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REVIEW ARTICLE

Dairy animal shelter in tropics with special reference to space requirement and air quality

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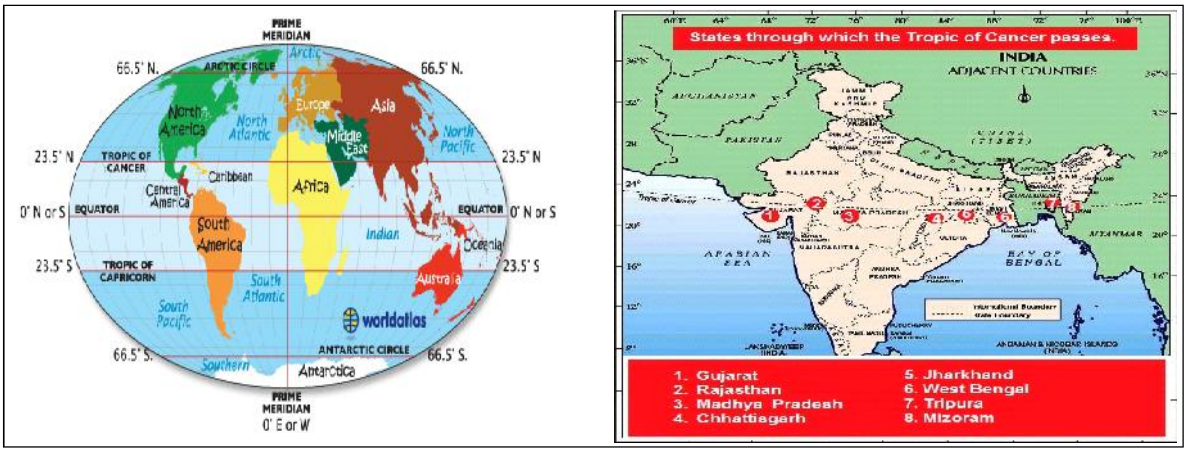
INTRODUCTION

The tropics are a region of the Earth surrounding the Equator. Tropical climate zones of the Earth where all twelve months have mean temperatures above 18.0 °C (64.4 °F). In tropics comfort zone of animals ranges from 15 to 27°C and milk production begins to drop only when temperatures rise above 35°C.

Housing is one of the foremost requirements of dairy cows for better production, health and welfare (Hsitov *et al.*, 2006). Shelter is required for protection and comfort of animal against extremes of temperature, sunlight, rainfall, humidity, frost, snowfall, strong winds, etc. Besides providing shelter from adverse weather a well designed barn provides a clean, dry, well drained and comfortable accommodation to the animals and a pleasant efficient work place for the workers which are important for quality milk production. Uncomfortable housing have detrimental effects on



housed animals which makes them not only more susceptible to diseases but also less productive. The basic justification for animal housing is that it should alter or modify the environment for the benefit of animals enclosed in it to reduce the peak stress with due consideration to the economics of construction. Under tropical climatic conditions as prevailing under most of the Indian conditions, some basic principles that should guide the dairy farmers embarking on building a farm is to reduce heat gain and promote heat loss from the structure of the animal house by radiation and conduction during summer.

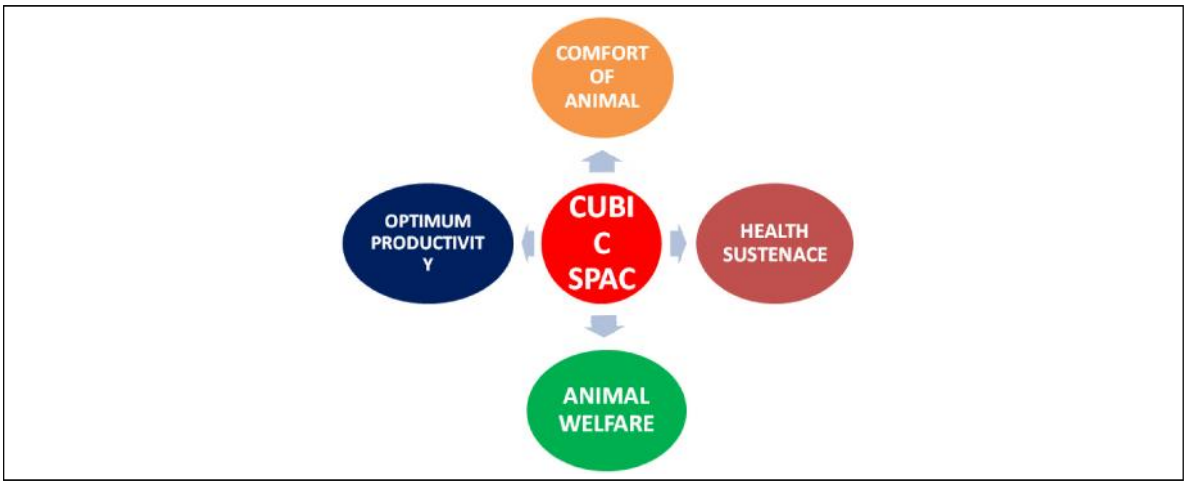
Thermal stress on livestock and productivity loss:

Gradual stress induced by global warming and climate change is also influencing fertility and productivity of livestock directly and through reduction in fodder production indirectly. More than 85 per cent places in India experiences moderate to high stress in April, May and June (THI-75 to 85). In 25 per cent places THI exceed 85 during May and June. Developing countries are more vulnerable to climate change as they largely depend upon climatic sensitivity (NDRI Vision 2030, 2011)

Significance of animal shelter in tropics :

Shelter must take into account of animal comfort, Animal health, sanitation and waste removal, convenience and comfort of the operator, automation and labour saving feeding, milking.

Importance of cubic space :



Fundamental basis for animal welfare :

World Organization for Animal Health, 2005

Freedom from hunger and thirst:

By providing constant access to fresh water and a diet to maintain full health and vigour.

Freedom from discomfort:

By providing an appropriate environment including shelter and a comfortable resting area.

Freedom from pain, injury, or disease:

By prevention or rapid diagnosis and treatment.

Freedom to express normal behaviour:

By providing sufficient space, proper facilities, and company of the animal's own kind.

Freedom from fear and distress:

By ensuring conditions and treatment which avoid mental suffering.

Suitable dairy housing in tropics :

Guide to good farming practices, FAO, 2011

Design of housing:

The design and management should be prepared in such a way, so that it improves the cow comfortduring resting, and provide an environment where the cow can maximize heat loss during hot weather and minimize heat loss during cold weather. Choosing a particular housing system design is difficult because it is not always known how the system design will affect growth, health, and production of the animal. Access to a dry, comfortable standing area reduces the risk of lameness. A rest period on pasture helps lame cows recover.

Component of housing design:

Floor:

The floors should be hard, impervious to water and easy to clean. Concrete floors (3,500 psi) must have adequate texture for good footing. Secure footing reduces injuries from slipping andfalling, enhances cow movement to feed, water, and stalls, and improves heat detection. In livestock housing, wood-float and broom-finished surfaces become smooth in time due to tractor scraping and constant animal traffic. Select the degree of floor roughness based on the intended use and animal type. The floors shall have a gradient of 1 in 40 to 1 in 60 towards the drains so that wash water can run into drains easily. The raised slotted floor with thatched roof is best suited for growth, feed conversion efficiency and economic. Dairy cows always prefer soft floor, soft materials such as rubber mats and mattresses were suitable coverings and have shown good results. Ammonia emission from the compartment with the grooved solid floor operating with open perforations is reduced by 46 per cent compared to the traditional slatted floor.

Roof:

The roof should be light, strong, durable, weather proof, bad conductor of heat and free from tendency to condense moisture inside. The pitch of roof should be, 350 for thatched roof, 25 to 300 for tile roof and 12 to 180 for a sheet roof. The pitch should not exceed 450 at any circumstances.

Wall:

For ordinary walls, thickness should not exceed 35 cm. Partition walls lining the open areas should be 22.5 cm (two brick) thick. Height of walls should be 2-2.5 m for houses with sloping roofs. When solid concrete walls are removed and replaced by steel piping, the roof is raised 1 m and outside paddocks is provided with palm thatch shelters,almost no trouble is experienced from climatic stress.

Type of housing :

Free stall housing :

Free-stall design must consider lying/standing space along with moving or dynamic space requirements of the cow. A solid front must not interfere with the cow lunging forward. The brisket board positions the cow correctly in the stall, thus keeping the rear of the stall cleaner. The stall width of 1.22 m is adequate for cow comfort and minimizing injuries. A lateral slope of three per cent across the width encourages cows to lie in the same direction, again reducing the chance of udder and teat injury from adjacent cows. A longitudinal slope of two to six per cent is suggested to encourage the cows to rest toward the rear of the stall. Another design consideration is the rear curb. With curbs of 20 to 30 cm in height, manure overflow from alley scraping is minimized. The partition for free-stalls isalso an important design consideration.

The cow's lying and rising space needs consist of three elements:

– Body space — The space from the rear of a cow to the front of her knees.
– Head space — The space ahead of a cow's body occupied by her head.
– Lunge space — The additional space necessary for the thrust of a cow's head as she lunges forward during rising.

Tie-stall shed :

Only in the case of purebred herds where considerable individual attention is given to cows can a tie-stall system be justified in tropical areas. The tie and feed barrier construction must allow the cow free head movements while lying down as well as standing up, but should prevent her from stepping forward into the feed trough. Stall partitions should be used at least between every second cow to prevent cows from trampling each other's teats and to keep the cow standing straight so that the manure falls in the gutter.

The surface of the free stall should be:

– Comfortable to the cows to encouragehigh occupancy
– Prevent hock damage and other injuries
– It should be easy to clean and be durable

The ideal lying surface is soft, absorbs moisture and does not promote the growth of bacteria. When cows are forced to lie down on hard surfaces, they do not lie down for long, are more easily unsettled and may develop knee and hock lesions and swelling (Tucker *et al.*, 2003). The floor of the cubicles can be earthen with a thick layer of bedding, or can be solid, with a soft top layer. The simplest bedding is packed earth or sand, this being inexpensive but requires care to maintain a flat surface. Sand is quickly pushed around by cows, so it should not be used with mechanical or liquid manure handling systems because it fills up storage tanks and is very abrasive, damaging equipment such as manure pumps. A concrete foundation with a disposable bedding of chopped straw, sawdust, wood shavings or crushed corn cobs is more common in Europe, because rice hulls are not readily available. Rice hulls would make ideal bedding for free stalls but their high silica content could damage liquid manure handling equipment. Hard surfaces should have a slope of at least 1 per cent so that urine willdrain into the alleys. Rubber mats andcow mattresses are new innovations for free stalls but the thin ones (10 mm or less) have short life spans. Thicker ones (25–30 mm), although more expensive,are likely to be more cost effective in the long term. The front of the cubicles with thick bedding should be 1.2 m high and the back 0.85 m. In cubicles with solid floors, these measurements are 1.1 and 0.75 m, respectively

Loose housing system :

Animals are kept loose in an open paddock throughout the day and night**,** one side of open paddock common feed manger and water tank**,** open paddock is enclosed

Advantages :

– Cost of construction is cheaper
– Future expansion is possible
– The animals will move freely so that it will get sufficient exercise.
– The animal can be kept clean
– Common feeding and watering arrangement is possible.
– Clean milk production is possible
– Oestrus detection is easy

Disadvantages :

– Not suitable for temperate Himalayan region and heavy rainfall areas
– Requires more floor space.

- Competition for feed.
- Attention of individual animal is not possible.
- A separate milking barn is needed for milking of animals

Types of animals	Floor space per animal (sq.ft)		Manger length / animal (inch)
	Covered area	Open area	
Cow	20-30	80-100	20-24
Buffaloes	25-35	80-100	24-30
Young stock	15-20	50-60	15-20
Pregnant cow	100-120	180-200	24-30
Bull pen	120-140	200-250	24-30
Old heifers	2.0	4.0	30
Bulls	12.0	120.0	1

Ideal animal shelter in Tropics-(Saini, 2014) :

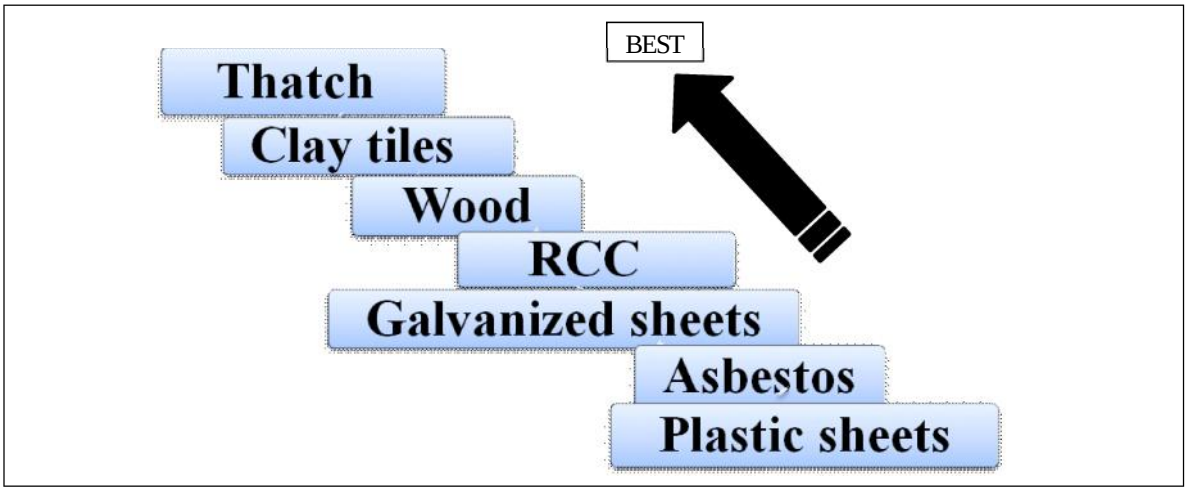
Parameter	Norms
Space	Cubic space
Floor space	20-30 sq. ft(covered); 80-100 sq. ft (open)
Orientation	East-west (long axis)
Height and slope of roof	Flat- 14 ft , Gable- 16 ft (at centre) and 8 ft (at eaves)
Floor material	Concrete, mattress murum+soil
Roofing material and colour	Lintel/ Asbestos sheet, thatch ; white and green
Manger	2-2½ feet (width)

Floor material and cow comfort-(Dumelow, 1993) :

Materials	Resting time (hours)
Concrete	7.2
Insulated concrete	8.1
Rubber mat	9.8
Straw on concrete (2 inch)	14.1
Mattress	14.4

Roofing material-(Rural structure in tropics, FAO, 2004) :

Light, strong, durable, weather proof, bad conductor of heat and free from tendency to condense moisture inside
Ranking of roof materials according to thermal insulation



Insulated roofing sheet :

– Single skin
– Double skin

Insulation material option:

Glass wool
Rock wool
Mineral wool

Benefits :

– Excellent thermal insulation
– Resistance to weather and harsh environments
– Long life and very low maintenance cost

Cooling system- (Bahga *et al.*, 2003) :

Sprinkler cooling :

Concluded that spray cooling of high yielding crossbred cows for 3 min after every 12 min (15 min/hr) from 09.00 to 05.00 hrs during hot climatic conditions(June - August) increased thermal comfort and resulted in 8 per cent increase in milk yield and maintained body weight.

Mist and fan system - (Aii *et al.*, 1998) :

Results showed an increase in milk production of 0.66 – 1.90 kg/ day for cows producing 20 – 25 kg/day. The holding pen should be cooled with fans and sprinkler systems and an exit lane sprinkler system may be beneficial in hot climates (Garner *et al.*, 1988). Fans may be installed to provide additional airflow that will increase evaporation rate. Zheng *et al.* (2009) suggests that heat stress significantly reduces the production of milk, percentage of milk fat and percentage of proteins, but that it has no effect on the content of lactose in milk. Brouk *et al.* (2005) observed that fans cool by moving air over the body of animals at a faster speed than normal air movement but when fans are not sufficient to elevate cooling levels, additional cooling can be achieved by using evaporative cooling and increase 10 per cent in milk production in cows that are cooled by fans and sprinklers compared with animals in free stalls.

Evaporative cooling system :

Increases DM intake- 7-9 per cent
Increases milk yield – 8.6-15.6 per cent

Air quality issues in dairy production :

Air quality affect through emissions of gases -ammonia and hydrogen sulfide, particulate matter, volatile organic compounds, hazardous pollutants and odor. Also produce carbon dioxide, methane, and oxides of nitrogen. Odorous compounds generally contain either nitrogen (*i.e.*, ammonia) or sulfur.

Air in the buildings heavily can be contaminated with inorganic dust, spores, moulds, bacterial and viral organisms, gases, vapours and other pollutants.

Airborne particles may cause infections, allergies and other responses while gases and vapours may be poisons, asphixiants, or irritants.

Hazardous air pollutants :

– Ammonia
– Hydrogen sulfide
– Methane and nitrous oxide

Ammonia has a direct, toxic effect on vegetation. When returned to the soil and water by rainfall, it disrupts

ecosystems causing algae bloom in water bodies and acidification of soils.

Hydrogen sulfide is a colorless gas with a strong and generally objectionable rotten egg odor. It is produced in anaerobic (oxygen-deprived) environments by microbial decomposition.

Methane and nitrous oxide are greenhouse gases that are known to contribute to global warming. Estimates that more than 30 per cent of the nation's methane emissions come from livestock operations. Similar to sulfur, agricultural methane, is emitted during microbial degradation of organic matter under anaerobic conditions.

Nitrous oxide forms via the microbial processes of nitrification and denitrification

Relative contribution of various sources to the global emission of methane (CH_4) and (N_2O) :

Gas	Natural sources (%)	Anthropogenic sources	
		Livestock production(%)	Others (%)
CH_4	30	20	50
N_2O	30	35	10

Recommended maximum concentration from dairy house-(Sirohi and Michaelowa, 2004):

Ammonia $\leq$10ppm
Carbon dioxide $\leq$3000ppm
Hydrogen sulphide $\leq$0.5ppm
Dust $\leq$10 mg / m^3

Emissions from buildings :

– Can be reduced by inhibiting contaminant generation, or by capturing and treating the air as it leaves the building
– by using biofilters
– Frequent manure removal is an efficient way of reducing contaminant generation within the building
– Bedded solid manure
– Chemical additives on animal litter and diet manipulation
– Setback distances from neighbors
– Trees plantation

Ventilation :

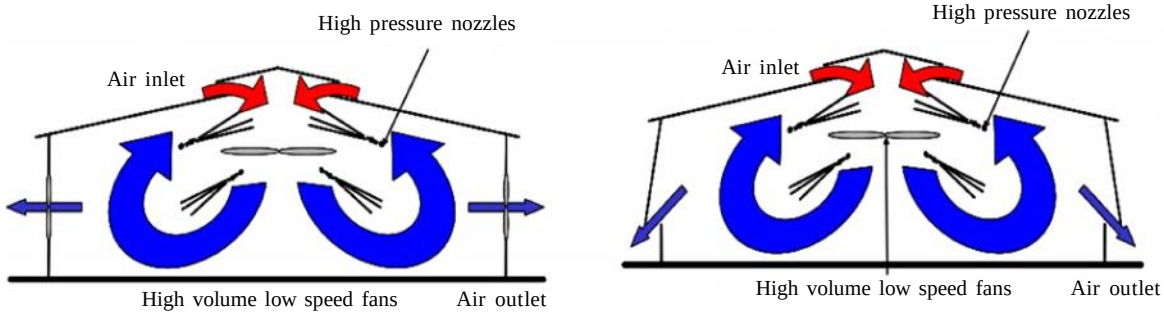
– Ventilation is an air exchange process that accomplishes the following:
– Brings fresh air into the building through planned openings
– Thoroughly mixes incoming and inside air
– Picks up heat, moisture, and air contaminants
– Exhausts warm, moist, contaminated air from the building

Types of ventilation :

– Natural ventilation
– Naturally ventilated buildings are best ventilated with
– A continuous ridge opening
– Large continuous sidewall openings
– Continuous eave openings

Forced ventilation- (Arbel *et al.*, 2002) :

Best where many animals are kept under one roof



Ventilation rate- (Gurkan *et al.,* 2003)

Ventilating rates depend on :

- Weather condition
- Type of fan
- Size of fan
- Size of Inlets and out let opening
- At least 1 air exchange per minute in summer

Ventilation rate can be calculated by, Q= E.A.V. :

Q= Ventilation rate (m^3/s)

A= Area of inlet (m^2)

V= wind velocity (m/s)

E= Efficiency of air opening

Animals	Cold weather[a]	Mild weather	Hot weather[b]
	Cfm/animals		
Calves 0-2 months	15	50	100
Heifer			
2-12 months	20	60	130
12-24 months	30	80	180
Adult cow	50	170	470

- An adult cow requires at least about 800 cubic feet of air space under tropical conditions.
- To make ventilation more effective continuous ridge ventilation is considered most desirable.

Conclusion :

– Optimum design and maintenance of suitable shelter is an important component of dairy animals production in tropics and accordingly it should be selected.

– Thus shelter management is not just about constructing a mechanical structure but it is an elaborate process of predicting analyzing designing, erecting and managing a livable environment to facilitate welfare and productivity of dairy animals.

– Floor and roof materials should be selected not only based on cost effectiveness but also taking their ability to provide thermal comfort which enhances productivity of dairy animals.

– The particulate and microbial contaminants also need to monitored and kept within the recommended limits to ensure quality of animal health and products, especially in tropical region.

– Effective ventilation utilizing natural and draft ventilation coupled with optimum cubic space requirement enables welfare of dairy animals and enhances production and hence need special attention while designing animal shed.

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