Cattle adapted to tropical and subtropical environments: Evolutionary aspects

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As the global climate changes, humans must re-evaluate management decisions regarding which animals to use for food production. Part of promoting the sustainability of protein production and the beef industry itself is identifying animals that are best suited to current conditions and optimizing the housing, husbandry, and genetics utilized for health, growth, and behavioral needs. Because humans can dictate what type, where, and how animals are raised, more emphasis must be placed in identifying animals that are optimized for current environmental conditions, and these changes may differ drastically from historical practices.

Bos taurus and B. indicus are Different Subspecies of Cattle

The evolution of cattle is a complex and dynamic phenomenon involving animal domestication, human migration from the Fertile Crescent, and environmental pressures. Based on mitochondrial DNA and fossil evidence, the Indian auroch (*B. primigenius namadicus*) diverged from Bison (*Bison bison*) approximately 1 million years ago (Figure 1). Approximately 300,000 years ago, the Indian zebu (*B. indicus*) diverged from the Eurasian auroch (*B. primigenius primigenius*). The Indian zebu represents today's modern Indian zebu breed. The Eurasian auroch subsequently diverged into the African zebu (*B. primigenius indicus*), European taurus (*B. taurus taurus*), and African taurus (*B. taurus africanus*). As humans began to populate the planet, the cattle that accompanied them on their journey had to adapt to current environmental conditions, and those animals who survived the environmental changes were selected for domestication. Environmental pressures (e.g., local predators, climate) dictated which individual cattle were successful in terms of survival rates (ability to find resources and avoid predators), thriftiness (efficiency in current environmental forage availability), adaptability (capacity to change with the environment), and productivity. Consequently, cattle diverged into subspecies that differed in physiology, nutritional requirements, social behavior, and body composition (Table 1).

Biome, or the community of plants and animals living together in a certain climate, had a strong impact on which cattle were best suited for the production in a given environment. These external pressures have influenced the behavior and physiology of *B. indicus* cattle that are observed in modern animals. The geographical locations and accompanying biomes in which humans migrated and settled with *B. indicus* consisted of harsh conditions in which plants had relatively low nutritional value. These biomes also had a high degree of internal and external parasites, and predators that employed "stalk and surprise" hunting strategies. Accordingly, *B. indicus* cattle were typically found in environments with increased environmental temperatures and dense foliage, which limited the field of view that they had to look out for predators. These factors led to the evolution of cattle that graze in meandering patterns (causing them to be more nutritionally efficient with low-quality forages), as well as those that are vigilant, more resistant to internal and external parasites, and quicker to respond to environmental stimuli.

Local predator hunting strategies also influenced prey behavior and response to stressors. Cattle adapted to environments in which predators that employ the "stalk and surprise" hunting strategy are more temperamental, have stronger activation of the nervous system, are more vigilant, more social, and may be more sensitive to interactions with humans. This is in contrast to cattle adapted to environments in which predators employ the “strategy and endurance” hunting strategy. Efficient cows had to change their calf defense strategy properly. Cows defending against “strategy and endurance” predators benefit from having experienced a less-intense interaction, as they are successful by properly using resources across time. On the other hand, cows defending against “stalk and surprise” predators benefit from having an intense short-term predator interaction or the opportunity to begin to flee while the predator is still at a long distance. If these cows can survive the initial attack, they will have time to recover as repeated attacks by the same predator are rare and not in the predator’s best interest. Therefore, these two types of animals have different thresholds for what will cause an aggressive maternal response. Selection for cows that are different in their mothering approach will result in cows that are different physically, as their behavior to similar types of stimuli differs.

Ecological Disruptions Influence the Biological Functioning Component of Animal Welfare

The planet’s environment is changing at the same time as global demand for high-quality protein continues to increase. A fundamental step in meeting the increasing global demand for protein while addressing the environmental care concerns due to climate change is to find management practices that work best for the animals in our care. Modern cattle management does not necessarily require paired relationships between cattle and the environment, since humans control breeding and transportation. For example, *B. indicus*-influenced cattle from subtropical and tropical regions of the planet, such as Brazil, will need different management strategies while housed in the US high plains during the finishing phase of beef production compared to a *B. taurus* animal. As previously mentioned, these subspecies differ in temperature regulation, behavioral reactivity, and nutritional efficiency (Table 1). Consequences from the increasingly frequent and intense disruptive weather patterns have shown that *B. taurus* and *B. indicus* cattle need different management strategies during extreme weather events including heatwaves, blizzards, drought, and flooding. Therefore, there is a need for animal managers to understand species-specific animal-environmental interactions to identify and use the best practices for their current scenario.

Bos indicus cattle are more social than *B. taurus* and have more excitable temperaments; thus, they are more susceptible to stress, may have greater difficulty coping, and may be more adept at hiding health issues. Bovine Respiratory Disease (**BRD**), lameness, and bulling are three welfare and productivity issues that require behavioral evaluation to identify and treat. However, the intensity of the predator-prey dynamic between handler and cattle can influence the success of behavioral monitoring and can influence the amount of effort that is needed to build a positive human-animal relationship. Little is known regarding lameness in feedlot cattle irrespective of breed, but cattle are prey animals designed to hide illness and pain. Moreover, *B. indicus*-influenced cattle are reported to be better at hiding pain and injury – granted, this varies based upon the individual animal’s previous experience and exposure to humans. Therefore, the description of species-specific behavioral indicators of discomfort and needs that require human-animal interaction is critical to early detection and treatment of these afflictions.

Bos indicus cattle display different social behaviors compared to *B. taurus* cattle, which may contribute to differences in production efficiency and outcomes. Besides mounting as a behavioral indicator of estrus, *B. indicus* cattle also perform head-butting, and this species-specific behavioral difference may have been influenced by what behaviors were evolutionarily important in acquiring a mate or reproductive signaling in the wild. Further, more dominant cows are more likely to perform mounting behavior, suggesting that social status can influence which cows behaviorally signal their readiness for mating, and suggests that similar behaviors may have different meanings across the different subspecies. Gaining an understanding of the behavioral and social aspects of these animals, and understanding their biological thresholds regarding temperature regulation, disease resistance, transportation resiliency, and the human-animal interaction will provide new data for developing appropriate stewardship practices. Predictive models show that the US high plains will see an increase in heat waves through 2070. Therefore, US regions that have historically been favorable for housing *B. taurus* cattle may need to alter their purchasing and management strategies to house the cattle that are needed to be productive through these environmental changes.

The Importance of Understanding B. indicus Cattle for a Secure Food Supply

Many calves are born and raised in the southeastern US, a geographical location characterized by subtropical climates. However, these calves spend the last 6 to 12 mo of their life in feedlots located in the US high plains, a region characterized by xeric scrublands, montane forest, and temperate steppe biomes. The US high plains is a foreign land to subtropical-born calves because the regions differ so dramatically in temperature, humidity, forage type and availability, and landscape. Therefore, the change in environmental conditions, combined with the inherent industry challenges surrounding transportation, disease exposure, dietary changes, social mixing, confinements housing, exposure to new humans, and weaning, are major challenges to *B. indicus* homeostasis and behavioral needs.

Cattle management requires adaptation and flexibility to both the animals and the weather. As weather patterns change, the knowledge gap widens, and the need for cattle to possess more *B. indicus* characteristics increases, spotlighting the need to better understand *B. indicus*-influenced cattle. Beef cattle, irrespective of what sector they are managed (e.g., feedlot, cow-calf, pasture housed), are directly affected by the weather. Therefore, as the climate changes, beef industries worldwide must begin to increase the use of animals that are better suited to these environmental conditions, and within that framework increase the understanding of their species-specific welfare needs.

Table 1. Comparison between *Bos indicus* and *B. taurus* morphology, physiology, and behavior.

Characteristic	*B. indicus*	*B. taurus*
Physical morphology		
Thoracic cavity length	shorter	longer
Heart, omasum, abomasum, lung, liver, spleen, pancreas, pituitary, thyroid, and adrenal weight	lighter	heavier
Size of reproductive tract and ovaries at mature luteal phase	smaller	larger
Intestinal length	shorter	longer
Skull length	longer	shorter
Skull width	narrower	wider
Dewlap	present	absent
Ear and leg length	longer	shorter
Hip height at 7 month old weaning	taller	shorter
Neural spines of posterior thoracic vertebrae	bifurcated	not-bifurcated
Cervico-thoracic or thoracic humps	present	absent
Sweat gland size	larger	smaller
Sweat gland location relative to skin surface	closer	farther
Behavior		
Phenotypic cohesiveness of groups	tighter	looser
Grazing duration	longer	shorter
Distance traveled while grazing	longer	shorter
Severity of offspring protective behavior	stronger	weaker
Frequency of mounting surrounding estrus	lower	higher
Growth and nutrition		
Longevity	longer	shorter
Average daily gain until weaning	greater	lesser
Body condition score at weaning	greater	lesser
Average daily gain in the feedlot	lesser	greater
Voluntary feed intake	lesser	greater
Maintenance requirements	lesser	greater
Feed efficiency on high roughage diet	greater	lesser

Water intake relative to increases in DMI and ambient temperature	lesser	greater
Feed intake during sustained hot conditions	unchanged	reduced
Physiology and health		
Susceptibility to heat stress	lesser	greater
Resistance to ticks, worms, pinkeye	greater	lesser
Mosquito attack tolerance	greater	lesser
Red blood cell counts and total cell volume	greater	lesser
Hemoglobin values	greater	lesser
Plasma cortisol in response to ACTH challenge	greater	lesser
Change in heart rate as core internal temperature rises	unchanged	decrease
Ability to regulate body temperatures in hot environments	greater	lesser
Internal heat production	lesser	greater
Basal metabolic rate	lesser	greater

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Figure 1. Simplified cattle phylogenetic tree based on Loftus et al. (1994).