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Mitigating winter vagaries in dairy animals: A review

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Abstract
Productivity of dairy animals gets compromised with adversity in thermo-neutral zone. Maintaining animals between lower and upper critical temperature of thermo-neutral zone optimizes production. Optimum health and production of dairy animal mandates adequate management. Acclimatization to cold stress thrusts on increase in voluntary food intake, rise in resting metabolic rate, augments metabolic capacity, increase in hair coat thickness, hair length and density, shivering and non-shivering thermogenesis accompanied with adrenal hormonal rush as cold exposure advances. Objective of the article articulates about mitigation of winter vagaries to optimize production and health. Mitigation of cold stress can be achieved through increasing barn temperature, reducing humidity, ensuring better ventilation, bedding to protect from cold floor, lukewarm water for drinking purpose, hay and concentrate provision for more heat generation and energy balance, dry teats to protect from frostbite, heat lamps, calf jackets and warm blankets.

Keywords: Cold, thermo-neutral zone, mitigation, dairy animals

1. Introduction
Vagaries of winter season compromises the effective management of dairy animals due to subzero temperature (-10 ºC), frost, snow and chilly winds [1]. Temperature plummeting to subzero in winter affects cow's productivity and efficiency [8]. Cows being homo-thermic animals need to maintain a constant temperature of 38 °C. Animals kept within the thermo-neutral zone; need not to expend extra energy to suffice their body temperature. Temperatures below the lower end of this range, the lower critical temperature, result in cold stress in cows [11]. Cold stressed cows increase their metabolic rate and energy expenditure [12]. Scarcity of fodder due to snow covered pasture lands and ill quality fodder also potentiates to cold related stress. The aim of the article is to elucidate the vagaries of winter and pragmatic approach to mitigate its compromising effect on dairy animals.

2. Cold Index
Coldness is iconed by wind chill index and is depicted as:
Wind Chill Temperature index= $13.12 + 0.6215\ T_{air} - 13.17V^{0.16} + 0.3965\ T_{air}V^{0.16}$
Where, T_{air} = Temperature of the air; V=Velocity of the air [17].

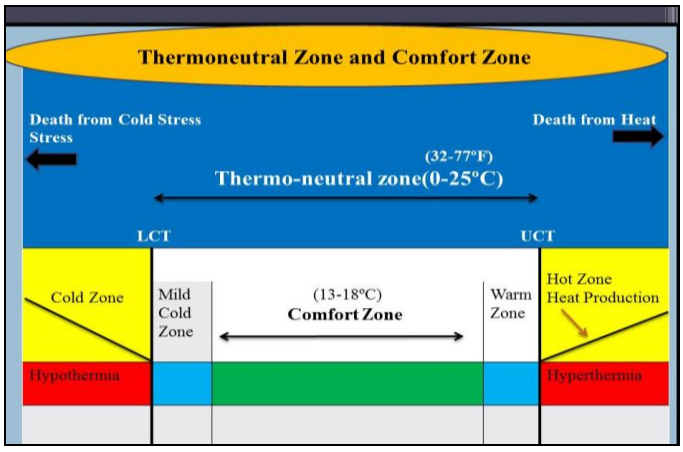

Fig 1: Diagramatic representation of Thermoneutral and comfort zone of dairy animals

Table 1: Upper and lower critical temperatures for dairy animals.

Animal	Lower Critical Temperature	Upper Critical Temperature	Comfort Zone
Cow	-5- -10 ºC	25-28 ºC	13-18 ºC
Buffalo	-10- -15 ºC	25 ºC	10-17 ºC
Calf	0- -4 ºC	25 ºC	15-22 ºC

For every degree fall in temperature below the LCT, energy requirements increase by 1% and 2% in dry and wet coat animals, respectively [1].

3. Effects of stressful winter on Dairy Animals

3.1 Direct effects: It affects production, reproduction, body condition score, feed utilization and health of animal.

3.2 Indirect effects: It affects forage production, water quality and quantity, causes shelter over-burden and mud accumulation.

3.1 (a) Milk production: Cold exposure may directly limit the synthetic capacity of the mammary gland by reducing mammary gland temperature, may act indirectly affecting the udder's blood supply. Temperature of -11.2 ºC resulted in loss of 2 Kg/day/cow [1].

3.1 (b) Reproduction: Increasing age at first calving (AFC), failure of proper follicular development, follicular atresia, loss of sexual desire, decreased pregnancy rates increases calving intervals and decreases fertility of bulls due to underfeeding [13].

Effective breeding strategy to obtain the calf per year.

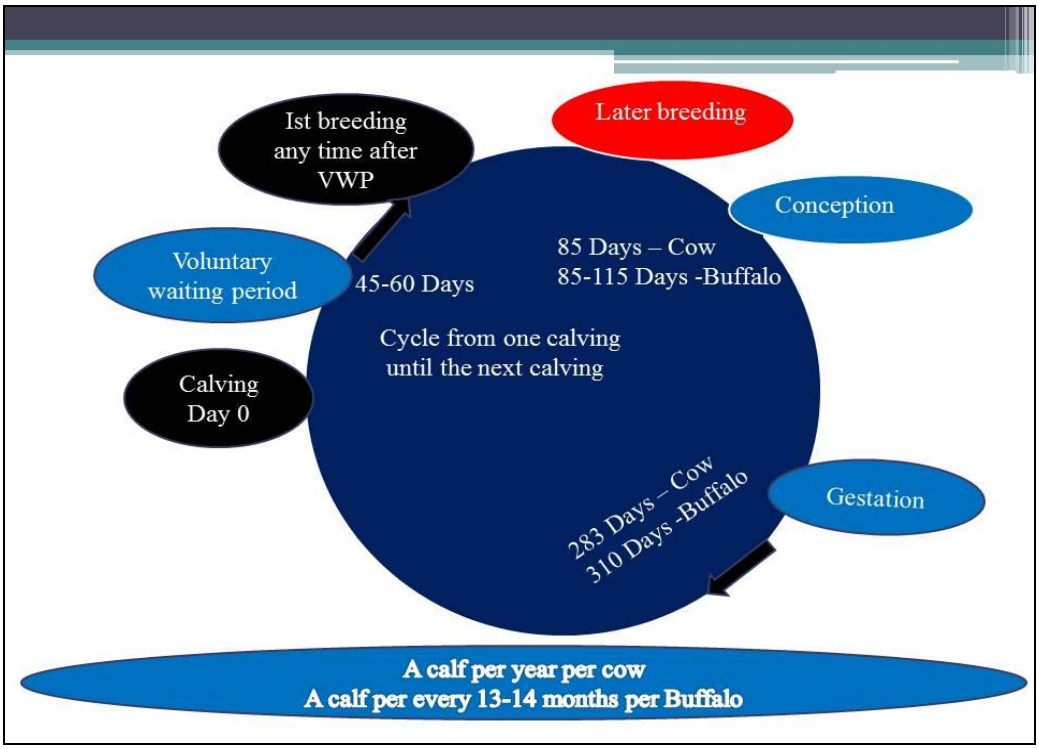

Fig 2: Diagramatic representation of breeding strategy to obtain the calf per year.

Table 2: Optimum and acceptable targets for maximizing the reproductive efficiency in dairy cattle and buffaloes

Parameter	Cattle		Buffalo	
	Optimum	Acceptable	Optimum	Acceptable
Calving to first service (days)	<60	<90	<60	<90
Calving to conception (days)	<85	<115	<85	<115
Calving interval (months)	12-13	13-14	13-14	14-15
First service calving rate (%)	>60	>55	>55	>50
Overall calving rate (%)	>80	>75	>75	>70
Calving rate (%)	>75	>70	>70	>65
Service/conception(no.)	<1.6	<1.8	<1.8	<2

Table 3: The following table depicts the reproductive efficiency status in crossbred, indigenous cattle and buffaloes in India

Parameter	Indian cattle	Crossbred cattle	Buffalo
Calving interval	416 days	404 days	479 days
Calving to conception	136 days	123 days	169 days
Mean calving to first conception	63 days	60 days	65 days
Conception rate to first service	44.2%	34.1%	30.5%
Services per conception	2.1	1.9	2.2
Age at first calving	40 months	32 months	40-53 months

3.1 (c) Body Condition Score: Higher body condition score augments cows to insulate against winter stress and cows position themselves to minimize surface area exposed to harsh weather [17]. Body reserves get depleted due to winter stress causing loss of live weights thus reversing weight gains made in summer. Cows losing more body weight (16%) are unlikely to re-conceive during the next breeding season. Winter stress increases cardiac output and body oxygen consumption, increases adrenalin, cortisol and growth hormone levels, increase lipolysis, glyconeogenesis, glycogenolysis, increase hepatic glucose output anddecreases insulin response to a glucose infusion. Starvation and pregnancy toxaemia of animals can also occur due to nutritional deficiency [17].

3.1 (d) Health: Increases incidence of respiratory infections & hypoxia, decreases immune response in ill ventilated barn, increases basal metabolic rate, frost bite, asthma, sore throats, coccidiosis, increases postnatal mortality, also causes hurdling, shivering and lack of coordination [8].

3.1. (e). Effect of winter conditions on feed utilization

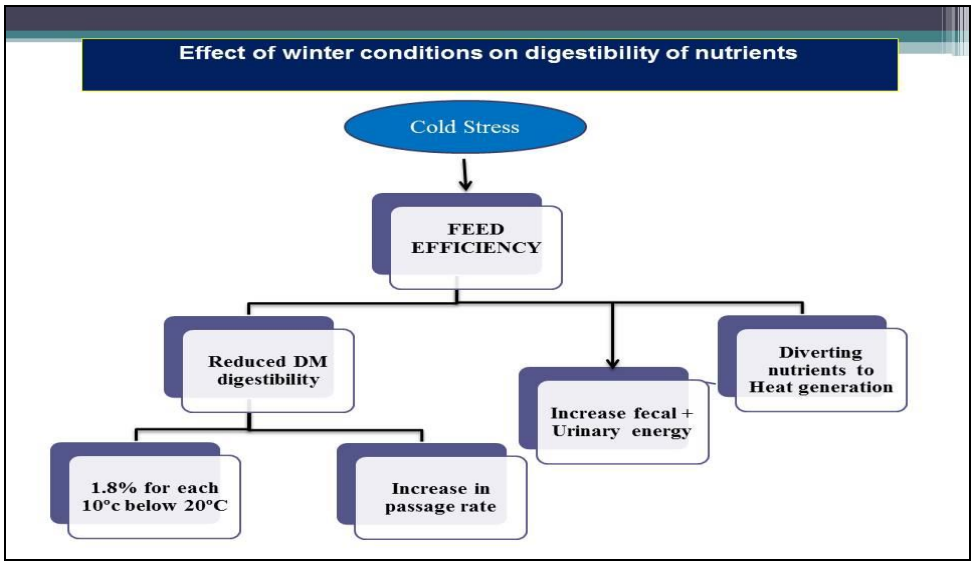

Fig 3: Diagramatic representation of feed utilization.

3.2 (a) Shelter and Mud accumulation: Need is - Procurement of effective shelter

- Inadequate shelter results in respiratory problems and compromises animal's efficiency
- Excessive shelter is costly

Mud is most commonly found where animals are forced to congregate may result in foot rot and thrush

3.2 (b) Forage deficiency both in quantity & quality due to:

I. Depletion in quality of forage
II. Frost, bleaching by the sun, level of CP falls from 8-11%during summer to 1-3%in winter, TDN falls from about 80% to <50%in succulent forages.
III. Depletion in quantity of forage resource due to non-availability of land for forage production and vagaries of climate [18, 2].

3.2 (c) Water Shortage: Depletion of water supplies, less water to drink, water quality goes down, frequency of watering goes down.

4. Effect of cold stress on animals and animal's response to cold

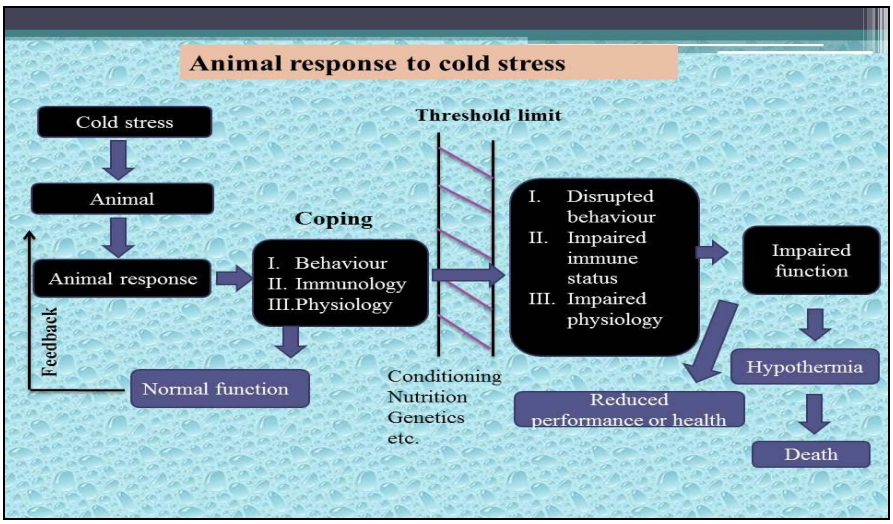

Fig 4: Diagramatic representation of animal's response to cold.

4.1 Innate defense mechanism against cold

Adaptive process resulting in numerous physiological and morphological changes enabling the organism to live in an extreme thermal environment with less thermal discomfort.

Tissue insulation and subcutaneous fat: Vasoconstriction of the superficial tissues of the body reduces the temperature gradient between the skin surface and environment, thereby the heat loss

4.2 Hair coat insulation: Entrapped air, which occupies 95% of the volume of the hair coat is responsible for insulation. With increasing coat thickness and hair density insulation of the hair coat increases. Piloerction causes rapid increases in hair coat insulation.

4.3 Air insulation: Thin film of still air adhering to the body surface causes air insulation.

4.4 Increase in heat production: The rise in heat production below the Lower Critical temperature occurs approximately linearly with depression in temperature. Summit metabolism gets arrived where no further rise in heat production occurs. Increased feed intake, increased muscular activity, increased heat increment and shivering thermogenesis can cause extra heat generation.

4.5 Non shivering thermogenesis: Brown fat in the neck andbetween the shoulders causes heat generate in animals or neonates that do not shiver. Hormones (Conversion of T4 to T3 inside brown fat cells; T3 increases cellular metabolic rate triggering mitochondria to speed up their metabolic process and generates heat instead of ATP. Body heat is maintained by signaling the mitochondria to allow protons to run back along the gradientwithout producing ATP by an uncoupling protein 1 (thermogenin) [17].

5. Strategies to manage winter vagaries

5.1 Nutrition Management

I. Increase the energy content (77% vs. 70 -72% TDN) and protein (17.5% vs. 14.5% CP)
II. Rations containing about 20% vs. 17% fiber in the animal feed are helpful to increase fat percentage in milk & reduce the effects of cold temperatures
III. Animals outdoors will require about 15 to 20% more feed for the season than animals kept in confinement housing [8].

5.2 Winter Provisions

I. Concentrates: Feed Blocks, UMMB Licks, Cubes, Meals and cakes.
II. Conserved Forage: Hay, Silage, Haylage, Leaf meal, etc.
III. Crop residues: Stover, Straw etc.
IV. Cultivated fodders: Paddy, Oat, Maize, Berseem, Leucerne, Turnip, etc.
V. Fodder tree leaves: Willow, Robinia, Alanthus, Callyandra, Sesbania, Salix Populus, Ulmus and Acacia, Moras and Malus [6].
VI. Aquatic vegetation: *Typhaangustata*, *Phragmiteselephantoides*, *Nympheatetragona* [16].
VII. Establishment of fodder banks: Surplus forages during summer is harvested and conserved or transported from nearby states to meet the periodic unavailability
VIII. Reduction of wastages by chaffing: 15-20% of the straw can be conserved from wastage by chaffing.
IX. Apple pomace: The dried apple pomace contains 7.7% crude protein (CP) &1.86 Mcal (ME)/kg DM. The ensiled apple pomace shows best feed conversion ratios at 15%incorporation in the diet [7].
X. Maize grain, molasses and chicken littercan be used for supplementary feeding of cows or growing stock.
XI. Urea treatment of straws:

Fertilizer grade urea @ 4-5% increases the digestibility by about five units, whereas, if it is ensiled for 10 days, the increases digestibility is twice this.

Cows fed urea treated wheat straw based diet got higher live weight gain than cows fed hay based diet [15, 14].

5.3 Shelter Management: Proper sheds should be provided to prevent from the prevailing chilly winds.

I. Provision of heating facilities like room heaters, provision of curtains.
II. Bedding (4-6 inches in large animals and 2 inches for smaller animals) should be clean and dry on concrete floor to reduce body heat loss.
III. Shed should be cleaned at least twice in a day for proper disposal of wastes and minimum piling up of ammonia gases [3, 4].
IV. Ventilation should be appropriate & draft free; relative humidity in the range of 40 to 80% is ideal.
V. Calf jackets and blankets are also helpful to keep calves warm.
VI. Snow creates serious feeding and bedding issues and a snow removal plan needs to be developed.
VII. Strategy to move calving season too late in spring/ early summer, preventing cows to spend late lactation in cold months.

5.4 Water Management: Water consumption is encouraged when water temperature is 47°F or above, tank heaters should be used to prevent water sources from freezing, ensuring adequate water intake encourages optimal health and performance.

5.5 Mud Management: Providing adequate resting time is an important aspect of dairy management, both for production and welfare [10]. Dairy cows in confinement should lie down for approximately 12 hours/day, however, if facilities are not sufficiently clean or comfortable, cows will often remain standing [5, 9].

Mud is most commonly found where animals are forced to congregate results in foot rot and thrush, wetness of mud can make parasite survival more likely as well.

- Suggestions may include the development of geo textiles, gravel, tile, gutters, sand or woodchips.

5.6 Health Management

I. Vaccinations, nutritional supplementation and deworming protocols should be followed
II. Encourage exercise by varying the location of feeding and watering sites.
III. Exercise will help prevent obesity and overgrown hooves.
IV. Prevent wet, muddy conditions and contamination of feed by manure as it will increase the threat of coccidiosis
V. A teat dip powder will reduce risk of frost bitten teats during cold winter.
VI. Check bruises on soles, trim overgrown hooves and prevent laminitis and lameness.

Conclusion

Animals show optimum performance in their production and reproductive traits with in the thermoneutral zone. The condition above upper critical temperature and below lower critical temperature, animal's performance gets compromised. To mitigate this ill effect the management in terms of nutrition, shelter, watering, mud accumulation, health, etc. are emphasized, so as to prevent the cold stress related abnormalities; also calving season is deferred to late spring /early summer.

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