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A Preliminary Assessment of the Reproductive Performance of Nilotic Bucks under Intensive Management in the Semi-arid Climate of Khartoum

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Abstract: Three Nilotic bucks were fed sorghum-based diet and three molasses-based diets to examine the effect of nutrition and seasons in Khartoum (Sudan) on the scrotal circumference, sexual behaviour and semen quality. Reaction time was recorded in seconds from introduction to a goat in oestrus until ejaculation into an Artificial Vagina (AV). The scrotal circumference was measured around the width of the two testicles once every month. Semen was collected by an AV at weekly intervals. Semen characteristics examined were volume of the ejaculate, spermatozoa motility and concentration. Although the Nilotic bucks did not have a period of sexual quiescence, they had an active mating season starting at the beginning of autumn as indicated by the improved semen quality and reaction time (22.8 and 17.0 sec in autumn and winter as compared to 72.3 sec in summer). Testicular circumference reached its maximal size at the beginning of autumn (20.17 cm), remained at this level until mid-winter, and then declined thereafter and reached its minimal value during the next summer (17.08 cm). The season affected all semen characteristics examined and the best semen was obtained in autumn and winter. However, the magnitudes of these seasonal effects may not be sufficient to prevent the bucks from being used for breeding

Key words: Feeding systems; scrotal circumference; season; semen; reaction time

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throughout the year. Improved semen quality with an average volume of 0.79 ml/ ejaculate, 3.91 mass activity score, 80.44% individual motility and $3.79x10^9$/ml concentration of spermatozoa was obtained in the molasses-based feeding system compared with 0.55, 3.44, 74.20 and $3.34x10^9$/ml, respectively, in their sorghum-based fed fellow mates.

INTRODUCTION

Among the four breed-types of goats, existing in Sudan, the Nilotic dwarf is indigenous to the south, while the Nubian, Desert and Taggari are indigenous to the north. Nilotic goats are distributed in a large area of natural and political conditions that prohibited the availability of information about their production potentials. However, the surveys of El Mahi (1979) and Tilmat *et al.* (1983) revealed that this type of goats has good reproductive performance, but with poor growth rate and higher mortality rate of youngs that is attributed to their environmental husbandry. Despite their considerable population, 36% of total goat population in the country, they have little or no share in the economy of the country. However, due to their higher prolificacy these goats may be speculated to play an important role on the livelihood of their owners. With the presence of peace now prevailing in most parts of the country, it is high time to collect some necessary information on the overall performance and systems of management and feeding for these animals in their natural habitat and compile them with in-station intensive management studies to characterize them into distinct genetic groups/breeds/strains and to determine their actual potentials.

Apart from season and age, nutrition is considered to be the most important environmental factor that can affect reproductive activity in small ruminants (Thwaites 1995). In seasonally dry tropical and subtropical areas, food availability is the main factor controlling timing of reproduction (Degadillo and Malpaux 1996). To the best of our knowledge, the effect of nutrition and season on the reproductive performance of the Nilotic bucks have never been reported before. Therefore, the objectives of this study were to evaluate the reproductive

potentials of the Nilotic bucks under intensive system of feeding and management by comparing the semen quality, testes size and sexual behaviour during the three seasons of the year in Khartoum area. The role of nutrition was investigated by examining the effect of sorghum-based and molasses-based feeding systems on the semen quality and sexual vigor of the bucks.

MATERIALS AND METHODS

This experiment was conducted at the College of Natural Resources and Environmental Studies Farm in Kadaru area, Khartoum North (latitude 15°36' N; longitude 32°33' E and altitude 380 m above sea level). The year is divided into three seasons: summer (March to June), autumn (July to October) and winter (November to February).

Six mature Nilotic bucks of 1-2 years old and with an average body weight of 28 kg, were used in this experiment. The bucks belong to a flock of Nilotic goats purchased from Upper Nile State, in June 2006, and consigned to Khartoum. They were accommodated individually in separate pens under a large animal shed and grouped into two feeding systems: sorghum-based and molasses-based feeding groups. The concentrate portion of the sorghum-based was composed of 32% crushed sorghum as the main source of energy, 36% groundnut cake as the source of protein, 29% wheat bran, 2% limestone flour and 1% salt. To this concentrate portion, sorghum straw was offered separately as a roughage portion. These two portions were given separately at the rate of 1:1 in one morning meal. The molasses-based feeding was a complete pellet-based diet. It was composed of 20% crushed sorghum, 35% molasses of sugar cane, 15% wheat bran, 15% bagasses, 1.5% urea, 1.5 salt, 2% limestone flour and 10% groundnut cake. The sugar cane and urea were incorporated as major sources of energy and nitrogen, respectively. The bagasses are the main source of crude fiber in this feeding system. This diet was offered in one morning meal. The total metabolizable energy in the concentrate and roughage portions of the sorghum-based feeding system was 11.4 and 6 MJ/kg DM, respectively. On the other hand, the total metabolizable energy in the molasses-based diet was 10.5 ME/kg

DM. The two diets (sorghum- and molasses-based) were offered at the rate of 0.5 kg per buck per day. Fresh alfalfa (*Medicago sativa*) was given weekly as a source of carotene for both feeding groups. Clean water and mineral licks were given *ad libidium*.

The scrotal circumference was measured monthly by grasping the neck of the scrotum with the hand using the fingers to push the testicles ventrally to eliminate any wrinkles. The measuring tape was passed around the scrotum and tightened at the greatest width of the two testicles. The scrotal circumference was measured in centimetres.

The bucks were tested weekly for reaction time by recording their sexual interest when introduced to a female goat in oestrus. This was measured in seconds from the time the buck was presented to a female goat in oestrus until ejaculated into an artificial vagina (AV).

Semen was collected at weekly intervals from each buck using standard artificial vagina (AV) for small ruminants. A teaser doe on heat was used as mount animal to stimulate the buck. Four adaptation collections and five experimental collections were conducted from each buck in each season. The collecting tubes of AVs containing the semen samples were removed, labeled and placed in water bath at 30^{o}C. The semen was then evaluated for colour, volume, consistency, mass activity and individual motility, according to the methods described by Evans and Maxwell (1987). The concentration of the spermatozoa was assessed on the basis of semen consistency according to the scoring system of Evans and Maxwell (1987).

The effect of the feeding systems and season of collection (summer, autumn and winter) on semen characteristics, reaction time and testicular sizes were investigated. The data was subjected to two-way analysis of variance followed by Duncan's Multiple Range test as a post *hoc*. The colour of the ejaculated semen was analyzed using the chi-square test. Data analysis was performed using StatView software (Abacus Concepts Inc., Berkeley, CA, U.S.A.).

RESULTS

As shown in Table 1, both the feeding system and the season of the year affected the testicular circumference without interaction. The testicular circumference of the bucks in the molasses-based feeding system was significantly ($P<0.05$) wider than that in the sorghum-based feeding system during autumn and winter but not during summer.

The reaction time was affected by both the feeding system and season without interaction. Regardless of the feeding system, the reaction time in the summer was significantly ($P<0.05$) longer than in the two other seasons (Table 1), and significantly ($P<0.05$) longer in the sorghum-based feeding group than in the molasses-based feeding group fellow mates in all seasons.

Table 1. Effect of the feeding system and season on the testicular circumference and reaction time in Nilotic bucks

Feeding system	Summer	Autumn	Winter
	Testicular circumference (cm)		
Sorghum-based	$16.67 \pm 0.39^{a\,A}$	19.58 ± 0.36^{bA}	16.83 ± 0.21^{bA}
Molasses-based	$17.50 \pm 0.34^{a\,A}$	20.76 ± 0.5^{bB}	18.42 ± 2.60^{bB}
Average	17.08 ± 0.27^{a}	20.17 ± 0.25^{b}	17.63 ± 0.23^{a}
	Reaction time (sec)		
Sorghum-based	80.7 ± 4.3^{aA}	29.3 ± 3.8^{bA}	22.00 ± 2.9^{bA}
Molasses-based	64.0 ± 3.6^{aB}	16.3 ± 1.6^{bB}	12.0 ± 1.5^{bB}
Average	72.3 ± 3.1^{a}	22.8 ± 2.4^{b}	17.0 ± 1.9^{b}

$^{a, b}$ Row (means ± S.E.) and $^{A, B}$ column (means ± S.E.) with superscripts differ significantly at $P<0.05$. different

There was no interaction between the feeding system and the season of the year on the entire semen characteristics investigated. As shown in Table 2, regardless of the season, the molasses-based feeding system significantly improved the ejaculate volume, mass activity score,

individual motility percentages and concentrations of spermatozoa. Significantly higher values of ejaculate volume, mass activity, individual motility and concentration of spermatozoa were obtained during the autumn and winter irrespective of the feeding system.

Table 2. Effect of the feeding system and season on some semen characteristics of Nilotic bucks.

Feeding system	Semen parameter			
	Volume (ml)	Mass activity	Individual motility (%)	Conc. ($x10^9$/ml)
Sorghum-based				
Summer	0.35 ± 0.63^{a}	2.93 ± 0.12^{a}	68.33 ± 1.67^{a}	2.30 ± 0.24^{a}
Autumn	0.57 ± 0.07^{abc}	4.07 ± 0.15^{b}	79.67 ± 1.33^{b}	4.27 ± 0.23^{b}
Winter	0.73 ± 0.13^{bc}	3.33 ± 0.13^{c}	74.67 ± 1.79^{c}	3.47 ± 0.35^{c}
Mean	0.55 ± 0.06	3.44 ± 0.10	74.20 ± 1.15	3.34 ± 0.20
Molasses-based				
Summer	0.48 ± 0.07^{ab}	3.33 ± 0.13^{c}	74.0 ± 1.30^{c}	2.77 ± 0.22^{a}
Autumn	0.80 ± 0.10^{c}	4.33 ± 0.16^{b}	83.3 ± 1.59^{b}	4.53 ± 0.22^{b}
Winter	1.12 ± 0.12^{d}	4.07 ± 0.07^{b}	84.00 ± 1.39^{b}	4.60 ± 0.21^{b}
Mean	0.79 ± 0.07	3.91 ± 0.09	80.44 ± 1.06	3.97 ± 1.77

[a, b] Column (means± S.E.) with different superscripts differ significantly at $P < 0.05$.

Although the colour of the ejaculates was mostly white (52 out of the 90 ejaculated samples, Table 3), it varied between bucks within the same feeding system. Seventy-five percent of ejaculated sample from the molasses-based group was white ($P<0.05$). On the other hand, 60% of the samples from the animals in the sorghum-based group were yellow. The season of the year did not affect the colour of semen.

Table 3. Effect of feeding system and season on the colour of ejaculated semen from Nilotic bucks

	Percentage of ejaculated semen colour (No.)			
	White	Yellow	Yellowish- white	Total
Feeding system				
Sorghum-based	40.0(18)	60.0 (27)	0.0 (0)	45
Molasses-based	75.6 (34)	22.2 (10)	2.2 (1)	45
Total	52	37	1	90
$X^2 = 43.36$, P = 0.000				
Season of collection				
Summer	63.3 (19)	36.7(11)	0.0 (0)	30
Autumn	53.3 (16)	43.3(13)	3.3 (1)	30
Winter	56.7 (17)	43.3(13)	0.0 (0)	30
Total	52	37	1	90
$X^2 = 2.49$, P = 0.647				

The correlation coefficients matrix between the reaction time, mass activity, individual motility, and semen concentration indicated that all the examined semen characteristics were positively correlated with each other but negatively correlated with the reaction time (Table 4).

Table 4. Matrix of correlation coefficients between reaction time (sec) and some semen characteristics of Nilotic bucks

Semen parameter	Semen parameter				
	Reaction time (sec)	Volume (ml)	Mass activity	Motility (%)	Concentration ($x10^9$/ml)
Reaction time (sec)	1.00				
Volume (ml)	-0.5	1.00			
Mass activity score	-0.59	0.33	1.00		
Motility (%)	-0.55	0.39	0.76	1.00	
Concentration ($x10^9$/ml)	-0.59	0.37	0.59	0.59	1.00

P <0.05, N = 90

DISCUSSION

Under tropical conditions, where the amplitude of photoperiodic changes is low, local breeds of goats are either non-seasonal breeders or exhibit only a weak seasonality of reproduction (Chemineau 1986). Below 25° latitude, seasonal food availability is the main factor controlling reproduction. Rams and bucks of most tropical and subtropical breeds if fed at maintenance level do not exhibit seasonal variation of spermatogenic and/or behavioural activity (Chemineau *et al*. 1991). In the present study, despite the fact that the animals were well-nourished and kept under an intensive system of management, the bucks exhibited slight seasonal variation in their sexual behaviour and seminal characteristics. They were apparently having an active mating season that started in autumn and continued during winter. Although the Nilotic buck did not have a period of sexual quiescence, an increase in their sexual drive was detected during autumn and winter as indicated by the short reaction time. This finding is apparently not consistent with that of Bitto *et al*. (2008) who reported that the West African Dwarf bucks have no restricted breeding season in their native tropical environment. The significantly shorter reaction time and consequently vigorous sexual desire observed in the molasses-based feeding group was always associated with improved seminal characteristics. This observation was confirmed by the correlation coefficient matrix (Table 4) where the reaction time was negatively correlated with all seminal characteristics examined, which were correlated positively with each other.

The sexual behaviour, manifested as reaction time, and seminal characteristics were significantly modified by the feeding system. In the molasses-based feeding system, a complete pellet-based diet was offered which would not allow the animal to discriminate roughages from concentrate and thus reduced feed loss. Moreover, this feeding system is expected to allow more ME intake than the sorghum-based system, because a maximum allowance of 5.25 MJ per day can be consumed by the animal (10.5 MJ/kg DM). On the other hand, animals fed sorghum-based diet were given 0.25 kg/day of the concentrate portion (11.4 MJ/kg DM) and 0.25 kg/day of roughages (6 MJ/kg DM) which allowed a

maximum of 4.5 MJ per day. Cameron *et al*. (1988) reported that nutrition resulted in 86% increase in testicular size which was associated with 2.5% increase in proportion of spermatozoa. They reported that males showed a flushing effect similar to that of females. Martin and Malkden-Brown (1995) stated that the energy concentration rather than the protein content of the diet has a major effect on gonadotrophin secretion. This may explain the superiority of the molasses-based feeding system with regard to the semen quality observed in the current study. The advantage of using the molasses-based system of feeding is that it reduces the competition between livestock and humans for feed resources.

Testicular circumference reached its maximal size at the beginning of autumn and remained essentially at this level until mid-winter, and then initiated a progressive decline thereafter until it reached its minimal value during the next summer. Similar trends were observed by Delgadillo *et al*. (2001) and Abi Saab *et al.* (2008). Testis size is considered a good indicator of spermatogenetic activity (Salau-Daudu, 1984). Hafez *et al*. (1955) reported that testis size is important because of its high correlation with sperm production potential and it is a highly heritable trait that could easily be improved by selection. However, the heritability of testicular size in the Nilotic bucks deserves further study. There is at present a dearth of information on testicular measurement and their application in the prediction of good sires in goats. Testicular measurements and the changes that occur during growth of the testis from birth to sexual maturity have, however, been well documented for rams (Dyce 2002).

The season affected all seminal characteristics examined in this study. However, the magnitudes of those seasonal effects were not sufficient to prevent the bucks from being used for breeding throughout the year. Great seminal volume per ejaculate in autumn and winter was observed. The changes of ejaculate volume are mainly due to changes in quantities of fluid secreted by the epididymis and accessory sex glands which are androgen-dependent (Mann 1981; Chemineau 1986), but androgen receptors in the targeted organ need a preliminary preparation in which prolactin is involved (Chemineau *et al*. 1991). In turn, prolactin secretion is associated with day light of long duration (Corteel 1977). Accordingly,

it can be stipulated that despite the lower amplitude of photoperiodic changes in the tropical climate at Khartoum, the endocrine system might not be deprived from the appropriate stimulation that evokes seasonal fluctuation in seminal volume in Nilotic bucks.

The dry and hot summer (maximum temperature of 40°C–45°C) in Khartoum may limit the reproductive ability of animals during this season. Many studies have revealed an adverse effect of ambient temperature on semen quality, including a decrease in spermatozoa motility and increase in the percentage of morphologically abnormal spermatozoa (Devendra and Burns 1983; Evans and Maxwell 1987). The detrimental effect of high temperature on spermatozoa production occurs as a result of an increase in testicular temperature which evokes degeneration at an specific and critical stage of the spermatogenetic cycle (Chemineau *et al.* 1991). Moreover, a primary response of most species to heat stress is reduction in energy intake (Bongso *et al.* 1982).

The average spermatozoa cells concentration obtained in the present study is comparable with that of exotic and indigenous goat breeds kept under similar tropical conditions (Sinha and Singh 1982; Roca *et al*. 1992). Devendra and Macleroy (1987) observed a remarkable breed difference in spermatozoa cells concentration. They reported that the Boar buck may ejaculate three times as many spermatozoa as the native Zambian buck. The colour of ejaculates varies between bucks within the same feeding system. According to Campbell and Lasley (1975), the yellowish appearance is due to a harmless pigment called riboflavin. This characteristic is probably not due to dietary factor since other bucks under the same feeding system produce white semen. There is evidence that the yellow pigmentation of bull semen is hereditary and that it may behave like Mendelian dominant (White and Lincoln 1958).

CONCLUSION

In conclusion, the Nilotic bucks like other tropical goat breeds are not seasonal breeders, but they have a tendency to mate at the beginning of autumn. The seasons affected all semen characteristics examined. However, the magnitudes of those seasonal effects may not be sufficient

to prevent the bucks being used for breeding throughout the year. The quality of Nilotic buck semen examined was significantly modified by the molasses-based feeding system and the best semen was produced in autumn and winter.

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مجلة جامعة الخرطوم للعلوم الزراعية: المجلد السابع عشر-العدد الثالث، 2009م

دراسة اولية عن الكفاءة التناسليه لذكور الماعز النيلى تحت رعاية مكثفة فى مناخ الخرطوم شبه الجاف

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موجز البحث: أجريت هذه الدراس ة لمعرفة تاثير النظام الغذائى وفصول السنه فى ولاية الخرطوم علي السلوك الجنسي ونوعية السائل المنوي لذكور الماعز النيلى. قسمت سته تيوس من الماعز النيلى لمجموعتين، حيث غذ يت احداهما على عليقة اساسها الذرة الرفيعه و الاخرى على عليقة اساس مكوناتها مولاس قصب السكر. تم تقدير الرغبه الجنسيه بقياس زمن التفاعل من لحظة تقديم التيس الى انثى ماعز فى فترة شبق حتى لحظة قذف السائل المنوى فى مهبل اصطناعى. اما حجم الخصيتين فقد تم قياسه عند اعرض مكان فى محيطهما. جمع السائل المنوي من كل تيس بواسطة المهبل الاصطناعي مرة في الإسبوع لدراسة بعض صفات المني مثل الحجم والحركة وتركيز النطف. أظهرت الدراسة أن تيوس الماعز النيلى لا تتصف بموسم تناسلى محدود وليس لها فترة خمول جنسى، إلا ان لهذه الحيوانات نشاط جنسى متزايد مع بدايه موسم الخريف حيث تحسنت نوعيه السائل المنوى وازدادت الرغبه الجنسية وقل زمن التفاعل ليصبح 22.8 و17.0 ثانية فى موسمى الخريف والشتاء على التوالى مقارنه ب 72.3 ثانيه فى الصيف. كما أظهرت النتائج ان حجم الخصيتين يتغير مع فصول السنه ، حيث ازداد ليصل اقصى حجم له (20.17 سم) مع بداية الخريف وبقى بهذا الحجم حتى منتصف الشتاء ومن ثم بدا فى التناقص ليصل اقل حجم له (17.8 سم) خلال الصيف. واظهرت الدراسة أيضا ان لفصول السنة تاثير معنوى على كل صفات السائل المنوى التى فحصت وان احسن نوعيه تم الحصول عليها فى الخريف. ومع ذلك فان هذه التاثيرات قد لا تمنع استخدام التيوس لغرض لتناسل طوال السنه. هذا وقد كانت لعليقة المولاس فوارق معنوية في صفات السائل المنوى حيث كان متوسط حجم القذفه 0.79 مل والحركه الجماعيه 3.91

والحركه لفرديه 80.44% وتركيز النطف $3.79x10^9$ بالمقارنه مع عليقه الذرة الرفيعه حيث كان متوسط حجم القذفه 0.55 مل والحركه الفرديه 74.20% والجماعيه 3.44 وتركيز النطف $3.34x10^9$.