Water Balance of Goats in Jeneponto – South Sulawesi under Sunlight Exposure and Water Restriction

DJONI PRAWIRA RAHARDJA

Fakultas Peternakan, Universitas Hasanuddin
Jl.Perintis Kemerdekaan, Km. 10
Makassar-90245

(Diterima dewan redaksi 29 Juni 2007)

ABSTRAK

RAHARDJA, D.P. 2007. Neraca air pada kambing di Jeneponto-Sulawesi Selatan di bawah penyinaran matahari dan keterbatasan air. *JITV* 12(3): 218-224.

Neraca air pada 6 ekor kambing kacang betina asal Jeneponto telah dipelajari pada kondisi penjemuran di bawah penyinaran matahari dan keterbatasan air. Penelitian ini dilakukan pada musim panas dengan 4 perlakuan masing-masing 10 hari yang diberikan secara berurutan dengan 4 – 5 hari periode pemulihan antara dua periode perlakuan: (1) dalam ruangan + air tak terbatas, (2) dalam ruangan + air terbatas, (3) 10 jam penjemuran + air tak terbatas, (4) 10 jam penjemuran + air terbatas. Suhu udara maksimum di luar ruangan adalah 39,3°C, dan di dalam ruangan 30°C. Volume plasma meningkat ketika kambing mengalami penjemuran, sedangkan pembatasan air minum nyata menurunkannya. Sementara, nilai hematokrit menunjukkan hubungan yang sebaliknya. Konsumsi dan kecernaan bahan organik tidak nyata dipengaruhi oleh penjemuran, akan tetapi kedua parameter ini menurun karena pembatasan air minum, dan pengaruh tersebut lebih nyata ketika penjemuran. Proporsi air yang hilang dari setiap jalur nampak dipertahankan relatif tetap baik, ketika penjemuran maupun pembatasan air minum saat mana frekuensi nafas meningkat dengan nyata. Hasil penelitian menunjukkan bahwa penjemuran di bawah sinar matahari dan tanpa pembatasan ketersediaan air, neraca air pada kambing dalam keadaan positif tanpa pengaruh nyata terhadap konsumsi dan kecernaan bahan organik. Pembatasan ketersediaan air menyebabkan neraca air berada dalam keadaan negatif, dan menurunkan tingkat konsumsi dan kecernaan bahan organik. Sebagai mekanisme adaptif yang ditempuh kambing menghadapi lingkungan panas dan kering di Jeneponto adalah dengan meningkatkan volume plasma, suhu tubuh dan frekuensi nafas.

Kata Kunci: Kambing, Neraca Air, Pancahayaan Sinar Matahari, Pembatasan Air, Kecernaan

ABSTRACT

RAHARDJA, D.P. 2007. Water balance of goats in Jeneponto - South Sulawesi under sunlight exposure and water restriction. *JITV* 12(3): 218-224.

Water balance of 5 does of Kacang goat of Jeneponto was studied under the condition of sunlight exposure and water restriction. The study was conducted in dry season with 4 consecutive treatments of 10 d with 4-5 d of adjustment period between two consecutive treatments: (1) indoor and unrestricted water; (2) indoor and restricted water; (3) 10 h outdoor–and unrestricted water; (4) 10 h outdoor – restricted water. The maximum air temperature of outdoor was 39.3°C, and it was 30°C in the indoor environment. In all treatments, the animals were placed in the individual crates. The plasma volume of the goats was higher under sunlight exposure, but it decreased by water restriction, while hematocrite value indicated a reverse responses. Sunlight exposure did not significantly decrease the intake and digestion of organic matter, but water restriction affected significantly and this effect was higher under sunlight exposre. The proportions of water loss through every avenue were maintained relatively constant either under water restriction or sunlight exposure in which the respration rate increased significantly. The findings suggest that sunlight exposure with unrestricted water resulted in a positive water balance without a significant change in organic matter intake and utilization. Water restriction resulted in a negative water balance, reducing organic matter intake and utilization. As the adaptive mechanisms, the goat appeared to be able to withstand in the harsh environment of Jeneponto by expanding plasma volume, increasing body temperature and respiration rate.

Key Words: Goat, Water Balance, Sunlight Exposure, Water Restriction, Digestion

INTRODUCTION

Environmental stress resulted from high air temperature or water restriction or combination of both has long been recognized as important constraints for animal production in many parts of Indonesia. In South Sulawesi-Indonesia, Jeneponto is famous as the hottest and driest regency with the annual rainfall less than 200 mm for only 63 rainy days and daily temperature fluctuates between the minimum of 17°C and the maximum of 42°C. This climate condition may have a negative effect on animal production directly and indirectly. However, the population of goats is more densely compared to other regencies. Apparently, this small ruminant species has well adapted to cope and thrive in the harsh environment (climatic, nutritional and water availability) of Jeneponto.

Determination of daily water exchange between animals and their environment is important for estimating their water requirement as well as for evaluating their adaptability and productivity. Concerning the actual condition of Jeneponto, some questions intrigue about physiological strategies of animals. Goats have been found to be frugal in using water. In the Australian arid zone during summer, DAWSON *et al.* (1975) observed that on the unit body weight basis the goats used more water than kangaroos and less than sheep, for the purposes of thermoregulation. Goats have also been found to have a slightly lower metabolic rate than sheep (MACFARLANE and HOWARD, 1972). McDOWELL and WOODWARD (1982) reviewed that goats appear to have a lower metabolic rate, higher tolerance to dehydration, less susceptibility to respiratory alkalosis resulted from high respiration rate and fewer metabolic disorders than cattle and sheep. These traits could favor the goat's survival in a hot climate, especially where water resouces are restricted.

Although the goat population constitute a prominent domestic animal in Jeneponto, the physiological strategies evolved in this animal for successful occupation of this regency have not been studied yet. Clearly, there is a need for understanding the adaptive mechanisms of this species in order to boost the economy of Jeneponto regency through more efficiently employed this valuable animal. The present study was carried out to investigate water balance and "millieu interiour" adjustment of the Jeneponto goats under the conditions of sunlight exposure (solar radiation and high temperature) and water restriction.

MATERIALS AND METHODS

Five does of goat originated from Jeneponto, aged 1.5 – 2 y were used. Their body weights were 16.92 ± 1.44 kg at the commencement of the study and decreased to 15.30 ± 1.25 kg at the end of the study. The experiment was conducted in the dry season and the animals were individually placed in the metabolisme cages. Feed (chopped native grass and urea-molasses multinutrient block) was provided *ad libitum* throughout the experiment.

There were 4 treatement periods of 10 days. Prior to collect data of each period, the animals were allowed to acclimatize (for 4-5 d) to the treatment conditions until daily intakes of food and water were more or less constant, and attained a steady state at a certain body temperature (± 0.2°C) and respiration rate (± 10 per minute).

Period	Water
Indoor (18–30°C and 60-70% rh)	Unrestricted
Indoor (18–30°C and 60-70% rh)	Restricted (50% of intake in the 1st period)
10 h/d outdoor (18-39.3°C and 40–60% rh)	Unrestricted
10 h/d outdoor (18-39.3°C and 40– 60% rh)	Restricted (50% of intake in the 3rd period)

Total daily water exchange was calculated as a sum of water drunk, performed water and metabolic water. Performed water of ingested food consisting the native grass and UMMB was calculated separately. The amount of metabolic water of each animal was estimated in accordance with BRODY (1945). Evaporative water loss was estimated by subtracting the sum of fecal and urinary water loss from the total daily water exchange. Evaporated water from drinking water in the vessel was corrected daily. Urine and faecal outputs of each animal were monitored 3 times daily along each period. Standard proximate analyses were used to determine the contents of crude protein, ether extract, crude fiber, nitrogen-free extract and ash of the food and faecal samples.

Rectal temperatures and respiration rates were monitored 4 times daily: 06.00 am, 11.00 am, 02.00 pm and 04.00 pm. Respiration rates were determined by counting flank movements. Air temperature of the indoor and outdoor environments was monitored using max-min thermometer. Plasma volume was determined in the last day at 04.00 pm. in each period by using dilution technique of Evan Blue (T1824) in accordance with the procedures of WILLIAMS *et al.* (1991).

The experiment was arranged as a repeated measure experiments, and "SYSTAT for Windows version 6" was used for variance analysis of the data (WILKINSON, 1996). The significant differences between mean values were tested in accordance with the procedures of Newman-Keuls (WINER, 1971).

RESULTS AND DISCUSSION

Sunlight exposure was particularly attributed with solar radiation and a higher daily maximum ambient temperature of the outdoor (39.3°C) compared to that of the indoor environment (30°C).

The daily maximum rectal temperature of the goats was significantly higher in the outdoor (41.8 ± 0.2°C) than that in the indoor environment (39.9 ± 0.1°C) (Table 1). However, water restriction did not significantly change these maximum rectal temperatures in either the indoor or outdoor environment. The maximum rate of respiration was significantly higher in the outdoor than that in the indoor environment. Increasing the respiratory rate to a maximum level in the indoor environment was about 4 times of the minimum level, while it was 6 times in the outdoor environment.

Panting and evaporation from respiratory tract seem to be the most important mechanism for heat loss in goat during heat load, (which discharge only small amount of sweat. An experiment reported by WHITTOW (1971) indicated that at 40°C, the maximum cutaneous evaporation rate of goat is only 50 $g/m^2/h$. Under the condition of maximum cutaneous evaporation rate, increasing respiration rate appeared to be the most important mechanism for dissipating the excessive heat. The hyperthermia observed during direct exposure to sunlight was associated with a remarkable rise in respiration rate, particularly during the hottest time of the day (afternoon). These present results are in agreement with those reported by several investigators (MCDOWELL and WOODWARD, 1982; EL-NOUTY *et al.*, 1988).

It is well known that water plays a central role, by way of evaporative cooling, in the mechanisms used for heat dissipation. Accordingly, homeostatic mechanism of body fluid plays an important role to balance the requirements of water. The result of the present experiment indicated that the plasma volume of the goat in the outdoor was significantly higher than that in the indoor environment. Water restriction decreased the volume significantly either in the indoor or outdoor environment. On the other hand, the hematocrit value was significantly lower in the outdoor than that in the indoor environment, and water restriction in the same environment resulted in an increased hematocrit value (Table 1).

The increase in the plasma volume were apparently in proportion to the thermoregulatory requirement of the Jeneponto goat. This response may be interpreted as a strategy of the Jeneponto goat to cope with the outdoor environment (higher temperature and solar radiation) in which drinking water was provided unrestrictedly. There are two basic receptors sensing the plasma volume changes, volume- and baro-receptors in the atria. MACFARLANE (1982) indicated that the mechanism of this response begins with a fall in blood volume brought about by increasing respiration rate – water evaporation. Pressure change is sensed by baroreceptor and this combines with a change of plasma sodium concentration detected by macula densa and juxtaglomerular apparatus of the kidney, to release renin, the enzyme which generates angiotensin I, and this in turn loses a dipeptide to become angiotensin II (REID *et al.*, 1978). This stimulates the adrenal cortex to release aldosteron, which then to decrease sodium excretion through urination, as well as in saliva. With sodium retention in the plasma, water is kept in the

Table 1. Effects of sunlight exposure and water restriction on plasma volume, respiration rate, rectal temperature, organic matter intake and digestible organic matter of goat

Parameters	Condition			
	Room – indoor		Sunlight exposure - outdoor	
	Unrestricted water	Restricted water	Unrestricted water	Restricted water
Plasma volume (ml/ $kg^{0.82}$)	54.06 ± 1.19^a	51.67 ± 2.91^{ab}	58.76 ± 1.82^c	55.79 ± 1.38^a
Hematocrit value (%)	35.79 ± 0.92^a	37.43 ± 0.83^b	34.26 ± 0.38^c	36.90 ± 0.69^{ab}
Rectal temp.(°C)				
Min.	39.1 ± 0.2^a	39.1 ± 0.2^a	39.1 ± 0.1^a	39.1 ± 0.1^a
Max.	39.9 ± 0.1^a	39.9 ± 0.1^a	41.8 ± 0.2^b	41.8 ± 0.1^{ab}
Min vs Max	**	**	**	**
Respiration rate (per minute)				
Min.	32 ± 1.2^a	32 ± 1.2^a	32 ± 1.8^a	32 ± 1.8^a
Max.	136 ± 1.2^a	98 ± 1.8^b	190 ± 1.8^c	190 ± 1.8^c
Min vs Max	**	**	**	**
OM Intake (g/kg.$LW^{0.75}$/d)	59.17 ± 1.84^a	42.89 ± 4.28^b	58.02 ± 1.65^a	34.85 ± 2.83^c
Digestible OM (%)	58.26 ± 1.40^a	60.30 ± 1.57^b	60.24 ± 1.79^b	63.48 ± 0.87^c
Digestible OM (g/kg $LW^{0.75}$/d)	34.47 ± 0.69^a	25.90 ± 2.11^b	34.97 ± 2.86^a	22.13 ± 2.05^c

Values in the same row with different letters are significantly different (P<0.05) plasma and extra-cellular space, which then resulted in increasing the plasma volume.

Additionally, the increase in plasma volume may also be attributable with an increase in plasma protein mass (colloidal osmotic pressure, COP), which provides the water retaining force of the plasma compartment (HOROWITZ and SAMUELOFF, 1985). The possible increase in COP augmented water passage from the extra-vascular to intravascular compartment which then resulted in expansion of the plasma volume as observed in this study.

The exposure of animals to heat is known to cause a great loss of body water, which lead to a water defisit if not replaced by drinking water as occurred in this study. Under such conditions, maintaining the increased plasma volume despite the body water defisit is necessary to maintain adequate circulation required for heat dissipation processes. This is accomplished through the dilatation of the peripheral vessels, which take place in the hot outdoor environment to dissipate heat to the surrounding. Such a vasodilataion may cause a decreased hydrostatic blood pressure below the blood colloidal pressure, so that more extravascular fluid pass to the intravascular fluid compartement.

The increase in plasma water may also come from the digestive tract, since the digestive tract of ruminants contains considerable amounts of water, particularly in the rumen. However, absorption of water from the rumen is relatively slower compared to the lower part of the digestive tract (VON ENGELHARDT, 1970). Therefore, even though there was a possibility of an increased flow rate of rumen fluid resulted from increasing water intake, but the increase was apparently proportional to an increased rate of water absorbed from the lower part of digestive tract.

The significant increase in plasma volume would apparently be concomitant with increasing extra-cellular fluid volume (ECFV). A previous result reported by TAYMOUR *et al.* (1984) indicated that heat load with free access to drinking water resulted in an increased TBW of the goats, and the most increase of TBW is due to the enlargement of the ECFV. Similar results were also indicated by other studies (SHEBAITA and EL-BENNA, 1982; EL-NOUTY *et al.*, 1988). The increase in TBW in a hot environment may be an adaptive mechanism for heat tolerance, since it will allow the animal to store a great amount of heat during the hot hours of the day and dissipate it during the cool hours of the night.

The most common strain resulted from exposing herbivore to excessive heat load is an elevated body temperature (FINCH, 1984), as indicated also by the Jeneponto goat in the present study. It is widely known that a raised body temperature results in depressing food intake. However, a higher body temperature of the Jeneponto goat in the outdoor environment had apparently no affect whatsoever on the amount of organic matter consumed and digested as long as water provided unrestrictedly.

This physiological aptitude of the Jeneponto goat seems to be similar to those found in the desert-adapted goats, such as the Bedouin goat and Baladi goat, two famous breeds for their capacities to cope with a harsh hot desert condition (SHKOLINIK *et al.*, 1972; BROSH *et al.*, 1988; EL NOUTY *et al.*, 1988; MUALEM *et al.*, 1990). The changes in vascular volume may be resulted from a delay and reduction in the increase of plasma renin activity and anti-diuretic hormone which then results in increasing plasma osmolality (MORIMOTO, 1990). The importance of the above response is to maintain the appetite which is attributed to the ability for supplying a sufficient blood flow to the digestive tract (MALTZ *et al.*, 1984). SILANIKOVE (1985) indicated that the ability of desert goats to maintain higher feed intake during heat load than that of the close related non-desert ones which was related to the superiority of the former to alleviate a rise in plasma osmolality.

BROSH *et al.* (1988) showed data of voluntary feed intake of the Bedouin goat maintained outdoor in the desert summer and indicated that it was depressed during hot hours of the days, and it was resumed in the afternoon. In general, ruminants given a choice will prefer to eat during cooler hours, i.e., during the afternoon and at night (FINCH, 1984). Apparently, during hot hours of the days, the rumen is primarily used as a water reservoir when it is most required and primarily as a container of fermentation processes in the afternoon and during the night. Under hot condition with unrestricted water provided the goats of Jeneponto may possibly maintain the fluid balance between the inflow of fluid into and outflow of fluid out from the rumen. In addition to restore osmolality and to increase volume of the plasma, this condition was apparently maintaining appetite, feed intake and its digestibility. The expanded plasma volume may possibly be maintained during the hot hours of the day, which is an indicatication of a positive balance of water.

However, the organic matter intake of the Jeneponto goat was significantly reduced by water restriction. Although there was a significant increase in the digestibility of organic matter, the absolute amount of digestible organic matter was significantly lower compared to that when water was provided unrestrictedly.

There is an indication of various ruminant species (dairy and beef cattle, sheep and goat), that water restriction results in a reduction in feed intake but an increase in digestibility (SILANIKOVE, 1992). The increased digestibility of the goat in the present experiment seems to be attributable with the increase in the mean retention time of feed particles in the gut, and the goat was apparently able to balance their water economy at a lower level. Under this condition, plasma tonicity and electrolyte concentration may be in steady state. It is suggested that the change in appetite and digestibility may be mediated by food-related drinking phenomena (KRALY, 1984). Concequently, variation in one of the variable (food or water) will lead to propotional changes in the other. Reduction in feed intake leads to reduce metabolic rate which then to reduce water losses. Therefore, the proportional response to water restriction was to allow the goat to establish a new steady state at a lower level of water balance either in the indoor or outdoor environment.

However, it is unlikely that the reduced feed intake could be regarded as a single factor responsible for the increase in the retention time, particularly in the outdoor environment. Apparently, it may also be related with a decreased secretion rate of the thyroid hormones (T3 and T4) (ABDULLAH and FALCONER, 1977). These hormones have been reported to exert a major impact on rumen motility and on passage rate (CHRISTOPERSON, 1985). Additionaly, MORE *et al.* (1983) reported that water restriction decreased thyroxine secretion rate (TSR) in direct proportion to reduce energy intake. Although the maximum rectal temperature of the goat in the outdoor was higher than that in the indoor environment, decreasing feed intake resulted from water restriction would apparently decrease the endogenous heat production.

In the indoor environment and unrestricted water provided, the daily total water exchange of the goat was about 181.58 ± 4.38 ml/kg$^{0.82}$/d. It was increased to 284.44 ± 8.81 ml/kg $^{0.82}$/d in the outdoor environment. Water restriction was to decrease their daily water exchanges to 107.20 ± 4.26 and 159.98 ± 4.89 ml/kg$^{0.82}$/d in the indoor and outdoor environments respectively. Urinary, faecal and evaporative water losses (g/kg$^{0.82}$/d) were significantly reduced by water restriction either in the indoor or outdoor environment. However, as the proportion of the total water exchange, water restriction did not virtualy change the losses either in the indoor or autdoor environment. Under heat stress, the goat reduced markedly the proportions of the water loss through urination and defecation, whereas the loss through evaporation was increased significantly.

Table 2. Effects of sunlight exposure and water restriction on water balance of the goats

Parameters	Condition			
	Room – indoor		Sunlight exposure - outdoor	
	Unrestricted water	Restricted water	Unrestricted water	Restricted water
	Intakes			
Ingested water (g/kg$^{0.82}$/d)	143.28 ± 4.20^a	74.41 ± 3.01^b	247.29 ± 8.6^c	132.96 ± 3.50^d
Performed water (g/kg$^{0.82}$/d)	34.05 ± 1.52^a	29.58 ± 1.59^b	32.85 ± 1.32^a	24.28 ± 1.72^b
Est. metabolic water (g/kg$^{0.82}$/d)	4.25 ± 0.12^a	3.21 ± 0.39^b	4.30 ± 0.27^a	2.74 ± 0.25^b
Total water exchange (g/kg$^{0.82}$/d)	181.58 ± 4.38^a	107.20 ± 4.26^a	284.44 ± 8.81^c	159.98 ± 4.89^d
	Loss			
In urine (g/kg$^{0.82}$/d)	71.10 ± 9.76^a	41.69 ± 4.68^b	53.32 ± 6.05^a	27.42 ± 2.21^d
In urine (% total W.loss)	39.15 ± 4.57^a	38.90 ± 3.90^a	18.74 ± 2.51^b	17.16 ± 2.55^b
In feces (g/kg$^{0.82}$/d)	27.04 ± 1.67^a	14.93 ± 0.82^b	20.22 ± 0.58^c	8.50 ± 0.40^d
In feces (% total W.loss)	14.89 ± 1.75^a	13.93 ± 1.91^a	6.27 ± 1.20^b	5. 31 ± 0.65^b
Est. ev. water (g/kg$^{0.82}$/d)	83.45 ± 7.90^a	50.58 ± 5.39^a	210.93 ± 13.56^{ac}	12406 ± 5.59^d
Est. ev. water (% total W Loss)	45.96 ± 4.98^a	47.15 ± 4.27^a	74.15 ± 3.63^b	77.53 ± 4.53^b

Values in the same row with different letters are significantly different ($P<0.05$)
Est. = estimated; Ev. = evaporative

CONCLUTION

In conclusion, the present study elucidates that there is not a simple physiological mechanism explaining the remarkable tolerance of the Jeneponto goat to sunlight exposure (solar radiation and heat loads) and to low water avaibility. The Jeneponto goat could be able to withstand and to develop in the harsh environment based on their own mechanisms of heat and water balances by expanding plasma volume and increasing body temperature and respiration rate without alteration in the amount of digestible organic matter. Regarding management, it may apparently be possible to have high productivity of the Jeneponto goat. In the areas where water is scarce and daily maximum temperature is high, high production of the Jeneponto goat may be achieved by utilizing water as efficiently as possible but still fulfill the requirement, and by feeding management to reduce high endogenous heat production during hot hours of the days.

REFERENCES

ABDULLAH, R. and I.R. FALCONER. 1977. Response of thyroid activity to feed restriction in the goat. *Aust. J. Biol. Sci.* 30: 207-215.

BRODY, S. 1945. Bioenergetic and Growth, with Special Reference to the Effeciency Complex in Domestic Animals. Reinhold Pub.Corp., New York.

BROSH, A., A. CHOSNIAK, A. TADMOR and A. SHKOLNIK, 1988. Physiocochemical conditions in the rumen of Beduoin goats: Effect of drinking, food quality and feeding time. *J. Agric. Sci. Camb.* 111: 147-157.

CHAIYABUTR, N., C. BURANAKARL, V. MUANGCHAROEN, P. LOYPETJRA and A. PICHAICHANARONG. 1987. Effects of acute heat stress on changes in the rate of liquid flow from the rumen and turnover of body water of swamp buffalo. *J. Agric. Sci. Camb.* 108: 549-553.

CHRISTOPHERSON, R.J. 1985. The thermal environment and the ruminant digestive system, *In*: Stress Physiology of Livestock. YOSEF, M.K. (Eds) CRC Press, Boca Raton, FL. pp.: 163-180.

DAWSON, T.J., M.J.S. DENNY, E.M. RUSSEL and E. ELLIS, 1975. Water usage and diet preferences of free ranging kangaroos, sheep and feral goats in the Australian arid zone during summer. *J. Zool. Soc. London.* 177: 1-23.

EL NOUTY, F.D., G.A. HASSAN, T.H. TAHER, M.A. SAMAK, Z. ABO-ELLEZZ and M.H. SALEM. 1988. Water requirement and metabolism in Egyptian Barki and Rahmani sheep and Baladi goats during spring, summer and winter seasons. *J. Agric. Sci. Camb.* 111: 27-34.

FINCH, V.A. 1984. Heat as a stress factor in herbivores under tropical condition. *In*: *Herbivore Nutrition.* GILCHRIST, E.M. and R.I. MACKIE (Eds). The Science Press, Pretoria, S.A. pp. 89 – 105.

HOROWITZ, M. and S. SAMUELOFF. 1985. Interaction between circulation and plasma fluids during heat stress, *In*: Adaptive Physiology to Stressful Environments. SAMUELOFF, S. and M. YOUSEF (Eds). CRC Press, Inc., Boca Raton, Florida. pp. 139-154.

KRALY, F.S. 1984. Physiology of drinking elicited by eating. *Physiol. Rev.* 4: 478-490.

MACFARLANE, W.V. and B. HOWARD. 1972. Comperative water and energy economy of wild and domestic mammals. *Symp. Zool. Soc. Lond.* 31: 261-296.

MALTZ, E., K. OLSON, S.M. GLICK, F. FYHROQUIST, N. SHANIKOUT, I. CHOSNIAK and A. SHKOLNIK. 1984. Homeostatic responses to water deprivation or hemorrhage in lactating and non-lactating Bedouin goats. *Comp. Biochem. Physiol.* A, 77A: 79 – 84.

MCDOWELL, R.E. and A. WOODWARD,. 1982. Concepts in animal adaptation, comperative suitability of goats, sheep and cattle to tropical environments, Proc. the 3rd International Conference on Goat Production and Disease. Tucson, Arizona, 10-15 January 1982. Dairy Goat J. Pub., Co., Scottsdale, Arizona. pp. 387-394.

MORE, T., B. HOWARD and B.D. SIEBERT. 1983. Effect of level of water intake on water, energy and nitrogen balance and thyroxine secretion in sheep and goat. *Aust. J. Agric. Res.* 34: 441-446.

MORIMOTO, T. 1990. Thermoregulation and body fluid: Role of blood volume and central venous pressure. *Jap. J. Physiol.* 40: 165-179.

MUALEM, R., I. CHOSHNIAK and A. SHKOLNIK. 1990. Environmental heat load, bioenergetics and water economy in two breeds of goats: The mamber goat versus the desert Bedouin goat. *World Rev. Anim. Prod.* XXV-3: 91–95.

REID, I.A., B.J. MORRIS and W.F. GANONG. 1978. The reninangiotensin system. *Ann. Rev. Physiol.* 40: 377 – 410.

SHEBAITA, M.K. and I.M. EL-BENNA. 1982. Heat load and heat dissipation in sheep and goats under environmental heat stress. Proc. 6th Int. Conf. on Animal and Poultry Production. Egypt, 26-29 Sept. 1982. Zagazig Univ., Egypt. pp. 459-469.

SHKOLINIK, A., A. BORUT and I. CHOSHNIAK. 1972. Water economy of the Bedouin goat. *Symp. Zool. Soc. London* 31: 229 – 242.

SILANIKOVE, N. 1985. Effect of dehydration on feed intake and dry matter digestibility in desert (Black Bodouin) and non-desert (Swiss Saanen) goats feed on lucerne hay. *Comp. Biochem. Physiol.* 80A: 449-452.

SILANIKOVE, N. 1992. Effects of water scarcity and hot environment on appitite and digestion in ruminants: Review. *Livestock Prod. Sci.* 30: 175 – 194.

VON ENGELHARDT, W. 1970. Movement of water across the rumen epithelium, *In*: Physiology of Digestion and Metabolism in Ruminant. Phillipson, A.T. (Ed.) Proc.

the 3rd Int. Symp. Cambridge, England 7-8 August, 1969. Camb., Oriel Press. Cambridge. pp. 132–169.

WHITTOW, G.C. 1971. Ungulates. *In*: Comperative Physiology of Thermoregulation. WHITTOW, G.C. (Eds.) Academic Press, New York. pp. 192-281.

WILKINSON, L. 1996. Statistics, Systat 6.0 for Windows. SPSS Inc., USA.

WILLIAMS, A.J., K.J. THORNBERRY and H. NICOL. 1991. A comperative investigation of the volume of plasma and extracellular fluids and renal clearence of urea and creatinine in Merino sheep from flock with genetic capacities for wool. *Aust. J. Agric. Res.* 42: 1311-1321.

WINER, B.J. 1971. Statistical Principles in Experimental Design. Int.Student.Ed., McGraw-Hill Kogakusha, Ltd., New Delhi.