Heat Stress and Goat Welfare

Subjects: Others

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Among the farm animals, goats arguably are considered the best-suited animals to survive in tropical climates. Heat stress was found to negatively influence growth, milk and meat production and compromised the immune response, thereby significantly reducing goats' welfare under extensive conditions and transportation. Although considered extremely adapted to tropical climates, their production can be compromised to cope with heat stress. Therefore, information on goat adaptation and production performance during heat exposure could help assess their welfare.

climate breeding genetics goat heat stress housing transportation welfare

1. Introduction

Livestock production is considered the most widely adopted agriculture practice by marginal and subsistence farmers, particularly in the developing part of the world [1]. However, sustaining livestock production has become a challenging task in the changing climate scenario [2]. Beyond the direct consequences, climate change disrupts animal agriculture by reducing both pasture and water availability as well as by increasing the frequency of sudden disease outbreaks [3]. The reduction in pasture availability and shrinking grazing lands has caused a marked reduction in livestock production in recent years. Therefore, these unavoidable adverse effects have focused research efforts towards identifying the most climate-resilient animals across different livestock species.

With the increasing concern in securing the global economic viability, recent research efforts have ascertained goats as the ideal climate animal model due to their better thermo-tolerance [4], drought tolerance [5], ability to survive on limited pastures [6] as well as their disease resistance capacity [7]. In the context of indirect effects of changing climate pertaining to feed and fodder availability, rearing goats is considered more economical than large ruminants.

In terms of numbers, geographic distribution and socioeconomic importance, goats are among the most critical global livestock species [8]. Together with sheep, they were the first ruminants to be domesticated around 11,000 years ago in the fertile crescent. They were subsequently dispersed across the globe, adapting themselves to diverse biophysical and production environments. Over the years of evolution, human intervention or artificial selection for production, reproduction and physical traits derived breeds of goats of temperate regions, which have been utilized in the specialized production systems in Mediterranean countries of Europe. To produce milk, natural selection was the most prominent factor for the evolution of goats dispersed in dryland regions [9]. In contrast with the phenotypic uniformity of temperate breeds, the goat population living under harsh environments has broad diversity traits and a lack of genetic structure, which provides evidence for high plasticity capacity that facilitates their productivity across a wide range of environmental conditions [10].

In seasonal biotopes of arid and semi-arid regions over the world, climate change increased prolonged drought events, and erratic weather has limited the production of large ruminants, such as cattle and buffalos, as opposed to the progressive increase in the rearing of goats [8]. Under such conditions, herders perceive goats as a more resilient animal to cope with multiple stressors, such as heat load, water and feed scarcity, with better skills to cope with bush compared to sheep and cattle [11]. There are many scientific pieces of evidence clarifying the particular traits of goats that help them to cope with environmental challenges in different types of ecosystems, which mostly include: first, the small body size of goats, which allows them to escape more efficiently from the high radiant heat load by using thermally buffered microclimates, as well as, a lower absolute requirement for energy, water, and home range [12][13]. Second, the unique capacity for employing behavioral plasticity and goats' morphological features imparts them the clear advantage over sheep and cattle to cope with seasonal biotopes with a lack of both feed and water [14][15]. Lastly, when facing low-quality feed, they also are superior to cattle and sheep in their ability to digest dry matter and recycle nitrogen [16]. These physiological, behavioral and morphological advantages in goats make them suitable species to survive in diversified geomorphological conditions.

Although there is sufficient information available to conclude that goats are the more climate-resilient species [4], still their production is not devoid of adverse impacts of climate. There are enough pieces of evidence for the reduced production, reproduction, health variables and energy efficiency due to heat stress in goats [17][18]. However, studies assessing the resilient capacities of different species have delineated goats to have a minimum deviation from their optimum performance efficiency [4][6]. Thus, the promotion of goat production can be considered an important step towards sustainable livestock production in the changing climate scenario.

2. Goat as the Future Animal from Food Security Perspectives

Sustaining livestock production under a challenging climate has necessitated the need for identifying an ideal species to cater to the needs of the growing human population. Several studies have identified goats as the go-to species to sustain animal agriculture under changing environmental conditions [19][20][21]. Pioneers in livestock research had identified the potential of goats over other small ruminants to adapt to a wide range of environmental conditions [22]. Goats are opportunistic feeders, and thus the depletion of pasture lands may hardly impose an impact on their dietary requirements. Moreover, the selective feeding behavior of goats help them consume even the poor quality forages, converting the nutrients obtained into high-quality products [23][24]. In addition, goats exhibit a bipedal stance, which helps them access tree leaves, which is considered advantageous to other livestock species [22]. Further, goats have a better feed efficiency than other ruminant species. In addition, goats do not require specialized shelter structures, and they could ideally survive in any location with minimum protection from the weather [22][25]. Additionally, labor availability is another crucial factor for livestock production, but which is considered less of a big constraint in goat production since much of the labor could be done by family members. Indeed, Rokonuzzaman and Islam [26] revealed that 20 to 48% of women were involved in goat rearing.

The world's population is expected to touch an alarming count of 9.6 billion by 2050. From the food security perspective, animal proteins are considered vital to meet the growing demands of the human population, especially in the developing world. Goats are projected as the ideal climate-adapted animals and are expected to perform better than other species. This projects their pivotal role in meeting the growing humanitarian needs for animal protein by the end of this century. Further, goats are also expected to perform better than other livestock species, particularly given the climate change-associated feed and fodder shortage. Therefore, researchers and policymakers should set priorities in designing appropriate programs to meet the growing human population's food demands by 2050.

In the context of the anticipated increase in the human population, goats play a vital role in catering to future generations' nutritional demands through the production of milk and meat [27]. As per the model prepared by Ngambi et al. [28], dairy goats produce approximately 15.2 million tons of milk, comprising 2% of total milk production from the livestock sector. Moreover, goat meat and milk demand have been rising exponentially above other livestock species for their health benefits and therapeutic values [29]. In harmony with this, recent reports suggest that goat enterprises have turned out to be of more commercial value as a result of the marketing preference of goat products all over the world [25]. With their unique ability to convert unconventional feedstuff to high-quality animal products, goats play a crucial role in eradicating poverty during disaster aversion [30]. Thus, having the potential scope to ensure food security serves as an important source of income for poor and marginal farmers around the world.

3. Heat Stress and Goat Production

Although goats are considered well adapted to the tropical climate, their adaptive responses significantly hamper their production [2]. Some studies established the impact of elevated ambient temperature on growth [20], milk production [31], meat production [19][32] and immune responses [33] in goats. These authors observed a reduction of 12%, 3–10%, and 4% for growth, milk and meat production, respectively. Goats start experiencing heat when they were exposed to 38 °C and above with the THI of above 75 [2]. Once the goats are exposed to this high temperature, they activate their physiological adaptability in terms of alterations in behavior, physiological responses, blood biochemical and endocrinological responses to regulate their body temperature to maintain homeothermy [21]. These adaptive processes are of energy demanding, and the animals channelize their energy from the productive pathways towards the adaptive pathway from the productive [2][21]. Such behavior of reducing the production to support the life-sustaining activities is the typical characteristic of adapted goat breeds.

The adverse impact of heat stress on growth performance can be attributed to the reduction in feed intake, digestibility and utilization efficiency [34][35]. Though goats have the capacity for adaptation to convert poor quality feeds to products in rangelands, still, if the heat stress prolongs for a longer duration, it can affect their growth performance. Further, Pragna et al. [20] established the severity of heat stress on different growth variables in three indigenous Southern Indian goat breeds. These authors observed a reduction of 11.0%, 8.0% and 6.0% of growth for Osmanabadi, Malabari and Salem Black breeds, respectively. Further, heat stress reduces the daily weight gain that subsequently influences their allometric measurements [36]. This reduction in heat-stress-associated growth variables could be due to the outcome of activation of hypothalamus–pituitary–adrenal axis (HPA) in response to heat stress. The activation of the HPA axis during heat stress directly influences the release of GH, negatively influences growth [35]. However, breed variations were observed for these mechanisms of HPA-axis-oriented heat stress impact on growth [20][36].

Besides being a threat to growth, heat stress acts as an aberrant effect on meat production and the goat's carcass characteristics. Hashem et al. [32] conducted a study to illustrate the effects of heat stress on Black Bengal goats. They reported a reduction in preferred meat quality characteristics, such as pH, cooking loss, water holding capacity, shear force and color. Further, Archana et al. [19] attributed the increased meat pH in heat-stressed goats to glycogen depletion. Apart from the increase in pH, Archana et al. [19] also noted an increased shear force in the meat of heat-stressed Osmanabadi goats, which significantly hampered the tenderness and juiciness. Further, these authors suggested heat stress also reduces the plasticity of muscle fibers, which in turn could contribute, together with ultimate pH, to the alteration in the quality of goat meat. These authors attributed the negative influence of heat stress on meat quantity and quality to depleted energy reserves in the animals as a result of partitioning energy towards life-sustaining activities during the adaptation process, especially when the heat stress is prolonged for a chronic period [19][32].

Several studies were conducted to establish the influence of heat stress on milk production [31][37], where it was ascertained that milk production was reduced considerably in response to reduced feed intake during heat stress exposure in goats. The lactation curve developed by Wood [38] can be used as an indicator to draw a better understanding of the seasonal influence on milk production in dairy goats. In general, the lactation curve of goats, irrespective of breed, invariably declines during hot summer months [39][40][41]. In addition, keeping milk production a major concern, extensive experiments were conducted to determine the effect of heat stress on milk quality and reported a reduction in milk fat, protein, lactose and total solids content, thereby reducing the ultimate milk quality [37][40]. Such an effect could be due to insufficient energy levels as in heat-stressed animals predominantly, the energy is deviated to maintain life-sustaining activities. However, the effect of such impacts varied accordingly with the genetic potential, lactation stage and nutritional availability of goats during their exposure to heat stress [37][41].

Apart from their effects on production traits, heat stress also influences the goats' immune responses. Sophia et al. [42] noted that innate immune response, which was considered the first line of defense, was compromised in goats after exposure to heat stress. However, various reports show the inefficiency of goats' primary innate immunity in response to heat stress [43][44]. With the decline in immunoglobulin release, the adaptive immune system becomes impaired, leading to likely parasitic infestation [45]. In agreement with this, Hirakawa et al. [46] noted that extreme temperatures resulted in a limited synthesis of lymphocytes along with suppression in phagocytic activities of leukocytes in goats. In addition, Yadav et al. [47] reported that heat stress depressed the production of antibodies in goats, particularly the production of IgM and IgG. The TLR2, TLR8, IL10, IL18, TNFα, and IFNβ are considered important inflammatory markers for quantifying the impact of heat stress on the immune system in goats [43].

Taken together, it is apparent that the goat compromises their production to cope with adverse environmental conditions and thus threatens the economy of poor and marginal farmers whose primary livelihood depends on goat rearing. Therefore, it is necessary to focus on implementing welfare measures to sustain goat production during heat stress exposure.

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