THE EFFECT OF TEMPERATURE CHANGES ON THE MATING PERFORMANCE AND SEMEN QUALITY OF RAMS

by

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INTRODUCTION

The role of environment in the reproductive process of domestic sheep (Ovis aries) has been researched extensively. Much of this research concentrated on the reproductive efficiency of the ewe, with renewed interest in the hormonal and environmental control of the estrous cycle.

With more emphasis placed on the ewe, less has been given to the breeding ability of the ram. Until recently, techniques for assessing the breeding soundness in the ram were limited or taken from research on bulls.

Most flock owners do not determine the libido, serving capacity and semen quality of their rams. The general assumption is that within a group of rams there will be enough individuals of high fertility to service all ewes in estrus. However, the average annual cost per ram is now approximately $279.00 (Kimberling et al., 1983) justifying the discovery and elimination of infertile rams. Small farm flocks employ the use of marking harnesses, colored grease and oils applied to the brisket of the ram to determine the breeding ability of a single sire. This method is dependent upon the rate of return to estrus in the ewe flock (SID Handbook, 1977). If a breeder waits until ewes return to estrus to replace a sire this can be an economical loss, particularly for purebred breeders that require older lambs for early show and sale schedules.

Increased lamb production throughout the year depends to a large extent on the thermal environment of the ram and the ewe. Thermal environment is composed of various climatic events and is described as the effective ambient temperature (NRC, 1981). A component of the effective ambient temperature which has the greatest effect on farm animals is air temperature.

High temperatures do adversely affect fertility in rams, however, little data is available to separate the effects of high temperature on serving capacity and semen production. This study was conducted to determine the effect of temperature changes on mating performance and semen quality.

LITERATURE REVIEW

Three important traits affecting the reproduction of livestock are the male's libido, serving capacity and semen quality. Libido has been defined as "the willingness and eagerness of a male animal to mount and to attempt service of a female" (Chenoweth, 1981) or is more simply stated as sexual activity (Mickelsen _et al_., 1982), sex drive (Craig, 1981), or sexual aggressiveness (Lunstra, 1980). Serving capacity describes the number of ejaculations a male will achieve under specific conditions (Mickelsen _et al_., 1982) and is often used in breeding soundness examinations or as a measurement of serving efficiency (Blockey, 1976). Semen quality characteristics usually include: volume, percentage of motile sperm, percentage of normal/abnormal sperm and concentration of spermatozoa in boars (Wettemann _et al_., 1976), rams (Howarth, 1969) or bulls (Hardin _et al_., 1981).

Sexual Behavior. Important mating patterns of the male sheep that are often observed in libido tests have been defined by Banks (1964), Fraser (1974) and Hafez (1974, 1975). These include; 1) sniffing the perineum or females genitalia and urine, 2) courtship, which includes the nudging of the ewe by extension and flexion of one foreleg, lowering the head accompanied by courting grunts (while approaching the ewe) and flicking of the tongue, 3) flehmen or lip curl with the ram holding his head rigidly in a horizontal position and (possibly) moving side to side with his neck extended for 10-30 seconds, 4) mounting, straddling and clasping the ewe's hindquarters with his forelegs, 5) rapid pelvic thrusts, 6) intromission, and 7) ejaculation accompanied by an especially deep pelvic thrust and rapid movement backwards of the head. Patterns of courtship in bulls are similar, except for a characteristic "leap" at ejaculation (Hafez, 1974). The mechanism of sexual behavior in swine is rather different but resembles sheep and cattle with the immobile or standing reaction of the receptive sow, therefore eliciting a mounting reaction by the boar (Signoret, 1970; Hafez, 1974; Hurtgen and Leman, 1976).

Lindsay (1965) investigated the importance of olfactory stimuli in the mating behavior of the ram. He concluded that anosmic rams determined which ewes are in estrus by attempting to mate and mount only those exhibiting the immobile posture when approached. Anosmic rams could mate like normal rams without foreplay except for increased displays of nudging. Lindsay (1965) shows that anosmic rams can mate with unrestrained ewes similar to that of normal rams, but not as well with tethered ewes, since they cannot distinguish between estrous and non-estrous ewes.

Postcoital behavior may include stretching of the head and neck, leaving to court another estrus female, remounting the same ewe, or standing while the ewe leaves. Fraser (1974) has expanded these behavioral activities to include all male farm animals which include: "1) threat displays, 2) challenges, 3) territorial activities, 4) female seeking and driving, and 5) female tending." He further contends that mounting is the principle component of male mating behavior and is somewhat learned but occurs more naturally by the highly aroused animal. Male animals with low levels of libido regardless of the cause will have disorientation problems during mounting. False-mounting without clasping the female with the forelegs or pelvic thrusts is also observed quite regularly during courtship. Hafez (1974) attributes this to the degree of receptivity of the females, i.e. if the female is receptive, mounting and ejaculation may occur rapidly.

Chenoweth _et al_. (1981) has described bovine libido as a behavioral factor that can influence the number of matings a bull can achieve. Although difficult to measure, libido has been recently regarded as an important factor in the breeding soundness examination of rams (Ott and Memon, 1980). Mickelsen _et al_. (1982) assessed sexual activity in rams by restraining intact diestrous, anestrous or tranquilized ewes and releasing a ram for a 5 minute period. The libido score for 24 rams was 8.95 per test period. The immobilization of the female appears to be the best stimulus to elicit vigorous breeding behavior by the ram, bull and boar (Signoret, 1975; Chenoweth, 1981; Craig, 1981).

Pepelko and Clegg (1965) studied sexual exhaustion of rams by allowing ten rams to individually mate with estrus induced ewes until no mounts occurred within 20 minute periods. The total number of ejaculations averaged from 2.9 to 8.4 for individual rams with an overall average of 5.5. They noted an increase in interval between the first ejaculation and the following mount and attributed this to the continuous stimulus condition of the experiment. When rams were exposed to a different, not recently mated female, sexual recovery in rams was significantly greater than if the same female or a different recently mated female was used. When the same ewe was returned at various intervals after sexual exhaustion, the rams' sexual responsiveness would increase but not to complete sexual responsiveness. These results agree with those of Thiery and Signoret (1978) who renewed the sexual activity of rams significantly by changing the teaser ewe. Hale and Almquist (1960) obtained complete sexual recovery of bulls through use of three successive teasers. Their interpretation is that sexual exhaustion is not fatigue per se but that the male tires of a specific stimulus animal in a specific test situation.

The relationship of libido and fertility in range rams was reported by Wiggins et al. (1953). Results of a 14 yr study indicate significant negative correlations between the reaction time of rams until ejaculation and the number of ewes lambing. Results reported by Hulet (1977) are similar in that rams with high sex drive mated with and settled more ewes sooner than rams with less libido. Blockey (1976 & 1978) evaluated the sexual efficiency and fertility of bulls by their serving capacity during pasture mating. His data show a strong correlation (r=.94) between serving capacity and the number of estrous heifers that bulls mounted and served (0, 1 or 2 times). Results of 1978 indicated that these heifers had a higher first service conception rate when bred to high serving capacity bulls. Blockey attributes the high correlation to the fact that a bull rarely served the same heifer twice, regardless of his serving capacity. Lunstra (1980) found positive relationships existed between libido tests and conception rates in fertility trials among beef bulls with the same semen quality. Working with yearling bulls, Chenoweth (1978) concluded that sex drive varies considerably between different lines of bulls, but a bull with high sex drive may have poor semen production and vice versa. Therefore, it is recommended that bulls be evaluated for libido and semen quality as measurements of fertility. The same can be said for rams and goats, since no significant connection exists between high libido scores and the production of good semen quality (Fraser, 1974). Chenoweth _et al_. (1979) concluded that the libido score vs the serving capacity score or the reaction time to first service was a more advantageous method of assessing sex drive in beef bulls. Libido appeared to be the most repeatable and required less exposure time than serving capacity tests. They also conclude that a 10 minute test was sufficient to provide information on the sex drive of yearling bulls. Osborne _et al_. (1971) worked with unhandled bulls and reported that exposure of a bull to an estrus female for only 5 minutes was adequate to evaluate the libido and serving capacity. Chenoweth _et al_. (1979) found that females in estrus are unnecessary for mating tests if females are properly restrained. As with Signoret (1975) in sheep, Chenoweth found that immobility of the female was the greatest stimulus to a bull to complete service.

The effect of season on mating performance has been well documented in rams. Whiteman and Brown (1959) observed more matings by Dorset rams and subsequently more lambs per mating after they were kept in a room controlled to reach a daily maximum of 85°F. It has been reported that libido and serving capacity scores of rams are highest in the autumn (particularly September through November), and the lowest in the spring and summer (Hulet *et al.*, 1977; Mickelsen *et al.*, 1981 and 1982; Tulley and Burfening, 1983). Tulley and Burfening (1983) noted a shorter reaction time for ejaculation in rams during the fall and winter but a clear pattern for libido was not established. Rams are willing to mate any time of the year since monthly averages for mounts per ejaculation do not differ significantly, but seasonal differences exist. However, the number of ejaculations vary significantly ($P<.01$) with month and season, the most frequent ejaculation occurring in the fall period of October, November and December (Pepelko and Clegg, 1965). Mattner (1977) found lower libido in rams during winter and spring and Kilgour and Herdegen (1977) found that rams in the Southern Hemisphere (New South Wales) were more active in April which corresponds to fall in the Northern Hemisphere. Hardin *et al.* (1981) found no difference in the way Angus and Brahman bulls maintain their libido throughout the year. However, the two breeds had significant ($P<.05$) differences in libido scores; Angus=4.4 and Brahman=2.5.

Using three breeds of rams, Lindsay (1969), showed that the sexual activity of all rams was affected by high temperatures (27°C-43°C), but the effect was different between breeds.

He noted that Merino rams maintained sexual activity at the highest temperature (43 °C), whereas Dorset Horn and Border Leicesters did not. Recovery from heat was also longer for Dorset Horn and Border Leicesters.

When assessing sexual activity in Finnish Landrace and Suffolk rams, Schanbacher and Lunstra (1976) noted seasonal variations in libido and mating index scores (the highest scores in October). However, Finn rams were more active than Suffolks and certain individuals within each breed group consistently scored high regardless of season or hormone levels. It appears that high temperature and/or season has a detrimental effect on the number of ejaculations an intact male can achieve. However, the practice of genetic selection for the maintenance or improvement of libido may have more practicality than determining the effect of thermal stress on sexual activity.

Mickelsen _et al_. (1982) found that regardless of age or experience, rams show similar serving capacities over consecutive years and it appears to be an inherent factor. Wilkins and Kilgour (1977) support the genetic basis of libido as does Fraser (1974), but cautions the use of this inherent factor to predict mating performances, as age could cause differences in mating performances.

Semen Characteristics. Thermal stress due to high ambient temperature has resulted in lower semen quality in rams (Bogart and Mayer, 1946; Dutt and Hamm, 1957; Dutt and Simpson, 1957; Ulberg, 1958; Hafez, 1959; Cupps _et al_., 1960; Alliston _et al_., 1961; Moule and Waites, 1963; Howarth, 1969; Lindsay, 1969;

Lunstra and Schanbacher, 1976; Hulet, 1977; Mickelsen et al., 1981; Mickelsen et al., 1982), bulls (Erb et al., 1942; Casady et al., 1953; Brown, 1960; Austin et al., 1961; Johnston et al., 1963; Igboeli and Rakha, 1971; Rhynes and Ewing, 1973; Meyerhoeffer et al., 1976) and boars (McNitt et al., 1972; Roller and Stombaugh, 1974; Wetteman et al., 1976; Wetteman and Desjardins, 1979). Thus it becomes evident that semen quality is an important factor in the breeding value of the male and should be regarded highly in breeding soundness examinations.

When exposed to elevated ambient temperature, semen volumes were not significantly affected in boars (McNitt and First, 1970; Roller and Stombaugh, 1974; Wettemann et al., 1976), rams (Dutt and Hamm, 1957; Dutt and Simpson, 1957; Howarth, 1969) or bulls (Meyerhoeffer et al., 1976). However, Bogart and Mayer (1946) and Cupps et al., (1960) report a decrease in semen volume of rams after exposure to high thermal temperatures. Lindsay (1968) also found that mean ejaculate volumes of rams decreased (0.4 ml to 0.23 ml) after a slow increase in controlled ambient temperature to a high of 43°C. Simpson et al., (1959) allowed 1 group of rams to have access to an air conditioned room and their subsequent semen volumes were significantly higher than that of controls.

Erb et al., (1942) reported significant seasonal variations in semen volumes of 4 different breeds of dairy bulls (volumes were lowest in July, August, and September). These results agree with those of Hardin et al., (1981) who reported significant ($P<.05$) differences in semen volumes in bulls collected during different seasons with volumes highest in the fall and lowest in summer. Casady *et al.*, (1953) found three different results in a single study when he exposed Guernsey bulls to 100°F temperature in 2 environmental chambers. The semen volumes in the chamber where temperature gradually increased, was not consistently affected. However, in the other chamber, the semen volumes increased as the temperature was lowered and then decreased during the subsequent rise in temperature to 86.4°F. A trial with Short Horn Zebu (Angoni) bulls resulted in significant differences in semen volume between seasons (rainy, cold, and hot) (Igboeli and Rakha, 1971). Scrotal insulation of bulls resulted in the lowering of motile spermatozoa, percentage live sperm, and concentration per ml of spermatozoa and raised the percentage of abnormal spermatozoa (Ross and Entwistle, 1979). This decrease in semen quality occurred by the second and third weeks after insulation in Hereford bulls (Austin *et al.*, 1961). Sperm concentration did not decline as rapidly but decreased significantly from the fourth through seventh week after insulation. The histological appearance of the seminiferous epithelium was also altered, but the rate of spermatogenesis and epididymal transport was not changed (Ross and Entwistle, 1979). Autoradiographic estimates gave mean values of 13.4 days for one seminiferous epithelium cycle and 13.5 days for epididymal passage. Raising the temperature of the testes by insulation appears to be as detrimental to semen quality as exposure to whole body heating.

The deleterious effect of high temperature on percent motile spermatozoa is evident in rams (Dutt and Hamm, 1957; Dutt and Simpson, 1957; Simpson et al., 1959; Cupps et al., 1960; Alliston et al., 1961; Howarth, 1969; Lindsay, 1969), boars (McNitt and First, 1970; Roller et al., 1974; Wettemann et al., 1976), and bulls (Erb et al., 1942; Casady, 1953; Brown, 1960; Johnston et al., 1963; Meyerhoeffer et al., 1976). McNitt and First (1970) exposed boars to 33°C and found a significant change in overall sperm motility but no change in progressive motility. They suggest that sperm are affected by high heat at two stages of development in which motility decreases along with increased abnormal spermatozoa as spermatocytes (late primary and secondary) and early spermatids. Heat stress affected the middle period of the primary spermatocyte stage resulting in the decreasing of total sperm concentration and total motile sperm. Abnormal spermatozoa were attributed to heat stress weakening sperm cells from the mid-primary spermatocyte to early spermatid stage. The variability between breeds had a significant effect on overall motility, total motile sperm, total sperm, and had a highly significant effect on percentage of abnormal sperm. Other work with boars found a significant decline in young spermatids in seminiferous tubules after exposing boars to whole body heat for 90 days (Wettemann and Desjardins, 1979). Moule and Waites (1963) exposed rams to high temperatures and found wide differences in individual responses to thermal stress and subsequent seminal degeneration. Their results are similar to that found in boars in which semen collected 2 to 3 weeks after heat treatment was low in concentration and motility, with an increase in percentage of abnormal spermatozoa (McNitt and First, 1970).

The detrimental effect of high temperatures on the morphology of sperm cells appears to be undisputed. Roller and Stombaugh (1974), McNitt and First (1970), and Wettemann et al. (1976) all reported increasing percentages of abnormal spermatozoa after heat treatments of boars. The same can be said for rams (Dutt and Hamm, 1957; Simpson et al., 1959; Cupps et al., 1960; Moule and Waites, 1963; Mickelsen et al., 1981; Mickelsen et al., 1982) and bulls (Brown, 1960; Austin et al., 1961; Johnston et al., 1963; Igboeli and Rakha, 1971; Rhynes and Ewing, 1973; Ross and Entwistle, 1979). Meyerhoeffer et al. (1976) found no difference in percentages of normal sperm between heat stressed bulls and controls. However the percentage of aged acrosomes increased in 3 weeks in treated bulls and remained higher during the trial. In all three species, the effect of thermal stress on the morphology of semen becomes evident 2 to 3 weeks after exposure to high temperatures. Dutt and Hamm (1957) exposed shorn and unshorn rams to high temperatures and reported large increases in abnormal sperm for unshorn rams. Recovery of semen quality generally requires 6 to 9 weeks post exposure in all 3 species.

The detrimental effect of high temperature on sperm morphology appears to be most drastic prior to the epididymal level. Howarth (1969) found that sperm in the epididymis was more resistant to thermal heat. This was demonstrated when the fertility rate of ewes bred to stressed rams remained high one week after treatment before declining 1 to 2 weeks later. Results indicated that B-type spermatogonia and pachytene spermatocytes at late stage 7 or early stage 8 were the most susceptible to higher temperatures within the testes. This is similar to that found by McNitt and First (1970) in boars. Austin et al. (1961) noted that insulation on the scrotum of bulls affected more mature stages of sperm development. Work with rams by Moule and Waites (1963) agrees that the effect of heat stress was more severe on sperm in stages of development in the seminiferous tubules. However, they noted that individual rams differed significantly in susceptibility to heat stress and its effect on semen. Johnston et al. (1963) noted that the percentage of abnormal sperm after heat stress was greater in the semen of purebred bulls than in crossbreds.

Yorkshire boars exposed to 34.5°C for 8 hrs and 31.0°C for 16 hrs daily for 90 days increased the percentage of abnormal sperm with aged acrosomes by the second week of treatment (Wettemann et al., 1976). This is similar to that found by Meyerhoeffer et al. (1976) in bulls.

Trials with all three species of livestock have reported decreases in the concentration of spermatozoa in ejaculates due to the effect of high temperature. In boars, concentration remains low 2 to 8 weeks post-treatment (McNitt and First, 1970; Roller and Stombaugh, 1974; Wettemann et al., 1976; Wettemann and Desjardins, 1979). Lower concentrations are evident 4 to 7 weeks after insulating the scrotum of bulls (Austin et al., 1961; Ross and Entwistle, 1979).

Seasonal and thermal stress will adversely affect sperm cell numbers in rams (Dutt and Hamm, 1957; Dutt and Simpson, 1957; Cupps et al., 1960; Alliston et al., 1961; Moule and Waites, 1963; Howarth, 1969; Lunstra and Schanbacher, 1976) and bulls (Casady et al., 1953; Johnston et al., 1963; Igboeli and Rakha, 1971; Rhynes and Ewing, 1973). The concentration of spermatozoa has also been noted to be highest during warmer months of the year in bulls (Erb et al., 1942; Hardin et al., 1981).

The fertility of semen measured as fertilization rates and subsequent embryo survival has been documented by Howarth (1969), who found a decline in conception rates in ewes 2 to 3 weeks after rams were exposed to 32°C (65% humidity) for 4 days. Housing rams at 65°F vs outdoors resulted in higher semen quality and conception rates of ewes. However, a 35 day nonreturn rate in ewes mated to rams with semen estimated as high quality resulted in a low nonreturn rate. Only the cooling of both ewes and rams significantly increased the conception rates (Ulberg, 1958). Alliston (1961) also noted a decline in the fertility of ram semen after exposure to high temperatures. Conception rates of ewes significantly correlated with semen volume, estimated motility, percentage of normal sperm, percentage of abnormal heads and percentage of live-normal spermatozoa (Wiggins et al., 1953). There is a drastic decline in pregnancy rates of gilts inseminated with semen from boars exposed to 33°C for 72 hrs. This decline occurs from 16 to 58 days post treatment of boars (Roller and Stombaugh, 1974). Wettemann _et al_. (1976) determined embryonic survival in gilts at about 30 days of pregnancy in which there was a 71.2 ± 3.7% survival rate when semen from control boars was used and 48.5 ± 5.2% survival rate when semen from stressed boars was used. Increased environmental temperatures resulted in lower 60 to 90 day nonreturn rates to first and second services in cows bred to heat stressed dairy bulls (Brown, 1960). However, Mickelsen _et al_. (1981) found no direct relationship between ram semen quality and fertility and Johnston and Branton (1953) found no significant seasonal or breed differences in fertility of dairy bulls or their ejaculates.

MATERIALS AND METHODS

Four Suffolk rams 29 to 30 mo old and weighing 149 ± 13.5 kg were maintained at the Kansas State University Sheep Unit, Manhattan, Kansas, and were used to study the influence of temperature on serving capacity and semen production during July, August and September, 1983. All rams were housed in two environmental chambers (two rams per chamber) during the experimental period. For 2 mo prior to entering the environmental chambers, the rams were maintained in one 5.8 m x 25.3 m drylot of an open front shed. Rams were haltered and exercised daily during this time to accustom them to handling.

During treatment, the rams were fed an 85% concentrate diet (17% CP DM basis) at 4 lbs. per head per day, and water was supplied ad libitum. Incandescent lighting was maintained in the chambers from 0700 h to 2100 h and lights were off from 2100 h to 0700 h except on Tuesday mornings when lights were turned on at 0600 h to run serving capacity tests. Both chambers had concrete slat floors. Relative humidity was not controlled and fluctuated between 58% and 76% in both chambers. Rams were examined for breeding soundness the day they entered the chambers. The examination included measurement of the scrotal circumference, rectal temperature, weight and a general physical examination.

Treatment. Rams were randomly divided into two groups and assigned to one of two, Forma Scientific Walk-In Rooms (3.6 m x 2.4 m). Based on a 30 y average for Manhattan, Kansas, the temperature in chamber 1 was controlled to simulate the month of

August (a low of 21 $\pm$ 4.53°C to a high of 32 $\pm$ 2.03°C), while chamber 2 simulated the month of October (10 $\pm$ .74°C to 21 $\pm$ .4°C). The temperature in each chamber was allowed to rise from 0600 h to the high temperature at 0800 h and remained high until at 2200 h. The temperature declined from 2200 h to the low temperature at 2400 h and remained low until the next 0600 h (Fig. 1).

After 6 wks of treatment rams were switched to opposite chambers for another 6 wks of treatment. The first 2 wks were for acclimation to these temperatures and training of rams to serve an artificial vagina. Serving capacity data were collected twice a week and semen was collected for evaluation once a week, for the next 4 wks. At the time the rams switched chambers the body weight, rectal temperature, and scrotal circumference were taken.

Serving Capacity Tests. Each chamber was divided in half (1.75 m x 3.22 m) on collection day with a plywood barrier to prevent the rams from observing each other during mating. One ram was haltered and tied on each side while an ovariectomized ewe was restrained in a serving stanchion. The stanchion was placed so that the hindquarters were immobilized and facing the center of the pen as described by Signoret, 1975; Craig, 1981; and Mickelson et al., 1982. This was done approximately 15 min before releasing the ram. Ewes were rotated to prevent mating with the same ram during two consecutive test periods as suggested by Pepelko et al., 1965. Rubber mats were placed behind each ewe to provide a solid surface for the rams during mounting. The teaser ewes were injected with 4 mg progesterone and 1 ug estrone per cc for 3 days and then .2 mg estrone 2 days later (Table 7) (Kiracofe, 1983).

Each ram was allowed to mate with the teaser ewe on one side of their respective chamber for 30 min. Mounts with and without ejaculation were recorded. All attempts by the ram to straddle the rear quarters of the ewe were recorded as mounts. A mount accompained with an ejaculatory thrust was recorded as a service. Observations were made from outside the chambers through a window in the chamber door. A mirror, placed in the far corner of the chamber, was used to view the sexual activity of the ram on the opposite side. Two observers were used and they alternated chambers with each test.

The serving capacity score was the number of ejaculations during the 30 min test period. Serving capacity tests were conducted twice a week (once at the low temperature, at approximately 0700 h on Tuesdays and once at the high temperature, approximately 1750 h on Fridays) on all rams for 4 wks.

Semen Analysis. Semen was collected via artificial vagina once a week as rams mounted a restrained ovariectomized ewe. Semen was collected once a week at approximately 1200 h every Thursday. Immediately after ejaculation, ejaculate volumes were determined with 1 ml pipettes. Estimates were made of the percent motile sperm per ejaculation by observing a drop of undiluted semen on a warm slide at 100X.

Each sample was diluted 1:48 with 2.9% sodium citrate buffer. Extended semen was cooled and evaluations made approximately 90 min later. Morphology was determined by examining 100 sperm at 400X. Sperm cell types were classified as percent normal spermatozoa, percent aged acrosomes, percent total protoplasmic droplets, percent abnormal heads, and percent abnormal tails. Sperm concentrations were determined with diluted semen in a calibrated spectrophotometer (KABSU,1983).

Data was analyzed by analysis of variance techniques and group means tested by least significant differences (Snedecor and Cochran, 1980).

RESULTS AND DISCUSSION

Sexual Behavior. The effects of the two temperature treatments on serving capacity and mounts are shown in Table 1. The number of services was significantly (P=.03) higher for rams in the cooler treatment (10-21°C). Whiteman and Brown (1959) also observed more matings by Dorset rams when the temperature was controlled to not exceed 29.4°C. The number of mounts was also higher (P=.07) in the cooler treatment, but the difference was not as great as for number of services. Serving efficiency (mounts with ejaculation divided by total number of mounts) was lower in the hotter temperature (32°C) indicating that high temperature had a greater affect on serving capacity than on the rams' desire to mount. Although the efficiency of serving capacity has not been used in the breeding evaluation of rams, Blockey (1976 & 1978) measured serving efficiency by the serving capacity of bulls and found a positive correlation (r=.94) between a bull's serving capacity and the first service conception rates in heifers.

When rams were tested at the high and low temperatures of each treatment the 32°C temperature was detrimental to both serving capacity and number of mounts; however, rams showed some improvement when tested at 21°C (Table 2). In fact, their serving capacity and number of mounts was not significantly different than when the rams were in the cooler treatment and were tested at 21°C. Summer temperatures of 32°C and greater would appear to be detrimental to libido and serving capacity; however, a buffered environment such as keeping rams in an air conditioned room during part of the day may provide enough relief to obtain satisfactory sexual behavior. The lowering of rams' serving capacity due to high temperature in this experiment agrees with other studies concerning seasonal effects on mating performance of rams. Those generally show significantly ($P<.01$) more ejaculations during the fall (Pepelko and Clegg, 1965; Schanbacher and Lunstra, 1976; Hulet et al., 1977; Mickelsen et al., 1981 and 1982; Tulley and Burfening, 1983) than during spring and summer. The rams' willingness to mount at any of the temperatures in this experiment is similar to results of tests where rams willingly mated every month but showed seasonal variations (Pepelko and Clegg, 1965).

Considerable ram variation was noted among the four rams (Table 3). Despite this wide variation in average number of ejaculations (1.63 to 5.38) and mounts (4.56 to 8.88) a significant ($P<.01$) difference was achieved due to treatment. Also, there was a ram x treatment (chamber) interaction on serving capacity (Table 4) and on number of mounts (Table 5). As may be expected, some rams were more adversely affected by high temperature than others and the order of treatment also affected a ram's response. Individuals within breeds have been affected differently by temperature and/or season before in a study by Schanbacher and Lunstra (1976). The mating performance of rams may be improved by selecting parental stock less affected by environment, age or breeding experience. This is supported by Wilkins and Kilgour (1977) and Fraser (1974).

Rectal Temperatures. An indication of thermal stress is an elevation in rectal temperature. Rectal temperatures were recorded on all test days after the rams were switched to opposite chambers. The rectal temperatures of the two rams switched from the cooler to hotter treatment increased from an average of 39.2 $\pm$ .34^{o}C when tested at 21^{o}C to 39.8 $\pm$ .35^{o}C when tested at 32^{o}C. The other rams switched to the cooler treatment averaged 39.0 $\pm$ .1^{o}C at the 10^{o}C test and increased to 39.3 $\pm$ .24^{o}C when tested at 21^{o}C.

Semen Characteristics. Table 6 shows a comparison of semen volumes and sperm motility between the two treatments. Volumes were not significantly different between the two; in fact, rams in the hotter chamber (treatment 1) had slightly higher volumes. Conflicting results are reported in the literature where Dutt and Simpson (1957), Howarth (1969), and Dutt and Hamm (1957) showed no significant effect on semen volumes of rams when they are exposed to elevated ambient temperature. However, Bogart and Mayer (1946), Cupps et al. (1960), and Simpson et al. (1959) have noted decreases in semen volume of rams after exposure to high thermal temperatures. Motility was drastically reduced by the higher temperature (Table 6). This was most apparent in rams moved from treatment 2 (10-21^{o}C) to treatment 1 (21-32^{o}C). Dutt and Hamm (1957), Dutt and Simpson (1957), Simpson et al. (1959), Cupps et al. (1960), Alliston et al. (1961), Howarth (1969), and Lindsay (1969) also found high temperatures to be detrimental to the percentage of motile spermatozoa. The fact that little change in motility occurred during the 6 weeks after rams were moved from the hotter treatment to the cooler treatment indicates it takes at least that long for sperm motility to recover after heat stress. Lindsay (1969) noted a delayed detrimental effect of high temperature on sperm motility in rams four weeks post exposure to a temperature of 43°C for one week. Dutt and Hamm (1957) exposed rams to a dry-bulb temperature of 32°C for a one week period which resulted in low motility until 7 to 8 weeks following exposure.

Due to the variation and limited number of rams and semen samples, values concerning concentration, percent protoplasmic droplets, normal sperm, abnormal tails and aged acrosomes cannot be accurately interpreted. There was a tendency for the percentage aged acrosomes to be higher in those rams that started the trial in the higher temperature treatment although this was not significant. The percentage of normal sperm significantly ($P<.01$) decreased in ram #1004 when moved from the cooler to hotter treatment (his pen mate #1075 could not be evaluated), and in ram #1084 ($P=.01$) when moved from the hotter to cooler treatment. There was also a significant ($P<.01$) increase in the percentage of abnormal tails in the semen of ram #1004 after being switched to the hotter treatment. Ram #1084 showed a significant ($P<.01$) increase in the percentage protoplasmic droplets when moved from the hotter to cooler treatment. There was no significant effect on sperm concentration and there were not enough abnormal heads to be evaluated. These data are in the appendix (Figures 2, 3, 4, and 5).

TABLE 1. EFFECT OF TWO TEMPERATURE TREATMENTS ON SERVING CAPACITY AND MOUNTING ACTIVITY OF RAMS[a]

	TREATMENT 1 32°C-21°C MEAN ± SEM	TREATMENT 2 21°C-10°C MEAN ± SEM
Serving Capacity	2.72 ± 0.44[b]	4.13 ± 0.44
No. of Mounts	5.38 ± 0.72[c]	7.28 ± 0.72

[a]Numbers represent the average number of ejaculations (serving capacity) or mounts by a ram during a 30 minute period with a restrained ewe.

[b]Different than treatment 2 (P=.03).

[c]Different than treatment 2 (P=.07).

TABLE 2. SERVING CAPACITY AND NUMBER OF MOUNTS BY RAMS TESTED AT THE HIGH AND LOW TEMPERATURE OF EACH TREATMENT

	TREATMENT 1		TREATMENT 2	
	32°C	21°C	21°C	10°C
	MEAN ± SEM	MEAN ± SEM	MEAN ± SEM	MEAN ± SEM
Serving Capacity	2.00 ± 0.62^{a}	3.44 ± 0.62^{ab}	3.13 ± 0.62^{a}	5.13 ± 0.62^{b}
No. of Mounts	4.75 ± 1.02^{a}	6.00 ± 1.02^{a}	5.25 ± 1.02^{a}	9.31 ± 1.02^{b}

^{a,b}Means without a common superscript within a row are different ($P < .05$).

TABLE 3. RAM VARIATION IN SERVING CAPACITY AND MOUNTING

	SERVING CAPACITY	NUMBER OF MOUNTS
RAM #	MEAN ± SEM[a]	MEAN ± SEM[e]
1004	3.94 ± .62[bc]	5.75 ± 1.02[f]
1075	1.63 ± .62[d]	6.13 ± 1.02[fg]
1082	5.38 ± .62[b]	8.88 ± 1.02[g]
1084	2.75 ± .62[cd]	4.56 ± 1.02[f]

[a]Means ± SEM were calculated based on the mean serving capacity score of each ram during the experiment.

[b,c,d]Means without a common superscript within a column are different ($P < .01$).

[e]Means ± SEM were calculated based on the mean number of mounts of each ram during the trial.

[f,g]Means without a common superscript within a column are different ($P < .05$).

TABLE 4. COMBINED EFFECTS OF CHAMBER, RAM, AND TEMPERATURE ON SERVING CAPACITY

	SERVING CAPACITY[a]			
	TREATMENT 1		TREATMENT 2	
	$32^{o}C$	$21^{o}C$	$21^{o}C$	$10^{o}C$
RAM #	MEAN ± SEM[b]	MEAN ± SEM	MEAN ± SEM	MEAN ± SEM
1004	2.00 ± 1.2^{cd}	6.50 ± 1.2^{e}	4.25 ± 1.2^{de}	3.00 ± 1.2^{cd}
1075	0.75 ± 1.2^{c}	2.25 ± 1.2^{cd}	2.00 ± 1.2^{cd}	1.50 ± 1.2^{cd}
1082	3.25 ± 1.2^{cde}	3.25 ± 1.2^{cde}	3.00 ± 1.2^{cd}	12.00 ± 1.2^{f}
1084	2.00 ± 1.2^{cd}	1.75 ± 1.2^{cd}	3.25 ± 1.2^{cde}	4.00 ± 1.2^{cde}

[a]This interaction had a highly significant ($P<.01$) effect on the serving capacity of 4 rams in two different temperature treatments.

[b]Means without a common superscript are different ($P<.05$).

TABLE 5. COMBINED EFFECTS OF CHAMBER, RAM AND TEMPERATURE ON MOUNTING ACTIVITY

	NUMBER OF MOUNTS[a]			
	TREATMENT 1		TREATMENT 2	
	32°C	21°C	21°C	10°C
RAM #	MEAN ± SEM[b]	MEAN ± SEM	MEAN ± SEM	MEAN ± SEM
1004	2.75 ± 2.0[c]	8.75 ± 2.0[d]	6.50 ± 2.0[cd]	5.00 ± 2.0[cd]
1075	6.00 ± 2.0[cd]	7.00 ± 2.0[cd]	4.75 ± 2.0[cd]	6.75 ± 2.0[cd]
1082	5.50 ± 2.0[cd]	5.50 ± 2.0[cd]	5.25 ± 2.0[cd]	19.25 ± 2.0[e]
1084	4.75 ± 2.0[cd]	2.75 ± 2.0[c]	4.50 ± 2.0[cd]	6.25 ± 2.0[cd]

[a]This interaction was highly significant ($P < .01$) on the number of mounts by all 4 rams in two different temperature treatments.

[b]Means without a common superscript are different ($P < .05$).

TABLE 6. EFFECT OF TEMPERATURE TREATMENT ON SEMEN VOLUME AND MOTILITY

	TREATMENT 1	TREATMENT 2	
	MEAN ± SEM[a]	MEAN ± SEM	PROB
Volume (ml)	0.52 ± .04	0.44 ± .03	0.1300
Motility (%)	15.00 ± 1.5	47.20 ± 5.1	0.0003

[a]Means ± SEM were calculated based on the semen volume and percent motile sperm of all 4 rams during the experiment.

SUMMARY

Serving capacity and mounting activity of rams were determined at fluctuating temperatures in two, six week treatments. Temperatures fluctuating from 21°C to 32°C in an environmental chamber were detrimental to serving capacity and to a lesser extent on the number of mounts when rams were tested at 32°C. However, the number of mounts and services were equal to that of rams kept in another chamber at 10°C to 21°C when rams in both chambers were tested at 21°C.

There was considerable ram variation among the four rams in the average number of ejaculations and mounts, but a significant difference due to treatment was still achieved. Some rams were more adversely affected by high temperature than others and the order of treatment also affected a ram's response.

The 32°C to 21°C temperatures were detrimental to sperm motility but not semen volume. Semen quality of rams first exposed to the higher temperatures did not improve over a six week period at 21°C to 10°C. Rams exposed to high temperatures may be sexually active but may still have poor semen quality due to thermal stress. Temporary relief from high temperatures may improve mating ability of rams but will not improve semen quality.

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APPENDIX

TABLE 7. HORMONE TREATMENT TO INDUCE ESTRUS IN OVARIECTOMIZED EWES

A) Inject teaser ewes with 4 mg progesterone and 1 ug estrone per cc for 3 days.
B) On day 5 inject teaser ewes with .2 mg estrone.

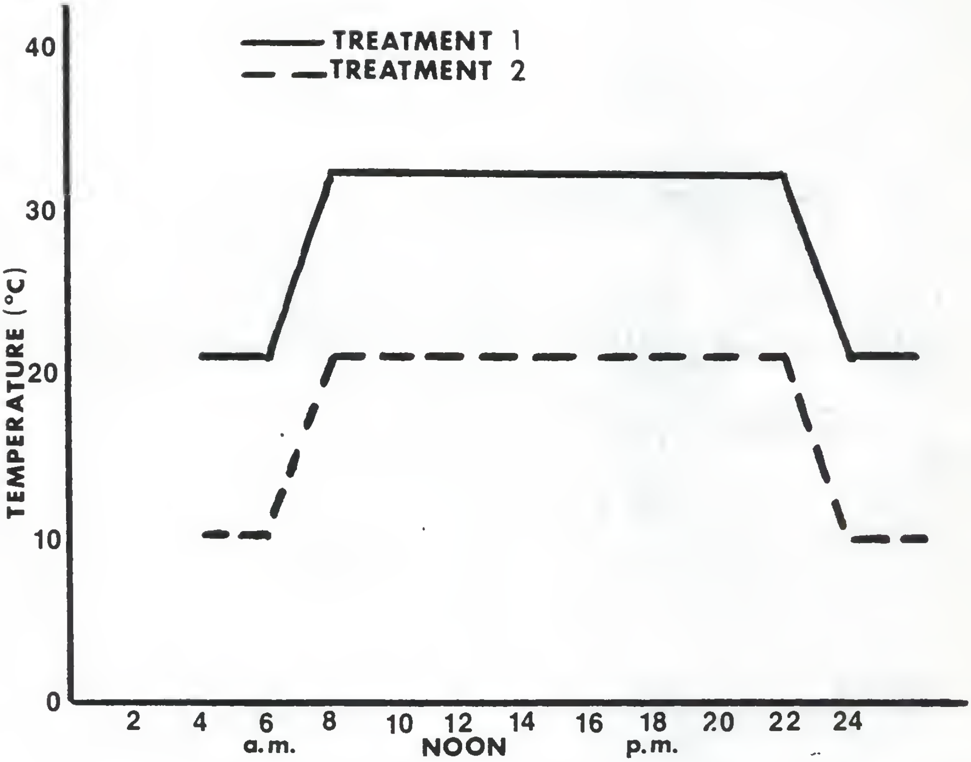

Figure 1. Temperature fluctuations in treatment 1 and treatment 2.

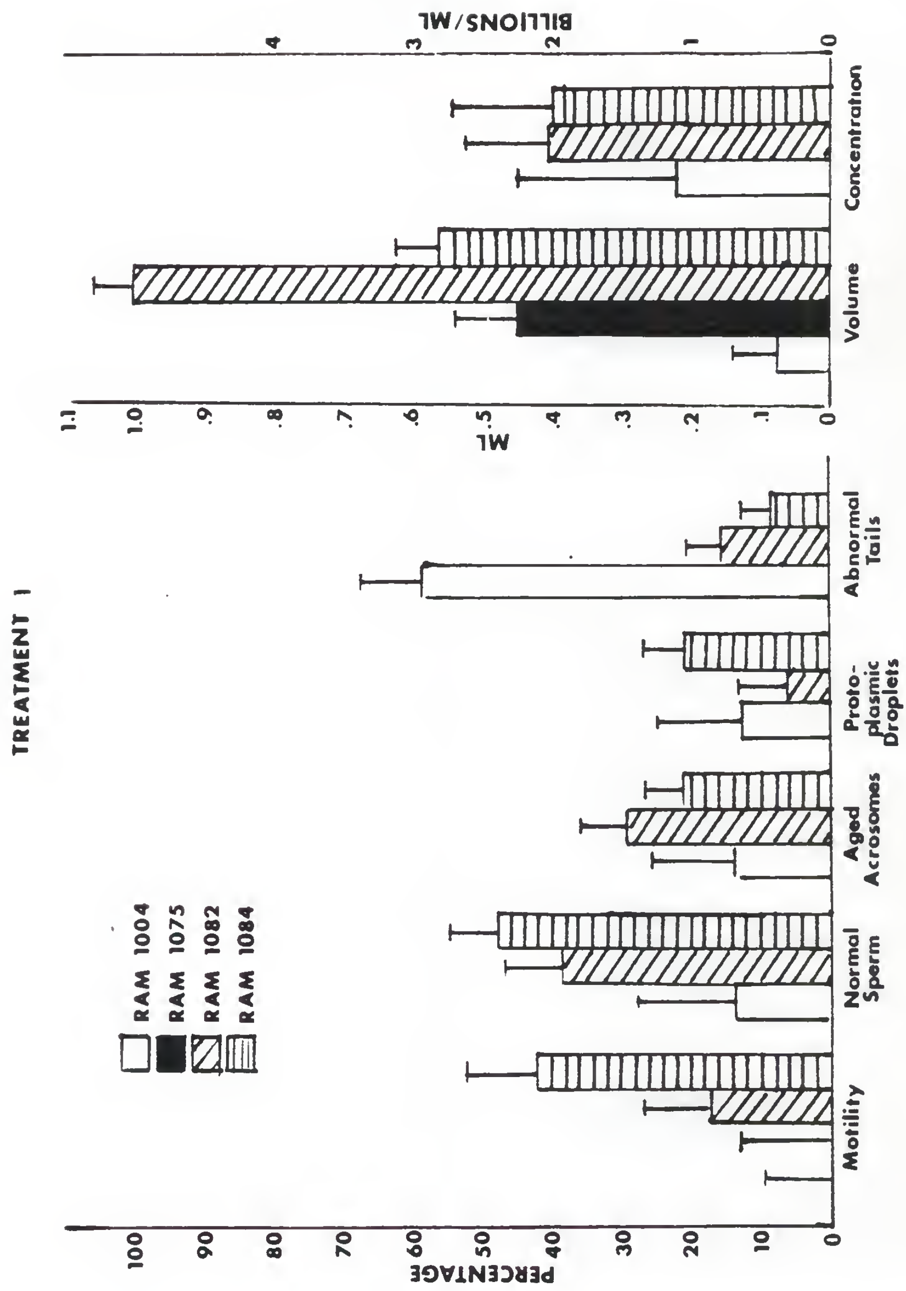

Figure 2. Means + SEM for semen characteristics of 4 rams for four evaluations per ram in Treatment 1.

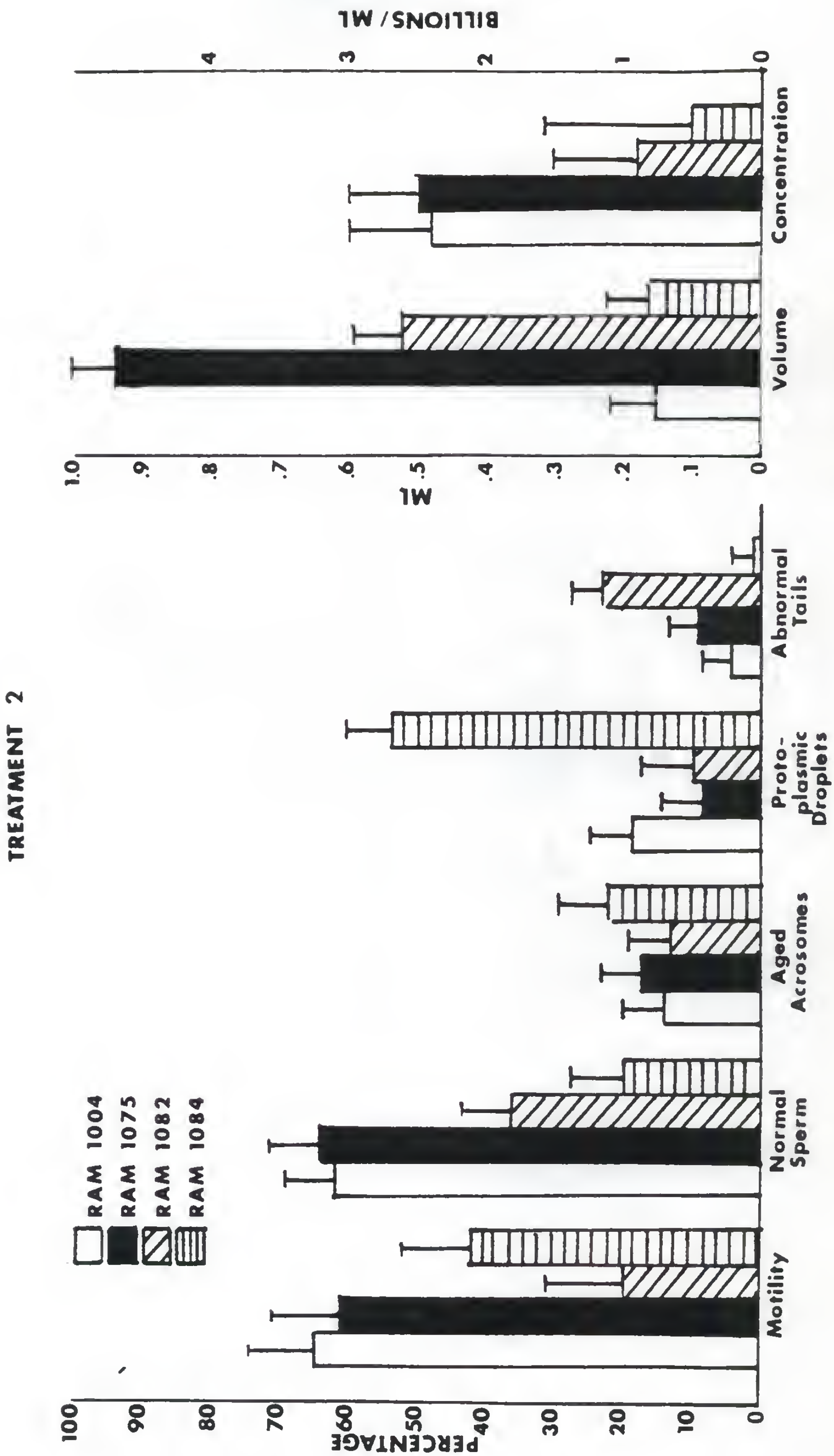

Figure 3. Means ± SEM for semen characteristics of 4 rams for four evaluations per ram in Treatment 2.

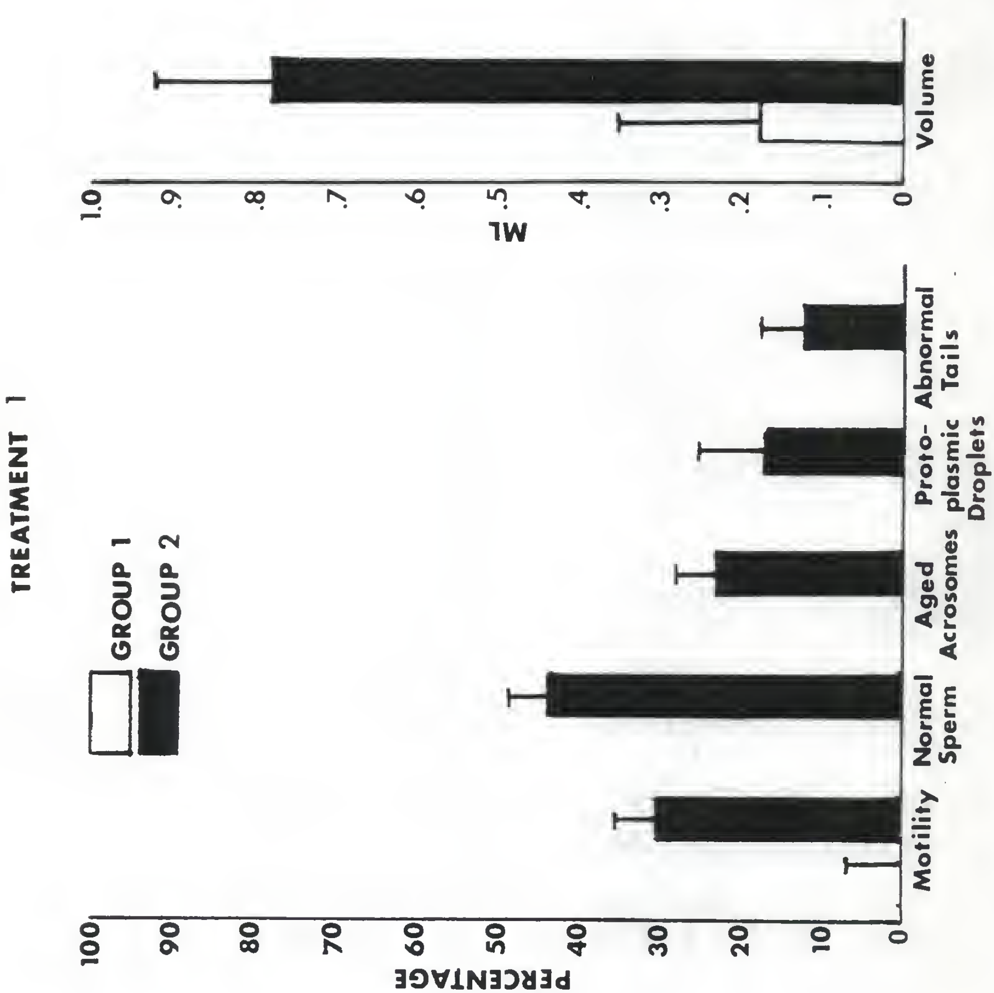

Figure 4. Means ± SEM for semen characteristics of two groups of rams for four evaluations in Treatment 1. Only motility (0% ± 6.86 SEM) and volume could be determined for group one rams in Treatment 1.

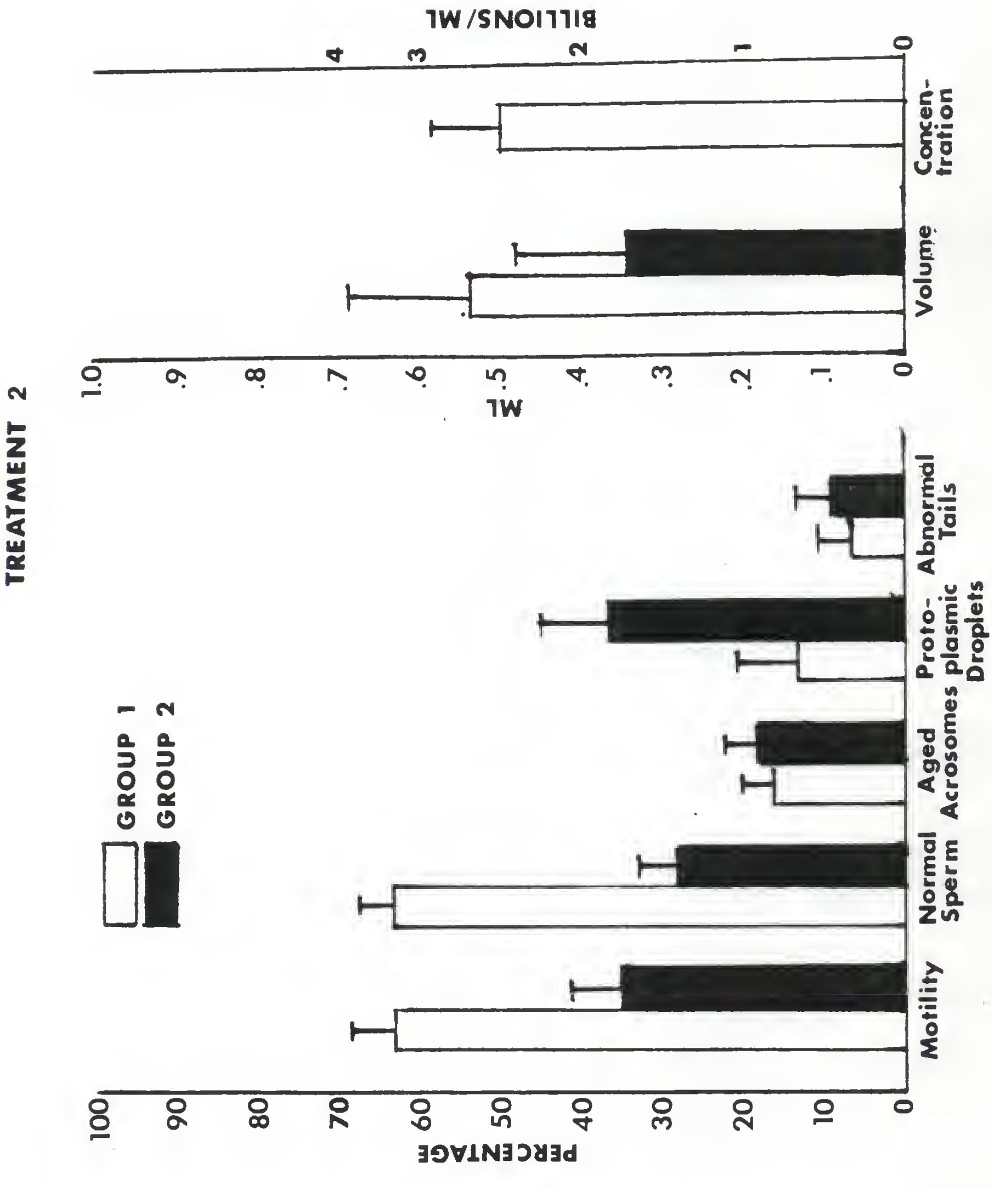

Figure 5. Means ± SEM for semen characteristics of two groups of rams for four evaluations in Treatment 2. Concentration of spermatozoa in the semen of group two rams could not be determined in Treatment 2.

THE EFFECT OF TEMPERATURE CHANGES ON
THE MATING PERFORMANCE AND
SEMEN QUALITY OF RAMS

by

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B.S., Colorado State University, 1978

AN ABSTRACT OF A MASTER'S THESIS

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This experiment was conducted to determine the effect of two temperature ranges on mating performance and semen quality of rams. Four 2-year old Suffolk rams weighing 149 $\pm$ 13.5 kg were randomly divided into two groups and assigned to one of two treatments. Each 6 week treatment period was conducted in an environmentally controlled room with concrete slatted floors. The temperatures of treatment 1 fluctuated between 21^{o}C and 32^{o}C and the temperatures in treatment 2 fluctuated between 10^{o}C and 21^{o}C. After 6 weeks in one treatment rams were switched to the opposite room for another 6 weeks. The first 2 weeks of each treatment was considered as an acclimation period and no mating tests were conducted or semen collected. Mating tests were conducted at the lowest temperature every Tuesday morning and at the highest temperature every Friday evening for 4 weeks in each room. For mating tests, each room was divided in half with a plywood barrier and one ram with one restrained ewe was placed on each side for 30 minutes. Semen was collected from all rams via artificial vagina each Thursday morning for the last 4 weeks of each treatment period. The number of mounts with ejaculation (services) was significantly (P=.03) higher for rams in the cooler treatment (10 to 21^{o}C). Although the number of mounts was also higher in the cooler treatment, the difference was not as great (P=.07) as for the number of services. Serving efficiency was the lowest when rams were tested at 32^{o}C and that temperature was detrimental to both serving capacity and number of mounts. Rams in the hotter temperature treatment mounted and served the ewes more often at 21^{o}C than at 32°C. The observed serving capacity and number of mounts was similar for both treatment groups when both were tested at 21°C. Rams varied in the average number of services from 1.63 to 5.38 and in mounts from 4.5 to 8.88. Some rams were more adversely affected by high temperature than others and the order of treatment also affected response (average mounts and services when tested at 32°C were 10.25 and 5.25 respectively for rams in the hotter treatment first, and 8.75 and 2.75 respectively for rams in the cooler treatment first). Treatment did not have a significant effect on semen volume; however, sperm motility was drastically reduced ($P<.01$) by the high temperatures, particularly when rams were moved from treatment 2 (10-21°C) to treatment 1 (21-32°C).