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# Role of housing in welfare of small ruminants

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Scientific research on factors causing the reduction in welfare of sheep and goats is rather recent and information on this topic is still scarce. Sheep and Goats, considered very rustic animals, are reared prevalently under extensive production systems and are widespread mainly in marginal areas. For these reasons, only few studies on the welfare of these species have been carried out in the past. Climatic extremes and seasonal fluctuations in herbage amount and quality are important causes of the reduction of well-being in extensive production systems, which can impair production efficiency of grazing animals and dramatically affect the welfare and health status of sheep and goats. More recently, the scenario has changed, due to a gradual diffusion of intensive and semi-intensive production systems, especially in sheep and goats to the growing concern of consumers. Research addressing animal welfare is largely focused on measurements of animal behavior, stress physiology, veterinary epidemiology, environmental physiology, environmental design, comparative psychology and studies of the behavior of animal handlers, together with conventional fields such as nutrition and microbiology[16, 17, 29].

India is a tropical country with hot and humid summer and relatively less stressful winter season. A provision of suitable housing design/system is perhaps the most effective way of protecting goats from adverse weather conditions. Space allowance and structures of sheep and goat houses are described as the main potential sources of discomfort for housed flocks, together with inadequate control of micro-environment, inappropriate milking procedures and human-animal interactions. Recently scientists have studied the impact of high ambient temperature, different ventilation regimes, high stocking densities, reduced air space and poor litter management on behaviour, immune and endocrine response on performance of sheep and goats.

The basic pre requisites for planning a goat shed structure, that animals should feel comfortable, adequate ventilation but not draftily and protect from adverse climate, provide plenty of fresh air and control parasitic infections which maintain desirable working conditions for labour, supervisory staff, feeding, watering, cleaning, handling and manure removal system. The main climatic factors from which protection is needed are high and low ambient temperatures, humidity, solar radiation, wind and rainfall. An ideal housing enables in moderating the range of microclimate to which the goats are exposed because goats do suffer from thermal stress and high humidity or extreme cold condition. In wet or unhygienic conditions goats are likely to suffer from stress, parasites and diseases while in very hot conditions with improper shelter, the goats will loss lot of water from their body which results in to stress. Hence, a suitable and economically viable housing system needs to be developed for goats for their efficient growth and production[10, 25, 34]. The comfort zone for dairy goats ranges between 55 to 70$^{o}$F.

In housing management, particularly floor is an important aspect for small ruminant, which provides both comfort and cleanliness with minimal risk of injury which ultimately gives better health cover, improves their growth rate and productivity because floor types have negative consequences on the welfare and production of animals. Therefore, ideal floor should be hygienic, dry, resilient, reasonably temperature resistant and comfortable to animals[14].

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## FLOOR TYPE PREFERENCE

Unfortunately, scientific data on floor preference in goats is meager. The floor with low thermal conductivity, softness, cleanliness and slipperiness will affect both animal preferences and thermoregulatory behavior both under cold and warm climatic conditions[47]. Goats in natural environments are often resting directly on the rocks in steep cliff areas[63] which indicates no preference for soft bedding. Goats can be kept relatively clean without any bedding materials at a low space allowance and with a minimum of work input on slatted floor. The different types of floors do not have the same degree of absorption[49] hence goats are less comfortable to lie or rest on wet and dirty floor[33, 66]. The straw bedding significantly reduces the lower critical temperature compared to bare concrete[18, 19].

## BODY WEIGHT, FEED AND NUTRIENT AND WATER INTAKE

The body weight, feed and nutrients and water intake under different housing system as an indicator of good health, general adaptability and feed conversion efficiency of animals can be taken as a tool of comparison[2]. Considering the information on goat's feeding behavior and performance under different housing system in complete confinement is meager[10, 25]. Madras red lambs[67, 72], Romanov lambs[36] and crossbred kids[11] reared on slatted floor gained significantly ($P < 0.05$) higher body weight then those under mud floor which is strongly supported by higher DM and CP intake (kg/day) on slatted wooden floor with thatched roof (0.75 and 0.13) followed by Kachcha floor with thatched roof (0.74 and 0.12) and concrete floor with concrete roof (0.71 and 0.12). Which is again supported by other workers[3,4] who reported significantly higher ($P < 0.05$) DMI (g/kg $W^{0.75}$) in goats kept on slatted wooden floor and thatched roof shed (96.17) in comparison with concrete floor and concrete roof shed (91.79). This is basically due to the better microenvironment and better hygienic conditions in the slatted floor where as daily body weight gain of Tellichery goats and Mecheri sheep reared in slatted floor was similar to those reared on the conventional mud floor[37, 68, 69]. Similarly, higher weaning weight in Osmanabadi kids on net roof and kachcha floor (13.07 kg) as compared to asbestos roof and slatted floor (12.17 kg) due to higher feed intake was also observed[39]. The Saanen kids grew significantly ($P < 0.01$) low (33.50kg) under house constructed from wood and polythene sheets, with cement floor[56] than under house made of wood and cement-fibre sheets with a packed-earth floor and open permanently on the south facing side (35.26kg). Similarly, kids grew at the lowest rate when kept without shelter in comparison to those kept in pucca house and thatched roof shelter[52, 53]. The average daily gain for Charollais and Suffolk crossbred lambs were 0.13 and 0.16 kg/day on straw bedding and 0.03 and 0.23 kg/day on woodchip. Daily feed intakes for Charollais and Suffolk crossbred lambs were 1042 and 1094g on straw bedding and 833 and 1145g on woodchip[71]. However, some of the researchers reported non-significant effect of housing system on body of sheep and goats[8, 25].

## PHYSIOLOGICAL RESPONSES

While deciding housing for different breeds of sheep (both crossbred and native) parameters like physiological responses, energy expenditure, health conditions and economic aspects should be taken into consideration. The physiological responses like respiration rate, pulse rate and body temperature of animal are influenced by microclimate within the animal sheds as well as by type of housing with different floor types. The body temperature, pulse rate and respiratory rate increases by heat stress[43] and that lead to marked reduction in feed intake, redistribution in blood flow, depression in the immune system and alteration in endocrine functions that ultimately affect the productive and reproductive performance of the goats[7]. The increase of body temperature in heat stressed goat is associated with significant depression in Thyroid gland activity resulting in a lowering serum concentration of thyroid hormones[64]. The significant activation of adrenal gland activity results in increasing the concentration of blood Cortisol level[46]. Therefore, these hormones are commonly used as indicators for physiological stress. There are very limited data dealing with

the effect of floor and heat stress challenge on the thermoregulatory system of goat.

The floors of low thermal resistance were suitable for hot climatic conditions to keep the animals cool[9]. It is therefore, very much desirable that animals should be provided the environment suitable for optimal biological activity for efficient production. The morning rectal temperature of Beetal goats was significantly ($P < 0.01$) affected by the housing systems, whereas, respiration and pulse rate (morning and evening) were not changed significantly ($P < 0.05$) [34]. Similarly, the rectal temperature and respiration rate of Egyptian lambs[8] and Ossimi sheep[44] were significantly lower ($P < 0.01$) in shaded housing system than unshaded ones. The rectal temperature and respiration rate under open and shed in both seasons (summer and winter) increased significantly ($p < 0.05$) at evening as compared to morning. The diurnal variation of rectal temperature, respiration rate and heart rate were significantly ($p < 0.05$) higher under open environment as compared to under shed, irrespective of season[51]. The physiological parameter positively correlated with ambient temperature and also with THI[12, 30].

The physiological parameters (PR, RR, RT) of Nigerian dwarf goats[48], Ramnad white sheep and Malabari crossbred goats[31] were increased when housed simple shelters made of rough concrete flooring covered with wood shavings and under conventional type shed. Similarly, respiration rate of sheep was significantly ($P < 0.05$) differed at morning and evening in all the seasons in a semi arid region of India under shed and open housing system. However, rectal temperature was similar during morning as well as evening in all the seasons[12,] where as the physiological responses (RT, RR, PR) of Tellicherry goats[37,69] and Mecheri sheep[37] were at par when reared on slatted floor and conventional mud floor and similarly Osmanabadi weaned kids[54] and cross bred goats[3] showed at par results of rectal temperature on Murom, mud, concrete and slatted floors, under different roofs (tin, thatch and concrete roof) and ventilator (one or two) but pulse and respiration rate differed significantly ($P < 0.05$) during both summer and winter season.

## BEHAVIOR AND DAILY ACTIVITIES

Behavior is considered as “first line of defense” of animals and early indicators of the welfare in response to environmental change in relation to different types of housing and management. Behavioral observation can give information on animal’s preference, requirements and internal states[27]. The social behavior of goat is quite different from sheep. In general, goats are more reactive than sheep, because they are more aggressive and they exhibit more exploratory behaviors, whereas sheep are more fearful and shy[35]. The behaviors and daily activities pattern are influenced by the Floor type, Stocking density, air space allowance and ventilation. Factor of welfare reduction in housed sheep and goats, confined rearing is usually characterized by high stocking density and prolonged faeces accumulation in sheep and goat houses. Therefore, adequate space allowance, careful litter management and scrupulous monitoring of the micro-climatic factors (interms of temperature, relative humidity and air quality) are crucial aspects in sheep and goat housing. In any case, it is fundamental to understand that maintenance of good hygienic conditions, associated with correct dimensioning of structural parameters and adoption of proper management practices, is important in either type of system. Unfortunately, sheep and goats often have shelters that are not appropriate, in terms of design, materials and size.

## FLOOR TYPE, STOCKING DENSITY, AIR SPACE ALLOWANCE AND VENTILATION

### Floor type

Most of the behavioral studies were carried out under grazing condition; hence the effect of floor on the behavior has not been studied much. The housing environment facilitates normal behavior, avoid stress and let animals arrive at a high age with high and stable performance[15]. The animals kept in free stalls and loose house spent more time on feeding as compared to those confined in barns individually[70]. The total time spent for feeding of alfalfa hay in young and mature Baladi goats were 44 and 41% of the 12 hr. day time respectively in a half-shaded stall during summer conditions in Egypt[1].

The feeding activities of Comisana ewes[20] were not affected by housing (26.9 vs. 21.7%) in indoor and outdoor group, respectively which indicated that ewe's welfare and productivity were not substantially affected by the housing system. Similarly, it was also reported that feeding environment (open and covered) did not have significant effect on time spent for intake of roughages in adult barbari goats[55] where as it was also observed that housing system (tethered in wooden stalls) had significant ($P < 0.01$) effect on feeding behaviour of Girgentana goats which leads better well being and higher milk yield[25]. The Sirohi goat lying mostly on slatted wooden floor (60.44 min) followed by slatted plastic (54.31 min) and brick floor (26.56 min). The higher thermal resistance of wooden floor rendered maximum comfort to goat[23]. Ewes showed no significant preference for a specific flooring material and after feeding the animal preferred to lie down on wooden floor to expanded metal floor, straw to wooden floor, and also straw to expanded metal floor. However, single housed, unsheared ewes preferred wooden floor to rubber mats ($P < 0.05$) and tended to prefer expanded metal floor to straw. After shearing, the ewe's preferred wooden floor to expanded metal ($P < 0.05$), straw to wooden floor ($P < 0.05$), and straw to expanded metal floor ($P < 0.0001$). There were no significant preferences between rubber mats and wooden floor. Mean lying time (%) was 64.7% (unsheared ewes) and 43% (sheared). The significant differences ($P < 0.05$) in pre-shearing versus post-shearing lying times existed when the ewes were housed in pens with no straw. It was observed that floor had no effect on standing or lying behavior of Boutsiko Ewe[28]. Similarly, it did result in more sheep choosing to lying on lateral recumbent on rammed soil in an attempt to reduce heat losses to ground due to conduction either standing or lying increased toward sunrise and sunset, respectively[49]. Surprisingly, straw was not perceived as an attractive flooring material in any of the temperate periods[13]. However, expanded metal was preferred to solid wood (moderate temperate climate) and mattress and solid wood (cold climate). There were no significant effects of bedding material on lying (0.69), standing (0.15), eating hay (0.07) or eating concentrates (0.06) times. Lambs used woodchip as a bedding material when lying or standing almost twice as often as straw ($P < 0.001$) but showed no preference between bedding types when eating hay or concentrate[71]. Goats spent less time in the outdoor yard during ($P < 0.0001$) when the air temperature dropped or snow fall. However, total lying time and time spent feeding were not affected by weather conditions. Lying time in the outdoor yard was reduced as the air temperature decreased ($P < 0.001$) and time spent standing/ walking inside increased ($P < 0.001$). Irrespective of weather conditions, the goats spent significantly ($P < 0.05$) more time in the outdoor yard in pens when the outdoor yards were covered with a roof ($P < 0.01$), but time spent for lying was not affected by roof cover or feed location. They concluded that even if the outdoor yard was less used at decreasing temperatures, the time spent lying and feeding was not affected by inclement weather. Similarly, total feeding time of Malpura lambs was 22.4% higher in thermocol-insulated clod protected shed, where as drinking time was higher in control groups. Standing time was significantly higher ($P < 0.05$) in bamboo dome lambs, where as lying time was higher in control groups[24].

**Stocking density and air space allowance**

The floor shows significant changes in social behavior of small ruminants which affects performance. Available floor space allowance may affect the feeding, lying, and standing behavior of animals[21]. Inadequate space availability may develop abnormal behaviors that injure the animal itself or other animals in the social group[45]. The environmental enrichment may reduce the frequency or severity of undesirable or abnormal behaviors or even prevent them from developing. Understanding the behavior patterns of goats can lead to more effective housing systems.

A minimum space allowance of 0.7 $m^2$/head (straw litter) and 1 $m^2$/head (slatted floor) for sheep weighing not more than 60 kg was also suggested[42]. Space allowance should be increased by about 30% for sheep weighing from 60 to 90 kg and a further 30% during suckling of lambs. Space allowance can be reduced by 10% for recently

sheared sheep and increased by 17% for horned ones[26]. Slightly higher values, i.e. 0.9-1.2 $m^2$/head on straw litter and 0.8–1$m^2$/head on slatted floor has also been reported[22]. This author also suggested assigning a 2 $m^2$ paddock area per sheep. The effects of stocking density on air quality and on health and production have been investigated in lactating ewes. A significant ($P<0.05$) decrease in air concentrations of total micro-organisms and coliforms in a room containing sheep kept in an area of 2 $m^2$/head compared to rooms where sheep had 1.5 or 1 $m^2$/head was also reported[60]. In addition, the ewes housed in the least crowded room showed a significant increase in milk yield and milk protein, casein and fat yield, which determined an overall improvement of milk coagulating properties. The milk from the ewes stocked at 2 $m^2$/head had 3 to 4 times lower SCC and significantly lower concentrations of mesophilic, psychrotrophs, and coli form bacteria, compared to milk from ewes stocked at 1.5 and 1 $m^2$/head. Cases of sub-clinical mastitis were absent in the least crowded group, whereas they appeared earlier and in a growing number of animals as space allowance decreased to 1.5 and 1 $m^2$/head. Space allowance reduction from 2 to 1$m^2$/head showed interesting effects on feeding behaviour in goats. A relevant reduction of feeding activity (-5%) and of resting time (-13%) in horned goats and a slighter reduction of the same parameters (-8% and -6%, respectively) in goats without horns was also observed[41]. Despite the presence of horns, feeding time was significantly ($P < 0.05$) reduced due to a reduction of feeding space from 20 to 10 cm/head. Air space is one of the most important factors that influence the concentration of air born particulates in animal houses[32]. This could be of practical interest for sheep housing, in particular if sheep are raised in warm climates and do not benefit from efficient ventilation systems. When assessing the effects of different airspace allowances on dairy sheep, it was observed that an airspace of less than 7 $m^3$/head led to a significant ($P<0.05$) increase in relative humidity and airborne micro-organism concentration (mainly *Staphylococci* count), a marked rise of somatic cell and of micro-organism count (mainly psychotropic bacteria) in milk, and a higher incidence of sub-clinical mastitis[61]. In addition to such effects on the hygienic quality of air and milk, and on ewe udder health, a reduced milk yield (-15%) and a lower casein content (-5%) were also observed. When sheep are housed at a high stocking density, careful litter management is particularly important to mitigate drawbacks on animal welfare and production performance. Spreading of appropriate chemical products on litter, such as bentonite and par formaldehyde, which can reduce bacteria proliferation and degrading processes of the nitrogen contained in urine and in faeces, is a suitable strategy to reduce airborne micro-organism levels and ammonia release from the manure[59,61].

**Ventilation**

Ventilation plays a main role in maintaining the welfare and performance of housed sheep and goats, by affecting thermal exchanges between the animal's body surface and the environment, by avoiding an excessive increase in relative humidity, and by keeping levels of noxious gases and air borne particles under control[57]. Ventilation rate is based on the length of ventilation cycles and on air speed because when air speed exceeds 1 m/s, the cooling efficiency of ventilation does not increase. On the contrary, turbulent air currents generated by very rapid ventilation rates may result in greater amounts of dust entering the animal house as well as in dust particles remaining suspended in the air for a longer time[59]. It was also observed that, during summer, dairy sheep need an average ventilation rate of about 65 $m^3$/h/ head, achieved by giving most ventilation cycles during the hottest hours of the day[58, 62]. However, results indicate also the importance of overnight air exchange. This aims mainly at removing dangerous gases (mostly ammonia) that easily develop from excreta decomposition and fermentation in hot weather. Summer ventilation rate of less than 40 $m^3$/h/ head causes altered behaviour, immune and endocrine responses, and about 10% lower milk yields in sheep. Poor ventilation also increases milk bacterial load and worsens milk cheese-making properties, leading to a high casein and lipid loss during curd formation and to an alteration of cheese ripening processes[6]. The role of air exchange during the

winter season is often underestimated. This can have important effects on welfare and production performance of dairy sheep and goats, by avoiding an excessive increase in relative humidity and by keeping levels of noxious gases and airborne particles under control. Some experiments,[5,59] have demonstrated that exposure of dairy sheep to low (about 25 $m^3$/h per ewe) and very high ventilation rates (about 75 $m^3$/h per ewe) results in increased noxious gases, dust and airborne microorganism concentrations compared to a moderate ventilation rate of about 45 $m^3$/h per ewe. In addition, exposure to inadequate ventilation regimes can reduce milk yield and deteriorate milk quality. Higher levels of somatic cell and mesophilic bacteria counts as well as a greater plasmin activity and a higher plasminogen to plasmin ratio in the milk collected from the ewes exposed to low (25 m3/h) and very high (75 m3/h) ventilation rates compared to the milk from ewes exposed to a moderate (45 m3/h) ventilation rate[7].

## DISEASE AND PARASITES

Internal parasites are a major constraint in livestock industry. They cause retardation in animal growth, poor reproductive performance, condemnation of goat carcasses at abattoirs and high kid mortality. The literature concerning worm infestation of goats on different floor is scanty.

The success of goat husbandry depends on the disease free status of the herd, for which knowledge of various disease entities affecting them is of paramount importance[38]. To provide full health coverage and optimize the production from goats, it is imperative to minimize the disease of goat and more particularly when goats are reared on intensive management practices. Amongst pathogen oriented diseases, ecto-endo parasites are known to cause lowered resistance, loss of production and even mortality. Helminths and Coccidiosis in adult goats are associated with subclinical production losses and have profound depressive impacts upon long term animal productivity. Egg per gram (EPG) of fecal matter can be taken as a tool of comparison on different types of floor which indicate the worm load. The goats reared on pucca floor possess more coccidian infection than that of katcha floor[40]. Similarly, Osmanabadi kids housed on kachcha and pucca housing system[50] and observed that average OPG (Oocysts per gram) counts were 9393 and 9715 in kachcha and pucca housing system, respectively differed significantly ($P < 0.05$). However, other scientists observed no significant difference in EPG (egg per gram) when Mecheri lambs[68] and Tellicherry kids[69] reared on slatted and mud floor, respectively. The parasitic infestation was significantly ($P < 0.01$) and positively correlated with housing quality whereas, it was significantly ($P < 0.01$) and negatively correlated with prevalence of coccidia[65].

## CONCLUSION

The welfare of livestock is burning issue hence the researchers across the world for so many years have tried to assess ideal housing system for small ruminants considering their geographical climate to optimize production and welfare. The scientists concluded that housing system for small ruminants must be cost effective, well ventilated, comfortable and hygienic and made from locally available resources. The flooring and roofing materials should be selected considering climatic factors, availability and animal preference and parasitic load. Similarly, behavioural and physiological changes, ventilation rate, THI inside the shed and corral, wind flow speed and direction must be kept in mind while construction of shed for small ruminants in the era of climate change and global warming. The daily activities pattern of small ruminants must be monitored at regular interval to access suitability of floor, feed and water space allowances.

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