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# HEAT TOLERANCE AND FERTILITY OF CROSSBRED EWES AS AFFECTED BY NATURAL SHELTERING AND THIRST UNDER SEMI-ARID CONDITIONS

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**SUMMARY**

Fifty two adult crossbred Merino x Barki ewes were used to find out the effect of both natural shading of trees (<u>Casurina equisetifolia</u>) and repeated 4-day thirst (at breeding) on their thermal response and reproductive performance. The experimental treatments were applied 2 weeks prior joining season in summer and lasted for 2.5 months covering the early embryonic stage.

Shadow of trees had tempered the thermal conditions of the local climate particularly radiant ambient and soil temperatures. Consequently, sheltering enabled the ewes to be more tolerant to heat and thirst. Sheltered groups had less ($P < 0.01$) average increases in rectal temperature (RT) and respiration rate (RR) from 08.00 to 14.00 h as compared to unsheltered ones (0.37 vs. 1.01°C in RT and 9.6 vs. 40.9 breaths/min in RR). When dehydrated, the sun-exposed groups showed a faster rate of weight loss than that of the shaded counterparts. Shaded ewes showed a more regular and lower average water consumption which represented only 85% of the water needed by unshaded ones.

Water deprivation had no bearing on the thermal reaction of ewes. Thirst, however, caused an accumulative loss in ewe's body weight over 4 days of dehydration cycle. On watering day, the dehydrated ewes could drink water as much as 2.7 times of that consumed by the hydrated ones. Thus, the dehydrated ewes compensated for 73% of water consumed by daily watered ewes.

Tree-sheltered ewes, as less vulnerable to heat and thirst, had expressed a better reproductive performance than that of non-protected partners. Providing natural shade to ewes at joining time resulted in an increment of 15.5% in conception rate, 11.5% in both lambing rate and lambs born. Thirst at mating did not affect ewes fertilization as judged by the equal values of conception rate (62.2%) for hydrated and dehydrated groups.

**Keywords:** Heat tolerance, fertility, natural sheltering, thirst, sheep

## INTRODUCTION

Both tolerance to heat and level of production were compiled by Johnson (1965) when classifying the farm animals into different categories of adaptability. Accordingly, heat tolerant-low productive group refers to the native breeds of sub-tropics whereas heat intolerant-high productive are usually temperate zone breeds. As early as 1958, the imported Hungarian Merino sheep had been crossbred with the local Barkis to enhance their performance with keeping the fitness to the harsh environment of Egyptian desert. Crossbreds, thereafter, were noticed to be inferior to Barkis in physiological responses to different constraints of semi-arid conditions (Azamel et al., 1987), which might limit their productivity.

In Egypt, the breeding of sheep usually coincides with a long-hot-dry summer besides a low availability of vegetation and drinking water. Performance of the breeding ewes have been expected to be much poor under such conditions. Yet, heat-stressed crossbred ewes showed a reasonable reproductive performance as subjected to a repeated 3-day thirst during breeding (Azamel et al., 1994). Those ewes, however, attained an extra improvement in reproduction due to re-breeding one month later under hydration and a more favourable climate.

Alternatively, modifications of the environmental conditions were reported to be a significant means for improving the productivity of tropical sheep (Hopkins et al., 1979). In such approach, artificial housing of sheep and goats resulted in a very limited increment in production (Azamel et al., 1987 and 1990 and Mokhtar et al., 1983). Therefore, the present work was conducted to test the effect of tree sheltering on tolerance of breeding ewes to both heat and 4-day thirst and consequently on their reproductive performance.

## MATERIALS AND METHODS

### Animals

Fifty two mature (3-6 yrs) crossbred Merino x Barki ewes of average livebody weight of 42.5±0.87 kg were used in this study. The ewes belonged to the flock of Maryout Experimental Station (32°N latitude), Desert Research Center. As ewes were shorn in May, their breeding timed with the hottest period in August, 1992.

### Shelterbelt

Trees (*Casurina equisetifolia*) of shelterbelt of the Station Farm were of more than 20 yrs. old, 15-20 m height and 10 m branching width. Shadow beneath such trees has been noticed to cover a vast area of the ground along the whole day. Therefore, the idea was to exploit such naturally sheltered area in protecting ewes at breeding from the high-energy radiation common to this location.

### Sheltering and Watering Treatments

On 2nd August, 1992, ewes were randomly divided into 4 equal groups (13 each) and assigned to 4 open-summer pens (5 x 5 m, just fenced by wire net). Two pens were erected under shelterbelt (shaded groups) while the others were near-by a shelterless yard (unshaded groups). A group of both shaded and unshaded categories was watered once a day and the other once every 4 days. Treatments extended up to the end of early embryonic stage (almost 2 mo from mating start). Ewes were kept in pens for day and night along the experimental period after which all groups were gathered and normally managed until lambing.

### Mating Season and Management

On 15th August, 4 fertile rams of the same breed type, joined the 4 ewe groups for 34 days (2 estrous cycles). Rams were well fed, watered and rotated daily among different groups to avoid any ram-treatment confounding effect on ewe fertility.

Group feeding was followed offering ad. lib. berseem (*Trifolium alexandrinum*) hay supplemented with concentrate mixture (50% cotton-seed cake, 15% yellow maize, 20% rice polish, 12% wheat bran, 2% limestone and 1% common salts) at the rate of 500 gm/head/day during treatment period and increased to 750 gm during the last 2 mo. of pregnancy through lactation period.

**Data and Measurements Recorded**

Rectal temperature (RT, °C) and respiratory rate (RR, breaths/min) were measured weekly at 08.00 and 14.00 hr, RT by a clinical thermometer inserted for 10 cm in the rectum for 1 min, whereas the RR by counting the flank movement for 1 min. The daily changes in both parameters were taken as indices for tolerance to heat load during summer. Throughout dehydration cycles, the changes in ewe livebody weight were taken as a response to each of watering regime. Water intake was measured using weight difference method for all ewes. Dry matter feed intake (DMI) was calculated on group basis for each group.

Full reproductive data including mating and lambing dates, litter size, birth and weaning weights were individually recorded. For each group, conception and lambing rates and percent of lambs born and weaned were calculated.

Meteorological data were recorded weekly at 08.00 and 14.00 h under both sheltered and unsheltered conditions (Table 1).

**Statistical Analysis**

Data collected periodically on the same animals were analysed as split-plot repeated measures experiment according to Kirk (1968). The non-repeated data, however, were analysed as $2^2$ factorial experiment. Traits calculated on group basis were analysed using $Chi^2$ test.

**RESULTS AND DISCUSSION**

**Shelterbelt and Alteration of Microclimatic Conditions**

Table 1 indicates that the trees had tempered the thermal conditions of the microclimate. At midday, trees reduced radiant temperatures as the dark material occupying the intermediate space impedes the transfer of radiant heat (Esmay, 1978). However, data of the morning were much similar in both sheltered and unsheltered locations. At the two occasions of the day, trees elevated the RH% values due to continuously evaporated moisture from their leaves. This may impose beneficial cooling to air. Although the shelterbelt reduced the air movement along the day, its velocity recorded at midday under shade was still adequate to permit an efficient convective and evaporative cooling for animals in confinement (more than 2 m/sec.) according to Hahn (1982).

Table 1. Meteorological data (ambient temp., AT; radiant temp., RAT; soil temp., ST; relative humidity, RH and wind velocity, WV) recorded at 08.00 and 14.00 h under direct sun and shelterbelt during treatment period

| Item | Sun | | | Shelterbelt | | |
|---|---|---|---|---|---|---|
| | Aug. | Sep. | Overall | Aug. | Sep. | Overall |
| At 08.00 h: | | | | | | |
| AT(°C) | 25.00 | 24.00 | 24.50 | 25.00 | 25.00 | 25.00 |
| RAT(°C) | 27.00 | 26.00 | 26.50 | 26.00 | 25.00 | 25.50 |
| ST(°C) | 23.50 | 22.50 | 23.00 | 24.00 | 22.50 | 23.25 |
| RH(%) | 90.00 | 87.00 | 88.50 | 96.00 | 95.00 | 95.50 |
| WV(m/min) | 162 | 170 | 166 | 100 | 100 | 100 |
| At 14.00 h: | | | | | | |
| AT(°C) | 32.75 | 29.00 | 30.88 | 29.00 | 26.00 | 27.50 |
| RAT(°C) | 49.00 | 38.00 | 43.50 | 30.00 | 26.75 | 28.38 |
| ST(°C) | 28.88 | | 28.88 | 25.13 | | 25.13 |
| RH(%) | 73.50 | 59.25 | 66.38 | 84.75 | 71.00 | 77.88 |
| WV(m/min) | 175 | 175 | 175 | 138 | 130 | 134 |

The present findings support those of Hopkins et al. (1979) and Hahn (1982) that the natural shade is a cost-effective means for modifying environmental conditions of the tropics. Worthwhile, the peak of RAT recorded beneath shelterbelt (28°C) was more closer to sheep comfort zone than that recorded under direct sun (43.5°C). Hahn (1982) proposed 4-24°C as a comfort zone for adult sheep.

**Tolerance to Thirst and Changes in Livebody Weight**

Thirst caused an accumulative weight loss over the days of dehydration cycle (Table 2). On the 4th day, dehydrated groups showed higher ($p< 0.01$) average weight loss (-19.6%) versus almost constant average body weight

(-0.15%) for watered groups. The excessive body water depletion during thirst (due to that input is far less than output) is mainly responsible for the rapid decrease in body weight (Mokhtar et al., 1988). However, a concomitant low appetite in addition to catabolic process for producing metabolic water might be involved in dehydration symptom (Wilson, 1970).

Over 4 days of dehydration cycle, sheltered-thirsty group not only had a less but also a more gradual pattern of weight loss (3.9, 6.7, 9.3 and 18.2%) than that of unsheltered-thirsty one (4.7, 11.8, 17.1 and 21.0%). Such contrast indicates that keeping the ewes in comfort weather under shelterbelt improved their tolerance to thirst and avoided the agitation impact of direct exposure to sun.

Likewise, averages of free water intake of sun-exposed groups were more fluctuating and higher than those of sheltered ones either watered (151.8 vs. 128.3 $ml/kg^{0.82}$ /day) or deprived (109.6 vs. 93.7 $ml/kg^{0.82}$ /day). In the two circumstances shaded ewes consumed only 85% of water needed by unshaded counterparts. Drinking desire seemed to be restrained by sheltering of ewes. Housing, in general, has been reported to improve water economy and utilization (Azamel et al., 1987 and 1990). On rehydration day, thirsty ewes could drink more than 2.7 times of the daily average of watered ewes. This result means that the former group compensated for 73% of water requirements. At the end of treatment, dehydrated ewes could restore almost 98% of their initial body weight (Table 2). Such capabilities are essential for sheep to cope with water scarcity in desert areas.

**Heat Tolerance in Relation to Sheltering and Watering**

In response to increasing AT from 08.00 to 14.00 h, all ewe groups showed significant ($p < 0.01$) increases in both RT and RR (Table 3). The corresponding rises of sun-exposed groups (average of watered and deprived) were 1.01°C (2.6%) and 40.9 breaths/min (170.8%), whereas those of the sheltered groups were of lower ($p<0.01$) magnitude to be 0.37°C (0.95%) and 9.6 breaths/min (32.9%). So sheltering improved ewe heat tolerance as indicated also by the significantly lower values of RT and RR of sheltered ewes, at 14.00 h, as compared to unsheltered ones (Table 3). At 08.00 h, however, the trends in RT and RR due to sheltering was opposite. Through the cooler night hours, the unshaded ewes would dissipate their day-gained heat more easily than shaded ones did (Mokhtar et al., 1986). Tree cover, as reduced air movement and likely prevented falling of dew, kept warmer ewes underneath in the morning. Shelterbelt, therefore, may act as temperature regulator for the microclimate and in turn for body temperature of sheltered animals.

Table 2. Changes in livebody weight (BW) of ewes, free water intake (WI) and dry matter intake (DMI) as affected by natural shading and watering regime

| Items | Shaded ewes | | Unshaded ewes | | S.E. |
|---|---|---|---|---|---|
| | Watered | Dehydrated | Watered | Dehydrated | |
| Av. initial BW(kg)[1] | 43.65 | 43.54 | 42.88 | 39.42 | 1.23 |
| Av. final BW(kg)[2] | 47.40 | 41.64 | 44.72 | 38.63 | 1.85 |
| (Change) | +3.75 | -1.90 | +1.84 | -0.79 | |
| Av.BW at zero | 48.50 | 45.00 | 45.73 | 40.48 | |
| time*: | kg (%) | kg (%) | kg (%) | kg (%) | |
| BW change at | -0.94(1.9) | -1.77(2.9) | -2.35(5.1) | -1.89(4.7) | |
| elapsing: | -1.12(2.3) | -3.02(6.7) | -0.12(0.3) | -4.77(11.8) | |
| 24 hrs | -0.54(1.1) | -4.19(9.3) | -0.52(1.1) | -6.90(17.1) | |
| 48 hrs | -0.87(1.8) | -8.18(18.2) | +0.69(1.5) | -8.48(21.0) | |
| 72 hrs | -0.87(1.8) | -4.29(9.53) | -0.58(1.25) | -5.51(13.65) | |
| 96 hrs | | | | | |
| (Overall mean) | l/head(%) | l/head(%) | l/head(%) | l/head(%) | |
| WI through | 12.375 | 8.505 | 13.960 | 9.115 | 0.98 |
| dehydration | 2.660(21.5) | - | 1.825(13.1) | - | |
| cycle: | 3.465(28.0) | - | 5.195(37.2) | - | |
| Total (as 100%): | 3.690(29.8) | - | 2.885(20.7) | - | |
| on 1st day | 2.560(20.7) | 8.505(100) | 4.055(29.0) | 9.115(100) | |
| on 2nd day | | | | | |
| on 3rd day | | | | | |
| on 4th day | 3.094 | 2.126 | 3.490 | 2.279 | |
| | 128.3 | 93.7 | 151.8 | 109.6 | |
| Mean WI per day: | | | | | |
| - l/head/day | 1.39 | 0.96 | 1.11 | 0.79 | |
| - ml/kg$^{0.82}$/day | | | | | |
| Av.DMI(kg/head/ day) | | | | | |

* BW values at zero time are the weights just after rehydration at previous cycle.
1, Initial weights were recorded at the beginning of treatments.
2, Final weights were recorded at the end of treatments.
S.E., Standard error of shading mean =that of watering mean for the same item.

Irrespective of sheltering, watered and deprived groups showed much similar heat tolerance indices in terms of increase percentage in RT (1.81 vs. 1.76%) and RR (108.6 vs. 95.0%). Mechanisms by which the thirsty ewes achieved relatively low thermal response are not exactly known. Low voluntary DMI that accompanied severe dehydration in the present study may indicate a reduction in metabolic rate and internal heat production. This behavioural response would be an attempt for limiting water expenditure in deprived ewes.

Table 3. Changes in rectal temperature (RT, °C) and respiratory rate (RR, breaths/min) due to time of day as affected by natural shading and dehydration treatments

| Items | Shaded Ewes | | Unshaded Ewes | | S.E.[1] |
|---|---|---|---|---|---|
| | Watered | Dehydrated | Watered | Dehydrated | |
| No. of bred ewes[2] | 13 | 13 | 13 | 13 | 0.05** |
| RT at 08.00 h | 38.95 | 38.87 | 38.42 | 38.65 | 0.06** |
| RT at 14.00 h | 39.28 | 39.28 | 39.48 | 39.60 | 0.10** |
| (change °C) | (+0.33) | (+0.41) | (+1.06) | (+0.95) | 2.5** |
| (change %) | (+0.85) | (+1.05) | (+2.76) | (+2.46) | |
| RR at 08.00 h | 29.8 | 28.5 | 23.9 | 24.5 | 2.5** |
| RR at 14.00 h | 39.9 | 37.6 | 67.7 | 62.5 | 3.62** |
| (change °C) | (+10.1) | (+9.1) | (+43.8) | (+38.0) | |
| (change %) | (33.9) | (31.9) | (183.3) | (158.3) | |
| Overall means: | | | | | |
| RT | 39.12 | 39.08 | 38.95 | 39.13 | 0.06 ns |
| RR | 34.9 | 33.1 | 23.9 | 24.5 | 1.92** |

1, Standard error of shading mean =that of watering mean for the same item.
2, Differences between conceived and barren ewes were checked to be insignificant using "t" test.
** Highly significant ($p < 0.01$) for shading mean only.

## Ewe Fertility in Relation to Tolerance to Heat and Thirst

Sheltering of the breeding ewes in summer had improved their reproductive performance (Table 4). Regardless of watering regime, sheltered ewes exceeded unsheltered ones by 15.5% in conception rate (CR, 76.9 vs. 61.5%), by 11.5% in lambing rate (LR, 69.2 vs. 57.7%) and by 11.6% in number of lambs born (LB, 73.1 vs. 61.5%). On the other hand, water deprivation at early embryonic phase had no effect on ewe fertilization judging by the equal values of average CR (62.2%) for hydrated and dehydrated groups. However, corresponding figures for LR were 65.4 and 61.5% and for LB were 73.1 and 61.5%.

Table 4. Effect of natural shading and water deprivation at breeding on the reproductive performance of crossbred ewes

| Items | Shaded Ewes | | Unshaded Ewes | | $Chi^2$ |
|---|---|---|---|---|---|
| | Watered No. (%) | Dehydrated No. (%) | Watered No. (%) | Dehydrated No. (%) | |
| Ewes joined | 13(100) | 13(100) | 13(100) | 13(100) | |
| Barren ewes | 3(23.08) | 3(23.08) | 5(38.46) | 5(38.46) | 3.42 |
| Ewes conceived: | 10(76.92) | 10(76.92) | 8(61.54) | 8(61.54) | 7.69 |
| -Lambed ewes | 9(69.23) | 9(69.23) | 8(61.54) | 7(53.85) | 2.56 |
| -Aborted ewes | 1(7.69) | 1(7.69) | 0(0.0) | 1(7.69) | 7.69 |
| -Viable lambs born | 10(76.92) | 9(69.23) | 9(69.23) | 7(53.85) | 4.17 |
| -Viable lambs weaned | 8(61.54) | 7(53.85) | 7(53.85) | 4(30.77) | 10.65* |
| -Litter size | 1.11 | 1.00 | 1.13 | 1.00 | |
| Av. birth weight(kg) | 3.39±0.25 | 3.21±0.22 | 3.24±022 | 2.91±0.33 | |
| Av. weaning weight(kg) | 13.38±1.58 | 14.93±1.27 | 15.00±1.43 | 12.75±1.03 | |

* Significant at $p<0.05$.

High tolerance to heat and thirst of tree-sheltered ewes may be reflected positively on their reproductive performance. Consistently, Hopkins et al. (1979) reported that the provision of natural shade alleviated the environmental heat stress and significantly improved pregnancy rate of ewes. Using an artificial-asbestos shelters for ewes, Mokhtar et al. (1983) found a more limited improvement in their reproductive traits. Since the experimental treatments were applied prior and during joining time only, their effects would be dealt basically with ovulation, conception and embryonic implantation phases, whereas embryonic development, lambing and weaning are expected to be much independent from these treatments. Artificially shaded ewes exhibited 20% more in embryonic survival as compared to sun-exposed ones (Mokhtar et al., 1983). First third of pregnancy was found by Yeates (1959) to be more critical period for incidence damage to the embryos in heat-exposed ewes (42°C for 7 hours/day). In the present work, sun-exposed ewes might have received similar heat load (Table 1) which may explain why they showed lower

CR value than that of sheltered ones.

The mode by which heat adversely affects ewe fertility is not fully agreed upon in literature reviewed. In sheep, heat stress does not affect estrous cycle length (Hafez, 1968) or ovulation rate (Mokhtar et al., 1983). Fertilization was reported as the most trait of ewe fertility to be vulnerable to heat stress at breeding (Dutt et al., 1959). Raising 1 to 2°C in body temperature may have a negative effect on ewe conception (Thwaites, 1985). This probably had happened to unsheltered ewes as they showed 1.01°C increase in RT versus 0.37 °C for sheltered ewes. In other studies, high temperatures were apparently without effect on fertilization itself but it resulted in heat-induced embryo mortality (Thwaites, 1967 and Mokhtar et al., 1983). Worthwhile, CR calculated in the present study is, in fact, a function of ovulation, fertilization, embryonic survival and development and lambing. Therefore, CR herein might be misleading for the actual fertility as the early mortal embryos would be resorbed and not detectable. However, increased foetal resorption was reported by Hafez (1968) to be a reason for lowering the fertility of heat-exposed ewes. High ambient temperature may act directly on the milieu interieur rather than on the embryo itself. Increasing vasodilatation and blood flow from the body core to superficial tissues and respiratory system under heat stress, would develop internal hyperthermia which impairs the normal reproduction.

Although the 4-day thirsty ewes suffered a significant weight loss (Table 2), they showed similar fertility as compared to watered ones. The two groups recorded as well similar values for heat tolerance indices (Table 3) which may indicate that crossbred ewes could cope with water scarcity. Azamel et al. (1994) reported similar ewe adaptability to 3-day thirst applied at early or late phase of pregnancy. Explanation of reproduction under severe water shortage needs additional investigation for body fluid compartments in pregnant-dehydrated ewes.

Neither birth nor weaning weights of lambs differed significantly due to watering or sheltering treatments during mating time. This result means that there is no residual effects of heat and thirst on post natal performance.

It could be concluded, from the present study that maintaining body thermal balance in summer should be a substantial target to sheep herds in desert area. This likely can be achieved successfully through propagation of the shelterbelts in new-reclaimed lands. It will be of multiple beneficial to the animals if the trees used are of nutritive value types such as acacia trees. A satisfied reproductive performance of the flock as well as saving drinking water would be ensured under such environmental procedure.

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# تأثير التظليل الطبيعى والتعطيش على التحمل الحرارى والخصوبة فى نعاج الخليط تحت الظروف شبه الجافة

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الفكرة من هذا البحث هى استغلال الظل الطبيعى لاشجار مصدات الرياح (الكازورينا) فى ايواء قطعان الاغنام اثناء موسم التلقيح فى الصيف وذلك لحجب حرارة اشعة الشمس الحارقة التى تنتشر فى ذلك الوقت بالمناطق حدثية الاستصلاح بمصر - وعليه صمم هذا البحث لدراسة اثر هذا التظليل وكذلك العطش لمدة ٤ ايام ( وهو العامل الهام تحت ظروف ندرة مياه الشرب بتلك المناطق) على صفة التحمل الحرارى لنعاج التربية وعلاقة ذلك بأدائها التناسلى .

استخدمت ٥٢ نعجة خليط (مرينو x برقى) ناضجة (٣-٦ سنوات) من قطيع محطة بحوث مريوط حيث قسمت النعاج عشوائيا الى اربع مجموعات تجريبية متساوية فى العدد ووضع كل منها فى حظيرة من السلك (٥×٥م) الأتى:

- الاولى : مظللة تحت الاشجار - ترتوى يوميا
- الثانية : مظللة تحت الاشجار - عطشانة (ترتوى كل اربعة ايام)
- الثالثة : معرضة للشمس - ترتوى يوميا
- الرابعة : معرضة للشمس - عطشانة

بدات المعاملات فى ٢ اغسطس ١٩٩٢ قبل اسبوعين من اطلاق الكباش فى المجموعات ( فى دورى يومى ) واستمرت لمدة شهرين ونصف ( حتى ٢٠اكتوبر) لتغطى الفترة الجنينية الاولى من الحمل - استمر وضع الكباش مع النعاج لمدة ٣٤ يوم فقط ( دورتى شبق) ، كانت تفصل خلالها الكباش نهارا وتروى وتغذى ثم تترك فى المجموعات ليلا حتى لا تتأثر الكباش بالمعاملات - تمت تغذية النعاج على الدريس اختياريا بالاضافة الى العلف المصنع كتغذية تكملية بمعدل ٥٠٠جم / راس / يوميا.

ادى التظليل الطبيعى الى تلطيف الظروف المناخية المحيطة وخاصة خفض حرارة الاشعاع الجوية والارضية بمقدار ١٥°م وسط النهار مما حسن من مقاييس التحمل الحرارى فى النعاج المظللة عن تلك المعرضة للشمس :