allowed to graze nearby and around the homestead. Calves and bull calves are kept in thorn-fenced kraals all year round. They are allowed to suckle their dams twice a day, during milking time in the morning and in the evening. Rarely are cows kept in confinement; only when they are sick or to avoid the risk of grazing the surrounding crop farms.

Breeding season is regulated so as to coincide the birth of calves with a period of better nutrition, which is the wet season. This is done by allowing the calves to suckle for a short period or preventing suckling altogether. To prevent suckling, thorns attached in two

rows to a rope are tied around the calf's muzzle. A major problem of this technique is that the cow becomes dry soon after conception and the calf gets little milk for nourishment.

In all systems, weaning was done gradually and mating was natural with bulls running with the herd. All farms depended on hired animal attendants to look after their herds and on their experience for health care and disease treatment. Vaccination against rinderpest and anthrax were carried out only when outbreaks were expected. Prevailing diseases were pneumonia, internal and external parasites. The supplementary feeds used in each farm are shown in Table I.

TABLE I. CONCENTRATE FEED INGREDIENTS USED IN THE FARMS

Husbandry System	Farm ID	Sorghum (%)	Wheat bran (%)	GNC (%)	GNH (%)	Salt (%)	Others (%)
Sedentary	SA	55	20	29	-	1	-
	SB	50	-	18 –19	30	1–2	-
	SC	60	9	30	-	1	-
	SD	43	-	16	42	1	-
	SE	40	-	-	-	-	BR (60)
	SF	50	20	19	10	1	-
	SG	60	10	29	-	1	-
Migratory	MA	48	23	28	-	1	-
	MB	47	22	30	-	1	GM
	MC	45	20	-	-	1	SC (34)
	MD	50	17	32	-	1	-
	ME	49	20	30	-	1	-
Transhumance	TA	50	20	29	-	1	-
	TB	79	20	-	-	1	-
	TC	-	20	-	-	1	BR

GNC, groundnut cake; GNH, groundnut hulls; SC, sesame cake; GM, guar meal (crude protein 16%, 4.4% ether extract); BR, brewery residue (22% crude protein, 1.1% ether extract).

2.3. Supplementation trial

For all three systems the period of study consisted of two phases, a survey phase of 10 months during which the husbandry practices were closely monitored and an intervention phase where the appropriate supplement was given over a period of 9 weeks.

In the case of the sedentary system poultry manure-molasses was given as a complete diet to farm SB (2 kg) during the intervention phase. As for the other farms, the concentrate ration usually used by farms was partially substituted by molasses i.e. for every 1 kg concentrate ration removed, 1kg of molasses was added. Farm SA was used as a control.

For farms in the migratory system, poultry manure/molasses was given as a substitute. Of the 2 kg of concentrate fed 1 kg was substituted with poultry manure/molasses mixture.

In the transhumance system molasses alone was given as a substitute mixed with farmers' concentrate diet.

2.4. Measurements

2.4.1. Milk Sampling

Milk samples (10 mL) were collected into tubes containing sodium azide at weekly intervals beginning at 10 days from parturition and every week thereafter until the animal was confirmed pregnant by non-return to oestrus. Milk samples were centrifuged for 10 minutes at 2500 *g* to remove fat and then stored in a sealed plastic container at –20°C until assayed for progesterone. Concentrations of progesterone in the defated milk were measured using the solid-phase RIA system supplied by the Joint FAO/IAEA Division [7]. Progesterone concentrations greater than 1 nmol/L were considered to indicate cyclic ovaries.

2.4.2. Body weight and body condition score

Body weight was determined by measuring the heart girth using a weigh band. Body codition score was carried out according to one-to-nine scale (1 emaciated, 9 obese) [8]. The above parameters were measured at calving and at 30, 60 and 90 days after calving. Faecal samples were regularly collected for determining the gastrointestinal parasite burden.

In addition to measuring the milk progesterone profile, body weight, body condition score and milk yield were also recorded, when ever possible.

2.4.3. Statistical analysis

Regression analyses were carried out using Statistical Analytical System (SAS). Least significant difference (LSD) was used to detect statistical significance between means.

3. RESULTS

3.1. Resumption of ovarian activity and conception

Few cows resumed ovarian activity within 45 days after calving under all three-production systems. However, by 90 days the percentage of cows resuming ovarian activity was over 60% and this reached 100% by 120 days. Conception followed a similar trend (Table II).

TABLE II. NUMBER AND CUMULATIVE PERCENTAGE (WITHIN PARENTHESIS) OF COWS RESUMING OVARIAN ACTIVITY AFTER CALVING

Husbandry system	Total number of cows	Resumption of ovarian activity (days)			
		<45	46–60	61–90	90–120
Sedentary	73	15 (21)	15 (42)	14 (62)	27 (99)
Migratory	62	3 (5)	18 (35)	21 (69)	19 (100)
Transhumance	36	12 (33)	6 (50)	11 (80)	7 (100)
		Conception (days)			
Sedentary	73	5 (7)	11 (22)	18 (47)	39 (100)
Migratory	62	12 (19)	23 (56)	12 (75)	15 (99)
Transhumance	36	7 (19)	9 (44)	12 (77)	8 (99)

The mean interval from calving to first ovulation was lowest in the transhumance system compared to the other two systems (68 vs 89 and 94). There was a wide variation in the resumption of ovarian activity between farms in the other two systems. A similar trend was observed in the interval from calving to conception (Table III).

3.2. Effect of season

The season appeared to have an effect on the interval from calving to first ovulation and the number of days to conception. There was early resumption of ovarian activity ($P < 0.05$) in both sedentary and migratory systems during the wet season (July to October) compared to dry months (April to June). Animals reared under the sedentary husbandry system showed early resumption of ovarian activity and early conception during the wet season compared to those reared under the migratory system. In the case of transhumance system of management all cows tended to calve in the wet season.

TABLE III. INTERVAL (MEAN ± SD) FROM CALVING TO FIRST PROGESTERONE RISE AND CONCEPTION IN ALL HUSBANDRY SYSTEMS

Husbandry System	Farms	Interval from calving to first progesterone rise	Interval from calving to conception
Sedentary	SA	71.3 ± 45.1^{c}	126.0 ± 46.0^{b}
	SB	92.1 ± 54.3^{b}	226.0 ± 52.6^{a}
	SC	61.7 ± 14.9^{d}	102.6 ± 48.9^{b}
	SD	85.5 ± 39.1^{b}	174.1 ± 81.6^{b}
	SE	71.2 ± 35.8^{c}	103.2 ± 16.2^{b}
	SF	74.5 ± 48.7^{c}	112.2 ± 21.8^{b}
	SG	167 ± 59.6^{a}	165.7 ± 57.1^{b}
	Mean	89	144
Migratory	MA	87.5 ± 31.6^{b}	108.2 ± 20.0^{b}
	MB	91.2 ± 14.7^{b}	99.1 ± 14.2^{c}
	MC	105.6 ± 29.4^{a}	123.4 ± 21.3^{b}
	MD	93.7 ± 21.2^{b}	102.1 ± 13.9^{b}
	ME	94.2 ± 25.7^{b}	120.4 ± 28.7^{b}
	Mean	94	110
Transhumance	TA	57.1 ± 38.2^{d}	100.0 ± 35.6^{b}
	TB	73.3 ± 31.2^{c}	105.3 ± 31.1^{b}
	TC	74.5 ± 43.9^{c}	139.2 ± 24.5^{b}
	Mean	68	114

[abcd] Values within the same column bearing different superscripts differ significantly at $P < 0.05$.

Under the sedentary system of management the interval from calving to first progesterone rise and calving to conception were significantly ($P < 0.05$) longer during the dry season compared to the wet season. Conception rate was better in the wet season. However, in the migratory system although cows that calved during the summer showed a significatnly ($P < 0.05$) longer interval from calving to first progesterone rise, interval from calving to conception were not significantly different between the two seasons (Table IV).

In the transhumance system all cows claved during the wet season and had realatively shorter calving to first ovulation and calving to conception.

3.3. Effect of breed

When the effect of breed was tested for post-potrum ovarian cyclicity or days to conception in the sedentary system of management, the cross breds took significantly ($P < 0.05$) more time to return to cyclicity compared to the local animals. The migratory system showed the opposite. Days to conception was also longer ($P < 0.05$) in the cross breds in the sedentary system. For both systems, conception rate was higher ($P < 0.05$) with the local breed. The transhumance local showed the lowest ($P < 0.05$) interval to first progesterone rise and the highest ($P < 0.05$) conception rate (Table V).

3.4. Body weights, body condition score and milk yield

At the time of calving the mean body condition score was 5.2, 6.7 and 4.6 respectively for sedentary, migratory and transhumance systems of production. The body condition score declined progressively up to 60 days under all three management systems and thereafter tended to improve.

Milk yield from cows of the transhumance was highest ($P < 0.05$) at both 30 and 60 days from parturition. The sedentary cows showed the lowest ($P < 0.05$) yield at 60 days. At 90 days differences in milk yield between the three systems appeared to be non-significant.

TABLE IV. EFFECT OF SEASON ON DAYS TO OVULATION AND CONCEPTION FOR COWS KEPT UNDER DIFFERENT HUSBANDRY SYSTEMS

Husbandry systems	Season	Calving to ovulation (Mean ± SD)	Calving to conception (Mean ± SD)	Pregnancy rate
Sedentary	Dry summer	87.0 ± 52.7 [b]	136.4 ± 67.2[a]	90.4
	Wet summer	69.4 ± 42.3 [c]	107.7 ± 71.0[b]	96.1
Migratory	Dry summer	106.2 ± 24.4[a]	118.0 ± 22.0[b]	93.5
	Wet summer	85.1 ± 22.1 [b]	101.9 ± 16.2[b]	96.8
*Transhumance	*Dry summer	-	-	-
	Wet summer	68.3 ± 37.7 [b]	114.8 ± 32.1 [b]	100

[abc]Values in the same column within a system bearing different superscripts differ significantly at $P < 0.05$.
* all cows calved in the wet summer

TABLE V. EFFECT OF BREED ON DAYS TO OVULATION AND CONCEPTION FOR COWS KEPT UNDER DIFFERENT HUSBANDRY SYSTEM

Husbandry systems	Breed	Days to ovulation (Mean ± SD)	Days to conception (Mean ± SD)	Pregnancy rate (%)
Sedentary	Local	79.9 ± 48.8[c]	133.1 ± 59.4 [b]	87.7[a]
	Cross	122.0 ± 52.2[a]	267.0 ± 25.5 [a]	6.8[c]
Migratory	Local	97.5 ± 25.0[b]	110.5 ± 21.2[b]	98.2 [a]
	Cross	73.6 ± 19.7[c]	101.6 ± 14.1[b]	71.4 [b]
*Transhumance	Local	68.3 ± 37.7 [c]	114.8 ± 32.1 [b]	100 [a]

[abc]Values in the same column within a system bearing different superscripts differ significantly at $P < 0.05$.
* All cows consisted of local breed.

3.5. The Intervention phase

The chemical analyses of the farm rations and introduced rations are shown in Table VI. When poultry manure/molasses was used as sole ration the crude protein (CP) and metabolizable energy (ME) were slightly decreased while ash content increased. Farms SC, SD, and SE shared the same diet; therefore, the chemical composition of the rations were similar. SF and SG used the same ration; the only change was shown in nitrogen free extract (NFE) content, which was increased due to the addition of molasses.

In the migratory system (Farms MA, MB, MC, MD and ME), where poultry manure/molasses mixture was added to the cattle owners' ration in the ratio of 50:50, the chemical analyses showed that the CP content changed only marginally while, CF, EE, NFE and ME changed substantially.

The addition of molasses to the diet of transhumance animals produced little or no change in the chemical composition.

3.6. Effect of supplementation on milk yield

Table VII gives a summary of the effect of intervention diets on milk production under the different husbandry systems. In the sedentary system, except for farm SA (control) all animals showed significant ($P < 0.05$) increases in milk production. The change in milk production ranged from 18–23% due to supplementation. A relatively small and insignificant change was seen in the migratory farms.

3.7. Cost:benefit analysis of milk production

An estimate of cost of feed, milk yield, gross revenue, and the ratio between revenue and cost for the different production systems are shown in (Table VIII). The net revenue under all production systems increased with supplementation, more in the case of sedentary and transhumance systems compared to the migratory system. The net increase in revenue was both because of increased milk production as well as reduced cost of feed.

4. DISCUSSION

Fertility of cows kept under traditional extensive systems was shown to be low as indicated by long post-partum anoestrus period and long days to conception in the majority of cows investigated. This was largely correlated with nutritional and other environmental stress. Similarly, other studies revealed the low fertility of zebu cattle in tropical and subtropical areas [9]. Other factors, which might have influenced fertility, included, body condition score (BCS), body weight (BWT) and health disorders [10, 11]. In the sedentary system, farm SC showed the shortest days to ovulation and conception as this farm used controlled suckling. Similarly, it has been shown that calf creep feeding strategies improved conception through reduced suckling [12]. In the migratory system cows in herd MB showed better fertility parameters and were in a better nutritional status since they were frequently supplemented with guar meal. The effect of BWT on fertility was clearly demonstrated by farm SG and cows in herds TB and TC of the transhumance system as these had significantly low BWT, which was reflected on extended post-partum anoestrus and long days to conception. Similarly, the studies of Singh [13] on the combination effect of age and BWT revealed that conception rate depended largely on BWT than age. Low BWT at birth and slow growth rate during pre-pubertal period may have been responsible for the poor fertility of these cows.

TABLE VI. CHEMICAL COMPOSITION (DM BASIS) OF RATIONS USED BY FARMERS AND THOSE OF SUPPLEMENTED OR SUBSTITUTED RATIONS

Composition of rations used by sedentary farmers (survey phase)							
Farm ID	DM (%)	CP (%)	CF (%)	EE (%)	NFE (%)	Ash (%)	ME (MJ/kg)
SA	93.5	34.8	8.2	4.5	45.9	6.5	12.4
SB	93.9	16.7	17.4	6.6	47.5	11.8	11.5
SC	93.4	33.1	4.8	6.2	50.2	5.7	13.1
SD	93.4	30.1	4.5	6.2	53.5	5.7	13.1
SE	92.9	32.2	4.3	6.4	42.9	7.2	11.8
SF	93.3	21.2	6.4	6.8	58	6.7	13.0
SG	93.2	20.4	10.3	4.5	58	6.8	12.2
Composition of supplemented rations used by sedentary farmers (intervention phase) *							
1 (SB)	97.3	20.0	9.2	1.5	46.6	22.6	19.8
2 (SC, SD, SE)	93.9	24.8	5.3	4.3	51.8	9.8	12.9
3 (SF, SG)	96.8	19.7	3.4	4.1	75.4	9.4	12.5
Composition of rations used by migratory farmers (survey phase)							
MA	94.5	21.1	7.8	4.4	61.1	5.6	12.8
MB	94.6	22.7	7.7	4.5	59.4	5.7	12.8
MC	94.3	23.7	7.7	6.3	59.9	5.4	13.8
MD	94.6	23.0	7.5	5.6	58.0	5.9	12.9
ME	94.4	22.6	7.5	5.6	59.8	5.6	12.9
Composition of substituted rations used by migratory farmers (intervention phase) **							
MA	95.9	20.6	3.9	2.9	41.6	6.1	9.3
MB	95.9	21.4	3.9	3.0	40.2	6.1	9.3
MC	96.0	21.6	3.7	3.8	34.9	6.0	8.0
MD	95.7	21.5	3.9	3.6	41.0	6.3	9.1
ME	95.9	21.5	3.9	3.6	40.9	6.1	8.1
Composition of rations used by transhumance farmers (survey phase)							
TA	95.5	9.9	10.3	3.7	67.0	4.5	14.1
TB	95.9	7.8	12.3	2.9	68.7	4.6	12.1
TC	95.1	5.1	22.1	1.1	62.0	4.8	10.7
Composition of substituted rations used by transhumance farmers (intervention phase) ***							
TA	95.5	9.3	14.9	2.7	64.0	4.5	14.1
TB	96.4	7.4	10.7	2.9	69.7	5.6	12.3
TC	97.2	6.1	23.1	0.1	63.0	4.8	10.7

***** poultry manure/molasses mixture was given as a complete diet to farm SB. For other farms except farm SA (Control farm) molasses alone partly (50%) replaced the farmer's ration. Also see note below.

** poultry manure/molasses mixture partly (50%) replaced the farmer's ration.

*** molasses alone partly (50%) replaced the farmer's ration.

Note:
1: poultry manure/molasses given to farm SB as complete diet (supplementation)
2: molasses given to farms SC, SD, and SE as substituted ration which constituted at the time of the study of sorghum grain and groundnut cake in the ratio of 1:1.
3: molasses given to farm SF and SG as substituted ration constituted at the time of the study of wheat bran alone.

TABLE VII. WEEKLY MILK YIELD (kg) AS AFFECTED BY SUPPLEMENTATION AND WITHDRAWAL IN DIFFERENT HUSBANDRY SYSTEMS

Farms	Before supplementation	Supplementation	Change (%)	Withdrawal	Drop in milk yield (%)
SA	^{A} 25.8 ± 2.3^{a}	^{A} 25.0 ± 2.8^{c}	–3.0^{d}	^{A} 18.2 ± 1.9^{c}	27.0^{d}
SB	^{B} 28.4 ± 8.4^{a}	^{A} 47.3 ± 7.3^{a}	39.7^{b}	^{C} 18.0 ± 4.3^{c}	61.8^{a}
SC	^{B} 26.4 ± 3.2^{a}	^{A} 25.9 ± 4.1^{c}	26.4^{c}	^{C} 19.6 ± 4.1^{c}	45.3^{b}
SD	^{B} 23.1 ± 3.9^{a}	^{A} 31.4 ± 6.8^{b}	26.3^{c}	^{C} 20.1 ± 3.9^{c}	31.6^{c}
SE	^{B} 23.7 ± 1.8^{a}	^{A} 35.0 ± 10.6^{b}	32.3^{b}	^{C} 23.6 ± 3.0^{b}	32.5^{c}
SF	^{B} 25.7 ± 4.3^{a}	^{A} 29.5 ± 9.3^{c}	13.1^{d}	^{C} 22.2 ± 1.7^{b}	24.9^{d}
SG	^{B} 19.2 ± 3.2^{b}	^{A} 30.6 ± 6.2^{c}	37.1^{b}	^{C} 22.2 ± 1.9^{b}	27.4^{d}
MA	^{A} 25.7 ± 3.8^{a}	^{A} 25.8 ±2.4^{c}	0.62^{e}	^{A} 25.9 ± 2.5^{a}	0.15^{e}
MB	^{A} 28.1 ± 2.6^{a}	^{A} 28.3 ±2.4^{c}	0.07^{e}	^{A} 27.9 ± 2.5^{a}	1.14^{e}
MC	^{A} 28.1 ± 2.8^{a}	^{A} 28.3 ±2.7^{c}	0.67^{e}	^{A} 28.5 ± 2.7^{a}	1.3^{e}
MD	^{A} 24.7 ± 4.8^{a}	^{A} 25.0 ±4.8^{c}	1.01^{e}	^{A} 24.8 ± 5.0^{b}	0.64
ME	^{A} 23.4 ± 7.6^{a}	^{A} 24.5 ±6.0^{c}	4.72^{e}	^{A} 23.5 ± 0.6^{b}	0.47
TA	^{B} 25.3^{a}	^{A} 27.6^{c}	41.9^{b}	ND	ND
TB	^{B} 24.2^{a}	^{A} 25.5^{c}	31.2^{b}	ND	ND
TC	^{B} 22.9^{a}	^{A} 24.9^{c}	66.6^{a}	ND	ND

$^{A, B, C, a, b, c, d}$ values with different superscript differ significantly at P <0.05. Upper case letters for comparing means within the row, lower case letters for comparing means within columns.
*ND = not determined

TABLE VIII. AVERAGE FEED COST AND REVENUE FROM MILK SALES, BEFORE AND AFTER SUPPLEMENTATION (RANGE WITHIN PARENTHESIS)

	Production system					
Item	Sedentary		Migratory		Transhumance	
	Before	After	Before	After	Before	After
Cost of concentrate (Ls/kg)	144 (108–186)	106 (96–136)	222 (212–228)	136 (131–139)	180 (87–272)	104 59–138)
Milk yield per kg feed (L)	1.84 (1.8–2.1)	2.3 (1.8–3.4)	1.88 (1.7–2.0)	1.93 (1.6–2.1)	2.10 (1.5–2.7)	3.02 (2.4–3.8)
Gross revenue *	1842 (1650–2025)	2300 (1800–3350)	1882 (1755–2030)	1931 (1670–2025)	2105 (1495–2695)	3022 (2450–3825)
Net revenue	1702 (1664–1922)	2193 (1664–3242)	1750 (1638–1801)	1795 (1532–1960)	1925 (1407–2514)	2917 (2450–3825)
Benefit:cost ratio	11.8:1	20.6:1	7.9:1	13.2:1	10.7:1	28.0:1

Ls, Sudanese Lira; *, Sale price of milk = Ls. 1000/litre.

Numerous studies have shown that the inhibitory effect of suckling is mediated by inhibition of luetinizing hormone (LH) secretion [14–16] through a reduction of pulsatile secretion of hypothlamic gonadotrophin releasing hormone (GnRH) [17]. On the other hand weaning was shown to hasten oestrus [17–19].

During the rainy season animals were allowed to graze the native pasture without additional supplemental feeding, which failed to fulfill the requirement for meat and milk production. Milking cows were supplemented with concentrate diets during the dry season only. Cows in their pre-partum period received no supplementation and hence were likely to calve in poor condition. Also it has been shown that cows, which calve in poor body condition, have only a small pool of recruitable (2–5 mm) follicles and few if any growing (6–9 mm) follicles for a prolonged period post-partum [9].

Prolonged post-partum anoestrus in lactating cows under extensive systems may reflect an adaptive mechanism, which prevents reconception until nutritional, or other environmental conditions become favorable for reproduction. Furthermore, it has been shown that responses to pre-partum BWT change may depend on BCS at parturition, since pregnancy rate of cows in good body condition at calving is affected little by minimal BWT changes either before or after parturition [20, 21] whereas dramatic BWT losses after calving can reduce pregnancy rate [21].

Days to conception were significantly longer and conception rates were significantly lower in the dry season compared to the wet season where ambient temperatures exceeded 40^{o}C. Similar findings were reported by other workers [22] which could be related to the inhibitory effect of thermal stress resulting in reduced hypothlamic GnRH secretion, lack of LH secretion and consequently affecting ovarian follicle development [23]. This condition might also be exacerbated by poor nutritive value of the pasture. Although concentrates offered by farmers were of good quality, they were not offered in adequate quantities as they were sometimes given every other day due to their high cost. This could place cows in negative energy balance and thereby affecting the calving to conception interval and conception rates. Farms SA and SB in the sedentary system did not seem to benefit from extra night grazing during the dry season. Most of the cows in both farms showed long days to conception which could be attributed to poor quality of the pasture and extra energy expenditure during grazing. Heat stress seemed to impose an adverse effects on the cross breeds as reflected on longer days to conception and lower conception rates.

Poultry/manure molasses used as a complete diet showed the highest increase in milk yield in the sedentary system. However, when used to replace 50% of the migratory diet, milk yield increased only slightly. In the transhumance system molasses was used alone as substituted diet and showed significant increase in milk yield. Similarly, it has been shown that supplements fed during the post-partum period are more likely to be diverted towards milk production, thus benefiting calf growth [9].

5. CONCLUSION

Nearly all farmers under extensive systems used sorghum grains in the diet of their animals. This is not a wise strategy since sorghum constitutes the major diet of Sudanese in many parts of the country. Using alternative diets, which are cost-effective and increase both milk yield and fertility should be encouraged. This will reduce competition with human food, increase farmers' income and allow surplus to be exported.

Management of post-partum anoestrus under extensive tropical environments should focus on the conservation of body weight and body condition score by strategic and adequate supplementation during late pregnancy and early lactation.

Restricted suckling would reduce stimulus of cow-calf interaction and hence reduce days to conception.

There was no benefit of keeping crossbreds since neither milk yield nor conception rates were improved. Selection could be done among indigenous breeds where adaptation and milk yield were optimum. These were the ones which came into estrus within reasonable time and could produce a calf every year.

ACKNOWLEDGEMENT

This study was conducted under the IAEA's AFRA Project (RAF/5/041). The authors would like to express their thanks to the International Atomic Energy Agency, Central Veterinary Research Laboratories, and Animal Resources Research Corporation, for their financial and technical support. Our sincere thanks are also due to those who, in one way or another, contributed greatly to the accomplishment of the study.

REFERENCES

[1] AHMED, S., EL WAKEEL. Pastoral and livestock development projects in Sudan, Sudan J. Agric. Research **2** (1999) 73–80.

[2] HARRISON, P., pasturalists and plougmen: livestock in the greening of africa. breaking through for the battle for land and food, International institute for environmental and development — earthscan (1987) 22–240.

[3] EL WAKEEL, A.S., ABU SABAH, M.A., Relevance of mobility of to rangeland utilization: the Baggara transhumant of Southern Kordofan, Nomadic Peoples **32** (1993) 33–38.

[4] MICHAEL, B.J., The impact of international wage labour migration on Hawazma (Baggara) pastoral nomadism, Nomadic Peoples **28** (1991) 56–70.

[5] MOHAMED SALIH, M.A., Government Policy and options in pastoral development in the Sudan (1990) 25–27.

[6] TECHNOSERVE., Credit component baseline survey. Technoserve Inc., Agricultural Bank of Sudan and US Agency for Agricultural Development, Elobied, Sudan (1987) 204.

[7] PLAZIER, J.C.B., "Validation of FAO/IAEA RIA KIT for the measurement of progesterone in skin milks blood plasma", Improving the productivity of indigenous African livestock, IAEA-TECDOC-708 (1993) 151–156.

[8] NICHOLSON, M.J., BUTTER WORTH, M.H., A guide to condition scoring of zebu cattle. ILCA, Addis Ababa (1986) 29.

[9] FITZPATRICK, Z.A., "Advances in the understanding of post partum anoestrus in *Bos indicus* cows", Strengthening research on animal reproduction and disease diagnosis in Asia through the application of immunoassay techniques, IAEA-TECDOC-736 (1993) 19–35.

[10] VALE, W.G., SILVA, A.O.S., SOUSA, J.S., LEITE, J.M.MN., SOUZA, H.E.M., RIBEIRO, H.F.L., OHASHI, O.M., "Factors affecting the reproductive performance in Nelone cattle raised in the humid tropical Amozon region", Development of feed supplementation strategies for improving ruminant productivity on small holder farms in Latin America through the use of immunoassay techniques, IAEA-TECDOC–877 (1996) 157–162.

[11] MUKASA — MUGERWA, E., "A review of reproductive performance of female *Bos indicus* (zebu) cattle", ILCA Monograph, International Livestock Centre for Africa, Addis Ababa (1989).

[12] SCHLINK, A.C., GIBSON, D.S., LIANY, Z., DIXON, R., Calf management strategies and reproductive performance in northern Australia cattle herds, Proc. Aust. Soc. Anim. Prod. **17** (1988) 326–329.
[13] SINGH, B., Effect of lowered age at first calving of German Block bred heifers — on body development and production performance up to the end of first lactation, Anim. Breed. Abstr. **61** (1990) 417.
[14] PETERS, A.R., LAMMING, G.E., Lactational an oestrus in farm animals Oxford Rev. Reprod. Biol. **12** (1990) 245–288.
[15] CARRUTHER, T.D., CONVEY, E. M., KESNER, T.S., HAFS, H.D., CHENGE, K.W., The hypothalamo-pituitary gonadotrophic axis of suckled and non-suckled dairy cows, J. Anim. Sci. **51** (1980) 949–957.
[16] WILLIAMS, G.L., KOZIOROWSKI, M., OSBORN, R.G., KIRSCH, J.D., SLANGER, W.D., The post weaning rise of tonic lutenizing hormone secretion in an oestrous cows is not prevented by chronic milking or the physical presence of the calf, Biol. Reprod. **36** (1987) 1079–1084.
[17] SHORT, R.E., BELLOWS, R.A., STAIGMILLER, R.B., BERARDINELLI, J.G., CUSTER, E.E.J., Physiological mechanisms controlling an oestrus and fertility in post partum beef cattle, Anim. Sci. **68** (1990) 799–816.
[18] CARTER, M. L., DIERSCHKE, D. J., RUTLEDGE, J .J., HAUSER, E. R., Effect of gonadotropin-releasing hormone and calf removal on pituitary — ovarian function and reproductive performance in post partum beef cows, J. Anim. Sci. **51** (1980) 903–910.
[19] OXENREIDER, S.L., Effects of suckling and ovarian function on post partum reproductive activity in beef cows, Anim. J. Vet. Res. **29** (1968) 2099–2102.
[20] CORAH, L.R., DUNN. T.G., KALTENBACH, C.C., Influence of post partum nutrition on the reproductive performance of beef females and the performance of their progeny, J. Anim. Sci. **41** (1975) 819–824.
[21] RAKESTRAW, J., LUSBY. K.S., WETTLEMANN, R.P., WAGNER, J.J., Post partum weight and body condition loss and performance of fall-calving cows, Theriogenology **26** (1986) 461–473.
[22] THATCHER, W.W., COLTUR, R.J., BEEDEE, D.K., WILLCOX, C.J., "Interaction of environment and reproductive processes in cattle", Nulcear and related techniques for improving productivity of indigenous animals in harsh environments, International Atomic Energy Agency, Vienna (1986) 61–72.
[23] PETER, A. R., "Recent techniques for improving reproductive efficiency of livestock", Isotope and related techniques in animal prouction and health, International Atomic Energy Agency, Vienna (1991) 423–436.