Jurnal Kedokteran Hewan
P-ISSN : 1978-225X; E-ISSN : 2502-5600
September 2017, 11(3):104-105
DOI: https://doi.org/10.21157/j.ked.hewan.v11i3.4352

PHYSIOLOGICAL RESPONSES OF SABURAI GOAT ON THE OF ADDITION DIETARY PROTEIN LEVEL

Kusuma Adhianto[1*], Muhtarudin[1], Sulastri[1], and Madi Hartono[1]
[1]Department of Animal Husbandry Faculty of Agriculture Lampung University, Lampung, Indonesia
*Corresponding author: kusuma.adhianto@fp.unila.ac.id

ABSTRACT

The purpose of this research was to study the effect of different level of protein addition in goat ration on feed addition in the ration on feed intake and physiological responses of Saburai goats (rectal temperature, respiratory rate, and heart rate). Twenty male Saburai goats were randomly divided into 4 treatments group with 5 goats each. Goats in group 1 (PO) were fed with forage, while goats in group 2 (P1), 3 (P2), and 4 (P3) were fed with forage + concentratre with 13%, 16%, and 19% crude protein, respectively. The treatments were P0= feeding forage, P1= feeding forage + concentrate with 13% crude protein (CP), P2= feeding forage + concentrate with 16% CP, and P3 feeding forage + concentrate with 19% CP. The results showed that the rectal temperature and heart rate did not significantly affected (P>0.05) in all treatment, however the heart rate was significantly (P<0.05) affected among the treatments. The conclusion is the addition of different protein level in the ration has no effect on rectal temperature and respiratory rate, but significantly increases the heart rate frequency.

Key words: feed intake, physiological responses, Saburai goat

ABSTRAK

Tujuan penelitian adalah mengetahui pengaruh pemberian konsentrat dalam ransum terhadap konsumsi pakan dan respons fisiologis kambing (suhu rektal, frekuensi pernafasan, dan denyut jantung,) pada kambing Saburai. Sebanyak 20 ekor kambing Saburai jantan digunakan dalam penelitian ini. Penelitian menggunakan rancangan kelompok teracak lengkap (RKTL) 4x5. Perlakuan terdiri atas P0 (pemberian pakan hijauan), P1 (pemberian pakan hijauan+konsentrat dengan protein kasar, PK 13%), P2 (pemberian pakan hijauan+konsentrat dengan PK 16%), dan P3 (pemberian pakan hijauan+konsentrat dengan PK 19%). Hasil penelitian menunjukkan perlakuan P0, P1, P2, dan P3 tidak berpengaruh nyata terhadap suhu rektal dan frekuensi pernafasan (P>0,05), akan tetapi berpengaruh nyata terhadap denyut jantung (P<0,05). Dari hasil penelitian disimpulkan bahwa penambahan level protein pada ransum tidak berpengaruh pada suhu rektal dan frekuensi pernafasan, namun berpengaruh nyata terhadap peningkatan frekuensi denyut jantung.

Kata kunci: konsumsi pakan, respons fisiologis, kambing Saburai

INTRODUCTION

The main problem of livestock reared in the humid tropics, such as Indonesia, is the high direct exposure of solar radiation throughout the year, resulting in uncomfortable conditions because of the excessive heat load, especially for high-producing livestock. In response to these conditions, livestock then are forced to increase their thermoregulatory activity in order to cope with the high heat load. Purwanto *et al.* (1995) stated that when the radiation intensity is in its maximum level, the animal thermoregulation activity will also reach its maximum point. In addition, the high intensity of solar radiation will lead to the increase of ambient temperature, including the temperature inside the livestock enclosure.

Excess body heat load will force livestock to maintain constant body temperature through behavioral, physiological, and hormonal changes. A decrease in feed intake is one sign of livestock experiencing excessive heat load or heat stress. The physiological mechanisms require the energy allocated for production and reproductive performance to be used to maintain body heat balance. Thus, it will have a negative impact, which is a decrease in productivity of livestock. In male animals, heat stress affects almost all body systems. Heat stress can reduce the level of libido, sperm production, sperm motility, and increase the proportion of abnormal sperm in the ejaculate (Perez-Crespo *et al.*, 2008). In female animals, it can reduce fertility, conception rate, and embryo survival (Sakatani *et al.*, 2004). The livestock production and reproduction appearance will be expressed optimally in accordance to the genetic capability if supported by environmental factors.

Among the environmental factors that greatly affect the productivity of livestock is the climate and feeding. Wet tropical climate in Indonesia caused goat herds to experience excessive body heat load throughout his life due to the high air temperature and solar radiation intensity. The livestock body heat derived not only from fermentation processes in the rumen and metabolic processes in the body, but also from the heat in the environment (heat gain).The amount of heat load due to air temperature and solar radiation is exacerbated by the relatively high humidity in Indonesia that can hinder the process of body heat expenditure through evaporation. Heat stress is forcing livestock to activate the thermoregulation mechanism, such as increasing rectal temperature, heart rate, and respiration, as well as decreasing feed consumption (Purwanto *et al.*, 1996). Moreover, in conditions of heat stress, transfer function of metabolized energy from the feed will occur, to be used for the body thermoregulation process, which is originally for growth or production. Thus, the physiological changes and nutritional status of livestock due to heat stress will impact the livestock productivity.

Some researchers report that cow heat production in a control diet is increased by 10-15% at a temperature

of 26° C and 32° C than at a temperature of 18° C (Shibata and Mukai, 1982). Moreover, in hot temperatures (32° C) energy requirements for maintenance metabolism is also increased by 15% compared to the temperature of 26° C (Kurihara *et al*., 1990). This makes the foundation to increase the proportion of concentrate in livestock diet in order to cope with a decrease in feed intake and increased metabolic energy requirements on a hot environment. Concentrate is a ration that is easy to digest or has low crude fiber content, energy-dense, and has favorable taste for livestock.

Information on the increase of concentrate rations for manipulating heat stress nowadays is mostly done in cows and carried on in a climate controlled room (chamber). Meanwhile, the increase of concentrate proportion in the diet of goats to cope with heat stress is not widely available, especially those carried out on the maintenance system in the natural hot environments. Therefore, it is important to conduct a study on the use of concentrates with different protein levels different proteins in goats that reared in natural hot environments.

Goats consistently demonstrated better adaptive ability than other ruminant livestock in harsh environments (Shkolnik and Silanikove, 1981). According to Shkolnik *et al.* (1972), goat adaptability to cope with heat stress was due to the higher ability of water conservation, higher degree of sweat production, higher respiration rate, higher skin temperature, lower basal metabolic rate, and constant heart rate and *cardiac output* (Shkolnik *et al*., 1972). In addition, Silanikove (2000) states that goat characteristics that help to cope with the harsh environmental conditions were small body size small body size, low metabolism need, the ability to reduce metabolism, highly efficient utilization of forage, the ability to save the need for nitrogen, and efficient water use.

Through the Minister of Agriculture Decree No. 359/Kpts/PK.040/6/2015 dated June 8th, 2015, Saburai goat is stated as one of goat mostly kept by farmers in Tanggamus. Saburai goats have been established as one of the Indonesian germplasm population needed to be maintained, improved, and developed so that it can provide many benefits to the farmers and also as an effort to meet the needs of meat, both local and national consumption levels. Saburai goats have several advantage such as easy maintenance, high adaptability to a various environmental condition, and high growth rates (Adhianto *et al*., 2015; Adhianto *et al*., 2016). This study aims to determine the effect of protein level addition in Saburai goat diet on the feed intake and physiological responses (rectal temperature, heart rate, and respiratory rate) of Saburai goat.

MATERIALS AND METHODS

The research was conducted in the village of Campang, Gisting, Tanggamus. Proximate analysis was carried out in the Laboratory of Animal Husbandry. Twenty Saburai goats used in this study were of the age 5-6 months with a weight of 18.25±6.13 kg. Maintenance and feeding during research were done in cage stage, which is divided into individual cages plots of 150 cm x 90 cm equipped with a feed and water. Rations used in this study were composed of basal feed forage and concentrates as source of protein, with protein contents of 13%, 16%, and 19%.

The design used was a complete randomized group; the goats were divided into four treatment groups, each consisted of five goats (complete randomized groups of 4x5). The treatment consisted of P0 (feeding forage), P1 (feeding forage + concentrate with crude protein, CP 13%), P2 (feeding forage + concentrate with CP 16%), and P3 (feeding forage + concentrate with CP 19%). Feeding was based on a calculation of 3.5% of body weight in the form of dry material consisted of 60% basal feed and 40% concentrates. Concentrates were given first, followed by feeding forage, both were fed *ad libitum*. Feeding was done twice a day, morning and afternoon. During feeding trial maintenance period, samples were taken from feed and total collections were made in the last seven days of the maintenance period to obtain consumption and physiological responses data.

Observed Variables

Variables observed consisted of consumption, the amount of nutrients digested, climate and physiological factors. Digested nutrients substances include dry matter and organic matter. The observed climate factors include air temperature and relative humidity (RH) in the cage. Physiological components measured were rectal temperature, respiratory rate, and heart rate. Observations of temperature, humidity, and physiological responses were done every day during the retrieval of data at 07:00, 08:00, 09:00, 10:00, 11:00 and 13:00, 14:00, 15:00, 16:00, 17:00 using environmental thermometer and hygrometer.

Data Analysis

Analysis of variance or co-variance carried out in accordance with the experimental design of complete randomized group model design, and means comparison was carried out using Duncan's multiple range test (DMRT) (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Micro Climatic Conditions

The average of environment temperature and humidity during research were studies were 25.41° C and 68.75% respectively, and such temperature conditions are still comfortable for livestock. Smith and Mangkuwidjojo (1988), states that a comfortable environment for the goats is between 18° C and 30° C. However, the ambient temperature in this study was relatively is relatively high in the normal range. In tropical and subtropical areas, high ambient temperatures are a major obstacle in improving livestock production (Marai *et al.*, 2007; Nardone *et al.*, 2010).

High ambient temperature is a major problem in tropical areas, where in the evening the ambient

temperatures was drastically low. This condition requires livestock ability to maintain power, heat, water, hormonal, and mineral balance. Temperature determines metabolic rate, heart rate, and other important factors in the body of livestock, so extreme temperature changes can easily affect the animal body. The high temperature effect was exacerbated when heat stress is accompanied by a high humidity environment (Silanikove, 1992).

Average consumption in the Saburai goats from different treatment groups were not significantly different (P>0.05) (Table 1). Addition of concentrate in groups P1, P2, and P3 did not necessarily increase the feed consumption the consumption of DM. This is because the provision of forage is not limited in all treatments so that the male goat Saburai maximally expected to consume the feed. Average consumption (Table 1) CP in the treatment group P1, P2, and P3 with additional concentrate was highly significant (P<0.01) than the group P0, while the average consumption of CP between treatment groups who received additional concentrate was not significantly different. However, along with the increasing content of CP on feed P1, P2, and P3 there was an increased CP consumption tendency patterns in P1, P2, and P3. In general, the addition of concentrate in the treatment group is seen to improve the consumption of CP, although no effect was seen on DM consumption. CF (crude fiber) consumption and TDN in this study were not significantly different among all treatment group P0, P1, P2, and P3 (P>0.05). This condition showed that the ability of each treatment in utilizing the feed was relatively the same.

The ambient temperature was still in the normal range of 15-29° C and did not influence the consumption and growth performance. Side effects could occur if the ambient temperature reach over 30° C, such as decrease in feed intake, body weight, carcass, fat thickness, and increase the incidence of disease (Nordone *et al.,* 2006; Mitlohner *et al.,* 2001), buffalo could even reduce its consumption by 40-60% (Morand-Feher and Doreau, 2001).

Respiration rate, pulse rate, and rectal temperature are parameter that describes the physiological adaptation mechanism. Some researchers study the mechanisms of physiological adaptation such as rectal temperature, pulse, and respiration rate of the small ruminants (Phulia *et* al., 2010, Sharma *et al.,* 2013). Livestock may experience stress caused by restraint when handling livestock, being in a new environment, or physical stress such as hunger, thirst, fatigue, injury or extreme heat (Dantzer and Mormede, 1983). The approach in this field is hampered by the lack of suitable psychological criteria for assessing the long-term adaptive changes. Stress as described by Moberg (2000) including changes in hormone secretion, leading to changes in metabolism, immunity, behavior, and reproductive failure. Conditions of prolonged stress can lead to loss of productivity and death of livestock.

Identification of strategies need to be conducted to determine the stress and the level of comfort appropriate to the livestock, so a maintenance management that can reduce stress of livestock could be developed, which in turn will increase animal comfort and performance level. Larry (2012) stated that physiological stress measurements depend on the interaction of many systems. Some of the stress responses can be measured with the function of major systems involved, for example high temperatures will increase the rate of respiration, induce sweating, and increase body temperature.

The average of goats physiological responses during the study are presented in Table 2. From Table 2 we can concluded that the rectal temperature in all treatments were not different, with a range between 38.24° C and 38.28° C. This result suggested that the goats in all treatments could maintain body temperature within the normal range. According to Adisuwiryo *et al.* (2001), a goat body temperature ranges between 38.0° C and 39.9° C with a mean temperature of 38.7° C. They maintain normal body temperature via thermoregulation mechanism, which may be indicated by increased heart rate and respiration (Alamer 2006; Mengistu *et* al., 2007). Body temperature is a good way of measuring heat tolerance in animals, since it is yielded from all of the gain of all the gain and loss of body heat. Rectal temperature is regarded as a good index to describe the body temperature even though

Table 1. Mean consumption of DM, CP, CM, and TDN

Consumption (g/kg $BB^{0.75}$)	Treatment group			
	P0	P1	P2	P3
Dry Matter^{ns}	91.37±0.14	90.93±0.18	90.49±0.16	92.52±0.26
Crude Protein	9.21±0.014^{a}	21.94±0.06^{b}	24.63±0.04^{b}	28.66±0.08^{b}
Crude Fiber^{ns}	16.39±0.03	16.98±0.03	16.80±0.03	17.03±0.05
TDN^{ns}	51.79±0.08	48.95±0.10	49.91±0.08	51.46±0.16

* TDN= true digestible nutrien was calculated using formula from Hartadi *et al.* (1997)
^{a,b}Different letter in the same row indicates significant difference (P<0.01)

Table 2. Mean heart rate frequency, respiratory frequency, and rectal temperature of studied goats

Variables	Treatment groups			
	P0	P1	P2	P3
Rectal temperatures (° C)	37.63	37.57	37.55	37.51
Respiratory frequency (times/minute)	26.87	26.8	26.81	27.05
Heart rate (times/minute)	84.59^{a}	88.06^{b}	89.49^{b}	89.49^{b}

^{a,b}Different letter in the same row indicates significant difference (P<0.05)

there is considerable variation in different parts of the core of the body at different times (Otoikhian *et al*., 2009). Rectal temperature in goats was higher at high ambient temperatures in some studies (Devendra, 1987; Marai *et al*., 2007).

According to Triakoso (2011) normal temperature range of goat is 38.6° C to 40.2° C with an average of 39.4° C. Although the difference was 1.2° C below normal temperature range, it indicated that the genetic influence and the environment had an impact on rectal temperature. As we know that the heat balance of the body can be affected by the body' internal and external conditions. Internal conditions include the physiological processes in the body such as metabolic processes of feed. In this study, the addition of the level of protein in the ration did not have a significant impact on Saburai goat rectal temperature changes.

Respiratory Frequency

The mean respiratory frequency in the experimental goats ranged between 26.80 and 27.05 times per minute (Table 2). Respiratory frequency did not differ ($P > 0.05$) among all treatments. The results of this study were still within the range of normal respiratory rate goat of 20-30 times per minute (Triakoso, 2011). These responses indicated that although the result was not different among all treatments, the goats had activated the thermoregulation system of the body to maintain body temperature to remain constant, with heat expenditure through breathing.

Judging from the ambient comfortable temperature range, the termoregulation activation was not needed. However, the activation of thermoregulation mechanism that happened through the increased respiratory frequency was thought to be caused by the higher proportion of forage in all treatments. A large proportion of forage caused more production of goat body heat/heat increment thereby increasing the heat load of the body and must be removed. The releases of body heat out of the body was mostly done by removing heat from the internal organs to the outer parts of the organ primarily sweat glands in the skin and mucous glands along the respiratory tract. Extra treatment of protein addition in the ration did not make the goat physiologically in a state of stress. The situation illustrated that the process of exchange between the inhaled oxygen from outside the body and carbon dioxide exhaled was still in a balance state. To process this exchanges, respiratory system alongside with blood system work to meet this goals, which is for the lungs to transfer oxygen into the bloodstream to be carried into the cell and exchanged with carbon dioxide, out of the blood into the lungs to the the gas exit (Mushawwir, 2010). Changes in metabolism and muscle activity of goats were also affecting the heart and respiration rate. Heat loss through respiration is highest compared to other mechanism (Devendra, 1987; Kumar *et al*., 2011).

Mean heart rate of experimental goats ranged between 84.56 and 89.49 times per minute (Table 2). Heart rate in all treatment groups were still in the normal range, which is 70-90 times per minute (Dawson *et al*., 2011). Although still within the normal range, the goat heart rates were approaching the upper limit. This showed that in all treatment groups the release of body heat to the environment still happened. However, in the treatment P0, the heart rate was significantly faster than the P1, P2 and P3 ($P<0.05$).

Several factors that affect the heart rate are body size, species, sex, age, physical condition, exercise, pregnancy, lactation, and the process of rumination (Frandson, 1992). Furthermore, increase in heart rate was also influenced by the consumption and quality of feed. Increased heart rate in this study is probably caused by increased activity of food ingestion. Moreover, an increase in heart rate served to draw blood to the surface of the skin so that the balance of body heat is maintained (Isroli *et al.,* 2004; Ocak *et al*., 2009; Bernabucci *et al*., 2010).

Increased heart rate and pulse rate were attributed to two causes, the increase in muscle activity to control the rate of respiration in conjunction with a high respiration rate, and resistance reduction of peripheral vascular and arteriovenous anastomoses. Increased heart rate would increase blood flow from the core to the surface as a result of a lot of heat loss (due to conduction, convection, radiation, and by the diffusion of water from the skin) (Maurya *et al*., 2004; Marai *et al*., 2007).

CONCLUSION

Based on the results and discussion, it could be concluded that the addition of protein levels in diets had no significant effect on rectal temperature and respiratory rate, but had significant effect on the increase in heart rate.

REFERENCES

Adhianto, K., M.D.I. Hamdani, dan S. Sulastri. 2015. Model kurva pertumbuhan pra sapih kambing Saburai di Kabupaten Tanggamus. **J. Sain Peternakan Indonesia.** 10(2):95-100.

Adhianto, K., M.D.I. Hamdani, S. Sulastri, dan I. Listiana. 2016. Performan produksi kambing Saburai jantan pada dua wilayah sumber bibit di Kabupaten Tanggamus. **Sains Peternakan.** 14(2):22-29

Adisuwiryo, D., Soetrisno, dan S.J.A. Setyawati. 2001. **Dasar Fisiologi Ternak**. Fakultas Peternakan Unsoed. Purwokerto.

Alamer, M. 2006. Physiological responses of Saudi Arabia indigenous goats to water deprivation. **Small Rum. Res.** 63:100-109.

Bernabucci, U., N. Lacetera, L.H. Baumgard, R.P. Rhoads, B. Ronchi, and A. Nardone. 2010. Metabolic and hormonal acclimation to heat stress in domesticated ruminants. **Animal**. 4(7):1167-1183.

Dantzer, R. and P. Mormede 1983. Stress in farm animals: A need for re-evaluation. **J. Anim. Sci**. 57(1):6-18.

Dawson, L., J. Allen, and B. Olcot. 2011. Meat Goat Herd Health–Procedures and Prevention. **http://www.luresext.edu/goats/training/herdhealt.html.**

Devendra, C. 1987. Goats. In **Bioclimatology and the Adaptation of Livestock**. Johnson, H.P (Ed.). Elsevier Publication, Holland.

Frandson, R.D. 1992. **Anatomi dan Fisiologi Ternak**. Gadjah Mada University Press, Yogyakarta.

Hartadi, H., S. Reksohadiprodjo, and A.D. Tillman. 1997. **Tabel Komposisi Pakan untuk Indonesia**. Cetakan keempat. Gadjah Mada University Press, Yogyakarta.

Isroli, S.A.B. Santoso, and N. Haryati, 2004. Respons termoregulasi dan kadar urea darah domba garut betina dewasa yang dipelihara di dataran tinggi terhadap pencukuran wol. **J. Indonesian Trop. Anim. Agric.** 2:110-114.

Kumar, S.B.V., A. Kumar, and M. Kataria. 2011. Effect of heat stress in tropical livestock and different strategies for its amelioration. **J. Stress Physiol. Biochem.** 7(1):45-54.

Kurihara, M., S. Kume, M. Shibata, S. Takashi, and T. Aii. 1990. The effect of environmental temperature on energy metabolism of dry dairy cows given hay at maintenance level. **Japan J. Zootech. Sci**. 61:315-321.

Larry, C. 2012. Stress Factors of Farm Animals and Their Effects on Performance. **http://www.waaesd.org.**

Marai, I.F.M., A.A. El-Darawany, A. Fadiel, and M.A.M. Abdel-Hafez. 2007. Physiological traits as affected by heat stress in sheep a review. **Small Rum. Res**. 71:1-12.

Maurya, V.P., S.M.K. Naqvi, and J.P. Mittal. 2004. Effect of dietary energy level on physiological responses and reproductive performance in Malpura sheep in hot semi-arid region of India. **Small Rum. Res.** 55:117-122.

Mengistu. U., K. Dahlborn, and K. Olsson. 2007. Effect of intermittent watering on water balance and feed intake in Male Ethiopian Somali goats. **Small Rum. Res**. 67:45-54.

Mitlohner, F.M., J.L. Morrow, J.W. Dailey, J.S.C. Wilson, M.L. Galyean, M.F. Miller, and J.J. McGlone. 2001. Shade and water misting effects on behavior, physiology, performance, and carcass traits of heat-stressed feedlot cattle. **J. Anim. Sci.** 79:2327-2335.

Moberg, G.P. 2000. "Biological Response to Stress: Implications for Animal Welfare". In **The Biology of Animal Stress.** Moberg, G.P. and J.A. Mendy (Eds.). CABI Publishing. CAB International, Wallingford, Oxion OX108DE, UK.

Morand-Feher, P. and M. Doreau. 2001. Ingestion et digestion chez les ruminants soumis `a un stress de chaleur. **INRA Production Animales.** 14(1):15-27.

Mushawwir, A. 2010. Sistem Respiratori. In **Fisiologi Ternak. Fenomena dan Nomena Dasar dari Fungsi Serta Interaksi Organ pada Hewan.** Soeharsono (Ed.). Widya Padjajaran, Bandung.

Nardone, A., B. Ronchi, N. Lacetera, and U. Bernabucci. 2006. Climatic effects on productive traits in livestock. **Vet. Res. Commun**. 30 (Suppl. 1):75-81.

Nardone, A., B. Ronchi, N. Lacetera, M.S. Ranieri, and U. Bernabucci. 2010. Effects of climate changes on animal production and sustainability of livestock systems. **Livest. Sci**. 130:57-69.

Ocak, S., N. Darcan, S. Cankaya, and T. Cinal. 2009. Physiological and biochemical responses in German Fawn kids subjected to cooling treatments under mediterranean climate conditions. **Turkish J. Vet. Anim. Sci**. 33(6):455-461.

Otoikhian, C.S.O., J.A. Orheruata, J.A. Imasuen, and O.P. Akporhuarho. 2009. Physiological response of local (West African Dwarf) and adapted Switzerland (White Bornu) goat breed to varied climatic conditions in South-South Nigeria. **African J. General Agric**. 5(1):1-6.

Perez-Crespo. M., B. Pintado, and A. Gutierrez. 2008. Scrotal heat stress effects on sperm viability, sperm DNA integrity, and the offspring sex ratio in mice. **Mol. Reprod. Dev.** 75:40-47.

Phulia, S.K., R.C. Upadhyay, S.K. Jindal, and R.P. Misra. 2010. Alteration in surface body temperature and physiological responses in Sirohi goats during day time in summer season. **Indian J. Anim. Sci**. 80(4):340-342.

Purwanto, B.P., F. Nakamasu, and S. Yamamoto. 1995. "Estimasi kebutuhan energi untuk termoregulasi pada sapi perah". **Forum Ilmu Peternakan**. 1:1-8.

Purwanto, B.P., M. Herada, and S. Yamamoto. 1996. Effect of drinking water temperature on heat balance and thermoregulatory responses in dairy heifers. **Aust. J. Agric. Res**. 47: 505-512.

Sakatani M., S. Kobayashi, and M. Takahashi. 2004. Effects of heat shock on in vitro development and intracellular oxidative state of bovine preimplantation embryos. **Mol. Reprod. Dev.** 67:77-82.

Sharma, S., K. Ramesh, I. Hyder, S. Uniyal, V.P. Yadav, R.P. Panda, V.P. Maurya, G. Singh, P. Kumar, A. Mitra, and M. Sarkar. 2013. Effect of melatonin administration on thyroid hormones, cortisol and expression profile of heat shock proteins in goats (*Capra hircus*) exposed to heat stress. **Small Rum. Res**. 112(1):216-223.

Shibata, M. and A. Mukai. 1982. The effect of environmental temperature on the heat production and some physiological responses of dry cows given high concentrate. **Jpn. J. Zootech Sci**. 53:33-38.

Shkolnik, A. and N. Silanikove. 1981. Water Economy, Energy Metabolism and Productivity in Desert Ruminants. In **Nutrition and Systems of Goat Feeding.** Morand-Fehr, P., A. Borbouse, and M. De Simiane. (Eds.). Vol. 1, ITOVIC-INRA, Tours, France.

Shkolnik, A., A. Borut, and J. Choshniak. 1972. Water economy of the beduin goat. **Syrup. Zool. Soc**. 31:229-242.

Silanikove, N. 1992. Effects of water scarcity and hot environment on appetite and digestion in ruminants: A review. **Livest. Prod. Sci**. 30:175-194.

Silanikove, N. 2000. The physiological basis of adaptation in goats to harsh environments. **Small Rum. Res**. 35:181-193.

Smith, J.B. and S. Mangkuwidjojo. 1988. **Pemeliharaan, Pembiakan dan Penggunaan Hewan Percobaan di Daerah Tropis.** Cetakan Pertama. Penerbit UI., Jakarta.

Steel, R.G.D. and J.H. Torrie. 1980. **Principles and Procedures of statistics**. McGrow-Hill, New York.

Triakoso, N. 2011. **Petunjuk Pemeriksaan Fisik. Ilmu Penyakit Dalam.** Departemen Klinik Veteriner. Fakultas Kedokteran Hewan. Universitas Airlangga Surabaya.