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REVIEW

Effect of heat stress on milk production of goats from Alpine and Saanen breeds in Brazil

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SUMMARY

The purpose of this bibliography review was to approach the thermal comfort rates on milk production of goats from Alpine and Saanen breeds in Brazil. The caloric stress caused by weather changes to which the animals are submitted, influence on the mechanisms of normal physiological processes of the body. Thus, the effect on the lactation process in goats can be mentioned, where it decreases the amount of water in the body with the consequent decrease in synthesis and milk ejection interfering in the production of hormone prolactin and growth hormone. The animal's interaction with the environment must be considered when the aim in livestock farming is welfare, because the different responses of the animal to the peculiarities of each region are crucial for the success of the animal adaptation. So, the correct identification of the factors that influence the productive life of the animal, such as the stress caused by the seasonal fluctuations of the environment, allow production systems management, making it possible to make them sustainable and viable. The maintenance of these parameters in normal levels is very important, to the point of being used in the evaluation of climate adaptability of breeds to a certain environmental condition. In this way, the concerns about animal welfare and environmental comfort are due to the climatic variables and the behavioral, physiological and productive responses are prevailing when implementing the suitability of certain production systems.

Palavras chave adicionais
Ambiência.
Parâmetros fisiológicos.

Efeito do estresse térmico sobre a produção de leite de caprinos das raças Alpina e Saanen no Brasil

RESUMO

O objetivo dessa revisão de literatura foi abordar os índices de conforto térmico sobre a produção de leite de caprinos das raças Alpina e Saanen no Brasil. O estresse calórico provocado pelas alterações meteorológicas às quais os animais são submetidos, tem influência nos mecanismos dos processos fisiológicos normais do organismo. Assim, pode-se citar o efeito sobre o processo da lactação nos caprinos, onde este diminui a quantidade de água no organismo com a consequente diminuição na síntese e ejeção de leite e interferindo na produção dos hormônios prolactina e hormônio do crescimento. A interação do animal com o ambiente deve ser considerada quando se busca o bem-estar na exploração pecuária, pois as diferentes respostas do animal às peculiaridades de cada região são determinantes no sucesso da adaptação animal. Assim, a correta identificação dos fatores que influenciam na vida produtiva do animal, tais como o estresse imposto pelas flutuações estacionais do meio-ambiente, permitem de manejo dos sistemas de produção, possibilitando dar-lhes sustentabilidade e viabilidade. A manutenção desses parâmetros em níveis normais é muito importante, a ponto de serem utilizados na avaliação da adaptabilidade climática das raças a uma determinada condição ambiental. Dessa forma, as preocupações sobre conforto ambiental e bem-estar animal, são cada vez conhecimento das variáveis climáticas e as respostas comportamentais, fisiológicas e produtivas são preponderantes na adequação do sistema de produção.

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INTRODUCTION

The goat production in Brazil stands out in the agricultural sector as an activity of great socio-economic importance in the northeastern region, gathering the greatest breeding of goats in the country. However, considering goats as animals well adapted to the semi-arid climate in the region needs reservations, espe-

cially if dedicated for milk production. In this case, the process of adaptation to environmental conditions and the extensive management of low quality races introduced in the region tend to sacrifice the potential of production.

So, for milk production in the region, the creators inserted specialized breeds standing out the Saanen and Alpine Brown. It is important to give special attention to these breeds in relation to their response to the environment, so that it doesn't incur in sacrifice of the production as a recurring way to suit the management and the local environment.

The animals of Saanen breed are best suited to confinement due to clear skin. Their origin is in Switzerland, in the Canton of Bern, in the Valley of Saanen which has largest distribution around the world compared to other caprine breeds. In Brazil, the average daily production of milk has varied from 2.5 kg to 4.9 kg for a lactation lasting from 260 to 305 days (Pereira, 2011).

The Alpine breeds is original from the Alps and are docile animals of medium and large size and well adapted to Brazil. Nowadays they represent the largest contingent of dairy herds in the country. Its average production of milk varies from 2, 5 kg/day in hot environment, characterized by high effective temperature and simulated sunlight (Mendes *et al*., 2009).

Even being adapted to the conditions of breeding in the region, the goats face adverse climate situation not favorable to production, especially in the hottest hours of the day during the dry season of the year (Viana *et al*., 2013). In some places the region the animals are exposed to conditions that go beyond the thermal comfort area, that for goats is from (20 to 30º) recommended by Baêta and Souza (1997). Therefore, this environment presents great potential to cause thermal stress, because the heat that can be absorbed from the environment, if added to the produced by metabolism, may be greater than the passively released to the environment and even resorting to thermo regulatory mechanisms.

Physiological changes may occur as a result of the effort made by the animal to guarantee comfort, which can be since a simple behavior change to the low immunity or fall of production. Therefore, when planning a production system for environment with this characteristics, it must be taken into consideration how the climatic environment associated with the conditions of health, nutritional management and accommodation conditions, form a set of factors that interfere in the productive performance of animals (Martello, 2006).

The main studies on thermal comfort of ruminants refer to environment conditions in regions of temperate climate. Thus, when the subject is production in tropical environment it is convenient to look for reference values obtained with animals in this environment, which for most authors consulted, the thermal comfort zone for goats varies between 25 to 30ºC.

The thermal stress caused by extreme levels of climate elements in tropical and or semi-arid regions, is one of the main factors limiting the efficiency of animal production in this environment. However, researches in bioclimatology field and animal genetic improvement, have pointed out, respectively, management options and potential response to selection of animals better adapted to the semi-arid climatic conditions. In that respect, the choice of the breed to be exploited in this environment shall not depend on only natural and physical characteristics of the environment, but also genetic characteristics and the degree of rusticity and adaptability of animals (Roberto *et al*., 2014).

Considering the great socio-economic importance of the production of goat milk in Brazil, researches must be developed in order to improve production in the country. The choice of the breed can be an important measurement used when facing extreme climatic conditions. So, the purpose of this review was to evaluate searching results with thermal comfort indices on production of goat milk in Brazil, with emphasis on Alpine and Saanen breeds.

THERMAL COMFORT ZONE

The thermal comfort zone for the animals is limited by the inferior minimum temperature, which is the ambient temperature below which the animal triggers thermo regulatory mechanisms in order to produce heat to balance the loss of heat to the cold environment, and the maximum temperature, which is the value above which the animal uses the active mechanisms for the thermoregulation in order to help the body heat dissipation into the environment (Sampaio *et al*., 2004). When the ambient temperature is out of these limits there is reduction in efficiency of gain and loss of heat, and the animal goes into stress by hypothermia or hyperthermia respectively (Souza *et al*., 2012).

An environment is considered comfortable for production animals when, as the heat is generated (Thermogenesis) by the animal's metabolism it is also eliminated (thermolysis) to the environment through passive process (Souza *et al*., 2012). When it does not occur there is accumulation of heat and the use of artifices that are able to maintain thermal equilibrium between the animal and the environment are needed (Pires and Campos 2009), so that high potential environment stressor causes a series of responses that are dependent on the ability of the animal thermoregulation, represented by the ability to adapt themselves.

The effect of thermal stress due to environmental factors acting on the body of the animals, causes a series of physiological reactions that are proportional to the potential stressor of the considered element of the environment and the ability of the organism to compensate deviations caused by this force. In both there is a very large number of factors acting, but to be dealed with efficiency, they must be reduced to a single variable that represents the combination of them. In this sense, the thermal comfort indices aggregating two or more climatic elements, have been used to quantify the potential stressor of environmental factors on animals (Neves *et al*., 2009), while the measurement of change in physiological parameters has been used to characterize the potential for animal response to stressor.

THE TEMPERATURE AND HUMIDITY INDEX (THI)

The Temperature and Humidity Index (THI) was set by Thom (1959) purposing to characterize the thermal comfort of the animals based on the temperature of the bulb thermometers (wet and dry) or the temperature of the dew point establishing a connection with the performance of the animals (Vitaliano *et al*., 2012; Viana *et al*., 2013) and determined from the following template:

$$THI = 0.8 \times AT + (RH\ (\%)/100) \times [(AT - 14.4) + 46.4]$$

Being that:

AT = air temperature in °C

RH = relative humidity in %.

The THI is very important for studies involving animal bioclimatology, considering that this is one of the most widely used climate indices to evaluate the thermal stress in animals (Passini *et al*., 2014).

For animals from temperate climate bred in countries with tropical climate, such as the Holsteins cattle, Ricci *et al*. (2013) indicate that values of THI above 76 indicate thermal stress. According to Dias *et al*. (2012), cattle reared in environments characterized with high solar radiation and with values of THI over 72, are found in stress conditions, especially the more productive cows.

In a study developed by Vitaliano *et al*. (2012) with Saanen goats bred in the Northeastern of Brazil, the average values of THI were up 79, indicating dangerous condition, that is, the animals are in heat stress, which can affect the production, considering that the animal will require the activation of thermo regulatory mechanisms to reduce the stress caused by heat.

According to Paula Mendes *et al.* (2014) when performing an bioclimatic zoning with Dorper sheep bred in the harsh of Pernambuco State, the THI values found varied from 68.5 to 73. According to the authors, environment conditions with values of THI around 72.8, can develop the activation of thermoregulatory mechanisms by sheep of this breed, such as respiratory rate recorded above the average rate for this breed.

With native goats from Moxotó and Canindé breeds, an important thermo regulatory mechanism that can be highlighted was the heart rate, in which THI values of 81,7 and air temperature of 31.6°c, the heartbeat presented by these animals were around 121 beats per 1 minute, values that represent state of thermal discomfort for goats (Lucena *et al*., 2013).

GLOBE TEMPERATURE AND HUMIDITY INDEX (GTHI)

The Globe Temperature and Humidity Index (GTHI) is a physical index used for characterization of thermal comfort rate for the most diverse animal species, by assigning a single variable. This index includes different elements of climate, such as: relative humidity, wind, precipitation intensity and thermal radiation (Santos *et al*., 2014). High values of this index indicate imbalance in thermo neutrality zone of animals, resulting in a situation of thermal discomfort (Nascimento *et al*., 2014). This fact can lead to a priori, changes in physiological parameters, heart rate and breathing, being these, major mechanisms of thermoregulation.

A number of authors consider this bioclimatic index as the most appropriate in the evaluation of thermal environmental comfort in situations in which the animals are exposed to direct sunlight in the tropics, because it combines the effects of solar radiation, dry and wet bulb temperatures and airspeed (Costa *et al*., 2013).

The Globe Temperature and Humidity Index (GTHI) is calculated based on the following model (Kodaira *et al*., 2015) proposed by Buffington *et al*. (1981):

GLOBE TEMPERATURE AND HUMIDITY INDEX (GTHI)

$$GTHI = Tbg + 0.36^{*}\ Tdp\text{-}330$$

Being:

TBG = thermometer temperature of black globe (°C);

TDP = temperature of the dew point (°C);

330 = constant.

According to Dias *et al*. (2015) to evaluate physiological parameters in sheep of Morada Nova breed in the South of Piauí, it was found medium values of GTHI from 74.52 and 79.27. Based on these values, the authors were able to conclude that the sheep of this breed were in an environment of thermal discomfort, where this presented a thermal condition beyond the recommended for the species, compromising the performance of the animals.

In work developed by Alves *et al*. (2014) with goats from Anglo-Nubian breed in the State of Paraíba, the average GTHI (79.37) proved to be below the value established as indicative of low stress in animals of goat species, that is 83.00, showing that animals were not in thermal stress during the study, which denotes the desirable adaptability in semi-arid regions.

CHANGE OF PHYSIOLOGICAL PARAMETERS IN RESPONSE TO THERMAL STRESS

The change in behavior of animals such as shelter from direct sunlight looking for shade, look for water slides, decrease food intake and increase the intake of water, all these are signs of thermo stress sensation caused by heat, while the increase in heart rate, peripheral circulation, respiratory frequency and sweating are clinical signs (Rodrigues, 2013).

The action of hormones regulates the main functions of the animals' body, being these sensitive to body temperature increase. For this reason the rectal temperature has been the most used physiological variable in bioclimatology studies to determine the degree of adaptability of the animals and for the evaluation of warm-blooded by keeping a great relation with the body temperature, therefore, a good indicative of the animal's body temperature maintenance within the normal range for vital activities. In goats the normal rectal temperature can vary from 39.7°C to 38.5°C,

with factors capable of causing some kind of change in body temperature, for example, station of the year (hot or cold) and period of the day (Pereira, 2011).

The criteria of tolerance and adaptation of animals are determined primarily through the respiratory rate and body temperature. Another parameter that is used in the maintenance of body temperature on evaluation of heat dissipation in animals is the superficial temperature (Souza *et al*, 2008). Its applicability is justified, as in condition of thermo stress, the transfer of heat from the nucleus to the skin can be increased by means of dilation of arterioles of cutaneous vascular beds and through the opening of arteriovenous anastomoses of the limbs, ears and muzzle lets it increase peripheral blood flow by facilitating heat loss to the environment from the skin (Cunninghan, 2008).

In studies related to maintenance strategies of body temperature within the normal range of the species, the physiological parameters such as heart rate, respiratory rate, rectal temperature and superficial temperature of the skin, which are very sensitive to room temperature influence, are the most used and cited parameters in research of thermoregulation in small ruminants.

In general, during the day in the afternoon the air temperature is generally higher when compared with the period in the morning, generating enough temperature gradient to promote increase of physiological variables (Silva *et al.*, 2010). In animals that are usually active during the day, there's a rectal temperature variation that is minimal in the morning and maximum in the afternoon, as a result of this activity and adds to the effect of the thermal gradient between the environment and the animal's body (Medeiros *et al.*, 2007).

The first response of the animal to thermo stress effect is the change of respiratory rate as a way to lose heat to the environment. However, the efficiency of this strategy is limited if the humidity of the air is high. Thus, the elevation of the respiratory rate is useful to animals as a way to keep the body temperature within the zone of thermal comfort, through the pulmonary evapotranspiration (Martins Júnior *et al.*, 2007). However, the accelerated and continuous respiratory movements can interfere directly on food intake and rumination, as well as add heat from muscle activity and divert energy that could be used in other metabolic and productive processes (Souza *et al*., 2005).

Other physiological parameter used in studies of thermoregulation in animals is the heart rate. It is influenced by the species, breed, age, physical exertion and air temperature (Kolb, 1987), reason why it has less importance than the rectal temperature and respiratory rate to characterize the animal's response to thermal stress. In this regard, Medeiros *et al*. (2007) analyzing the effect of age and color of coat on the physiological characteristics of goats without a established racial pattern, kept in the shade, it was verified the effect of the turns on heart rate, being higher during the afternoon.

According to Al-Tamimi (2007), the increase in heart rate can be attributed to two potential causes: First, due to increased muscular activity to control the simultaneous increase of respiratory rate; Second, because there is a reduction in peripheral vascular resistance which promotes higher blood perfusion to dissipate heat through the skin.

LACTATION CURVES IN GOATS

Goat milk production in Brazil is increasing, however, it isn't always that such increase is accompanied by improvement in productivity of the animals. Thus, the study of lactation curve to use it in selection processes aims to improve productivity. The lactation curve can be defined as the graphic representation of the milk production during lactation and their study contributes to a better understanding of the production system, assisting the producer in the production of milk at a certain stage of lactation and also in making decisions about the disposition or management of animals (Melo *et al*., 2011).

In many researches on milk production it was used statistical models to describe lactation curves, being a practical and consistent way to obtain information about the peak of production and persistency of lactation (Menezes *et al*., 2010). According to Guimarães *et al*. (2006), the most widely model used for estimation of lactation curves is the incomplete gamma function, proposed by Wood (1967), which has provided good adjustment to lactation curves. In addition, simple models such as Wood (1967) have the advantage of presenting a biological interpretation of its parameters.

According to Jacopini *et al*. (2011) the importance of lactation curve lies in the wide characterization of animal production throughout lactation, being identified: ascension time to peak, peak of production, time of fall (production or persistence of lactation), lactation duration, duration of the dry period, length of gestation, as sudden drops in production, response to diets and management, among other factors. According to McManus (2003), by means of the lactation curve it is possible to follow the evolution of milk production of animals, knowing its variations along a lactation, estimating their partial or total milk production.

The persistence of peak of lactation of the animal is the maximum capacity of the milk production that be one of the main components, defined as the ability of the peak of milk production until it reaches the maximum production during lactation. Silva (2008) defined persistence as the speed of decline in daily production, between consecutive months and that the persistence is what defines how lactation curve of the female in question will be. The persistence of animals during lactation can be characterized as the ability of the female to keep its milk production after reaching its maximum production during lactation for a longer period of time, so the persistence has direct relation with economic aspects of the dairy activity (Jacopini *et al*., 2011).

EFFECT OF ENVIRONMENT ON MILK PRODUCTION IN GOATS

The goats are considered rustic, but when exposed in hot regions with high temperatures, humidity of air and radiation, they show changes in physiological be-

havior such as increase of skin temperature, elevation of the rectal temperature, increase of respiratory rate, decrease of food intake and reducing on the level of production (Pereira *et al*., 2011).

According to Camerini (2008), the thermal stress is reflected in the reduction of immunity, the occurence of diseases, high mortality rate, decrease of the productivity, reduction of the quality of meat and derivatives, occasioning damage to producer.

The caloric stress leads to decrease in the production of meat and milk, reproductive disorders and eating disorders (Viana *et al*., 2013). These processes take place because of the effects of air temperature, relative humidity of the air, solar radiation, wind and intensity/duration of stressor agent (Pereira, 2011).

The Saanen goats in the Paraibano Semi-arid in Brazil showed significant elevation of respiratory frequency in response to stress caused by environmental factors, without, however, interference in the control of body temperature of the animals (Pereira *et al*., 2009). Saanen goats bred in the State of Ceará in confinement and at the shade were influenced by the effects of climate, showing change in respiratory rate (Souza *et al*, 2009).

One of the main products being exploited in bred of female goats is milk. There are many environmental factors that can interfere in the production of the goat milk such as genetics, lactation stage, physiology, climate and nutrition elements. Environmental factors interfere in productivity significantly, strengthening its influence according to the use of genetically improved animals (Martello, 2006).

In order to be successful in the dairy activity it is necessary some requirements in the production system, such as the use of specialized animals, nutritional, reproductive management and, especially, the provision of adequate conditions of thermal comfort. When the animals are subjected to thermal stress they show reduction in food intake, increase of water intake and reduction of milk production (Costa *et al*., 2009).

According to Baccari Júnior *et al.* (1996) when Saanen goats are subjected to 32.5° C temperatures in bioclimatic chamber they reduce dry matter intake and increase daily consumption of water, but they keep milk production similar to the group in thermal comfort. Juaréz (1986) in a study with goats of Saanen, Anglo-Nubian and Alpine breeds in tropical climate, revealed that in addition to low production, some components of milk such as fat and total solids were less than when the same breeds were bred in temperate climates, due to inadequate diet and high air temperatures.

The goat dairy herd may have low production due to the adverse weather conditions of the Semi-arid (Souza *et al*., 2011). Darcan and Guney (2008) show that milk production was higher in 21% in the group of sprayed and ventilated goats, when compared with the control group without spraying or ventilation. The climate is the component that has more effect on animal welfare and also on the productivity being this a limiting factor on animal exploitation to economic purposes (Souza *et al.*, 2012).

PRODUCTION SYSTEMS OF DAIRY GOAT

Goat's milk production in the world presents a strong individual variation associated to production systems. The dairy goat production has been developing in Brazil and it has shown to be a greater investment, due to the initiative of great breeders with better business vision (Souza *et al*., 2012). The production and quality of goat's milk are directly related to the type and quality of the diet that are provided to the animals, the breed, the period and duration of lactation, climatic variations and the combined action of these factors, in environmental conditions of each country or region (Zambom *et al*., 2005).

According to studies by Dal Monte *et al*. (2010), the production systems differ from the technologies adopted and the specialization of production aiming to be included in the market, which leads to a greater productivity of the animals. The production and composition of milk varies according to the diet provided to animals, which depends on the production system used - pasture or with predominance of concentrated food or harvested to be distributed in the trough, in case of housed animals (Goetsch *et al*., 2011).

In another survey conducted with goats of breeds Saanen, Anglo-Nubian and Alpine, it occurred less milk production and lower concentration of some of its components such as fat and total solids in milk of goats bred in tropical climate, compared to those animals bred in temperate climates, due to the high air temperature and inadequate diet (Juaréz, 1986). In environments with high temperature, when the thermo genesis is greater than the thermolysis, all sources that generate heat are inhibited, especially food intake and metabolism (Souza *et al.*, 2008).

In this sense, a viable alternative to a better milk production in Brazil is the introduction of goats from Saanen and Alpine breeds for its exceptional technical and economic results, besides to the excellent adaptability to the tropical climate. The Saanen breed are animals more adapted to confinement due to clear skin. They have its origin in Switzerland, in the Canton of Bern, in the Valley of Saanen with greater distribution around the world compared to another goat breed. In Brazil, the average daily production of milk has varied from 2.5 kg to 4.9 kg for a lactation lasting 260 to 305 days (Pereira, 2008).

The Alpine breed is native from the Alps and they are docile animals of medium and large size and well adapted to Brazil and nowadays they represent the largest contingent of dairy herds in the country. Its average production of milk is 2.5 kg/day in hot environment, characterized by high effective temperature and simulated sunlight, they suffered thermal stress, reduced food intake, increased water consumption, lost weight, showed a significant decline in the production of milk and its components (Brasil *et al*., 2000).

CONCLUSIONS

Under thermal stress many physiological changes occur in goats, resulting in reproductive and produc-

tive losses in the herd. Thus, it's necessary to adopt technologies and management strategies to promote the exploitation of animals with comfort, in order to ensure product quality.

Appropriate management techniques must be prioritized besides productivity and animal welfare.

Due to have an increase in the production chain of goat's milk in Brazil, it is necessary to understand the behavior of animals in their function, what can be done through lactation curve analysis of the animals by selecting the best ones.

Thus, those who spend longer time on lactation curve have a higher milk production and greater economic interest.

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