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COMPENSATORY RESPONSES: A MEASURE TO MINIMIZE HEAT STRESS LOSSES IN ANIMAL PRODUCTION

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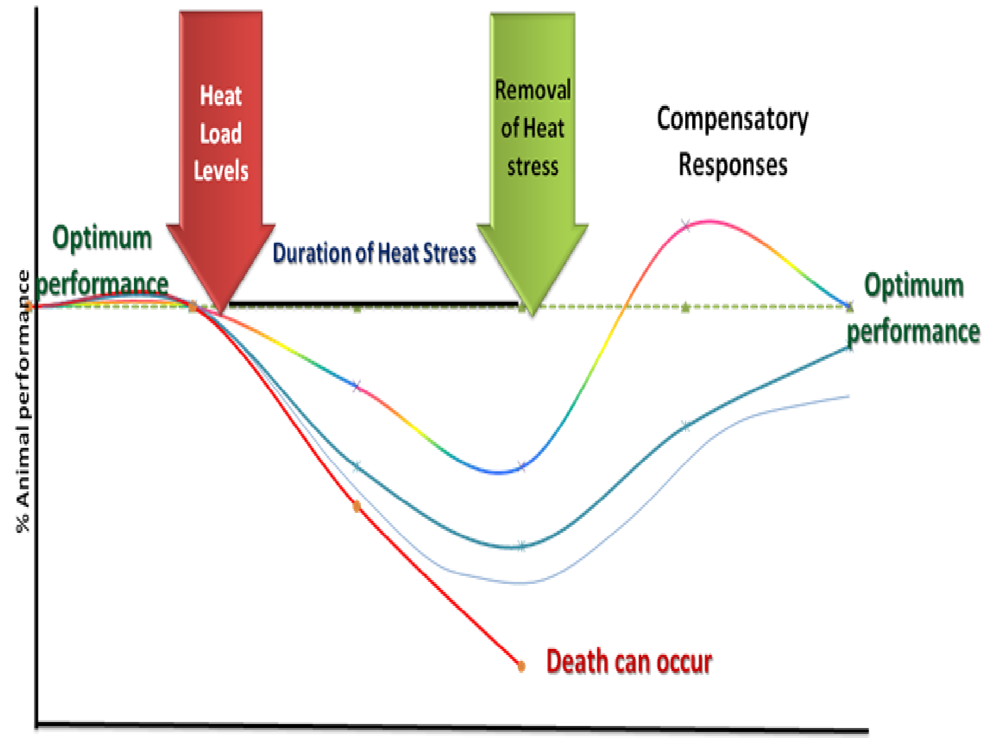
INTRODUCTION

Heat stress is documented to be one of the primary constraints facing sustainable progressive animal production. In this regard, there is wealth of literature to describe the physiological, biochemical and behavioral responses of various livestock breeds to heat stress (Aggarwal and Upadhay , 2013; Collier and Collier , 2012; De Shazer , 2009; yousef , 1985 a,b,c). Surprisingly , very few studies addressed these responses following removal of heat stress. About 35 years ago, Hahn (1982) described the changes in animal performance during recovery after removal of heat stress. Following removal of certain levels of heat stress , depending on duration and intensity of the heat load, animal may respond by rapid recovery , and the response may over shoot above normal level. Such level of recovery may nullify most if not all of the productive losses during the duration of heat stress (Figure 1). The responses after removal of heat stress are called "compensatory responses". Intensity and duration of heat stress significantly modify these responses.

For example, if severity of heat stress exceeds a limit to be called" Upper Limits for compensatory responses " (ULCR), animal's productivity and well-being will be adversely affected . Thus, a good estimate for the ULCR can provide an early warning system for animal producers to recognize the potential threat of heat stress. In turn, producers will be able to make proactive plans to minimize productive losses . New research effort is urgently needed to measure the ULCR for a given animal production level in the various breeds of livestock. To measure ULCR requires: (a) development of a good index to measure environmental heat load; i.e feeling of warmth; (b) measurement of threshold limit of heat load above which compensatory responses can not prevent economic losses.

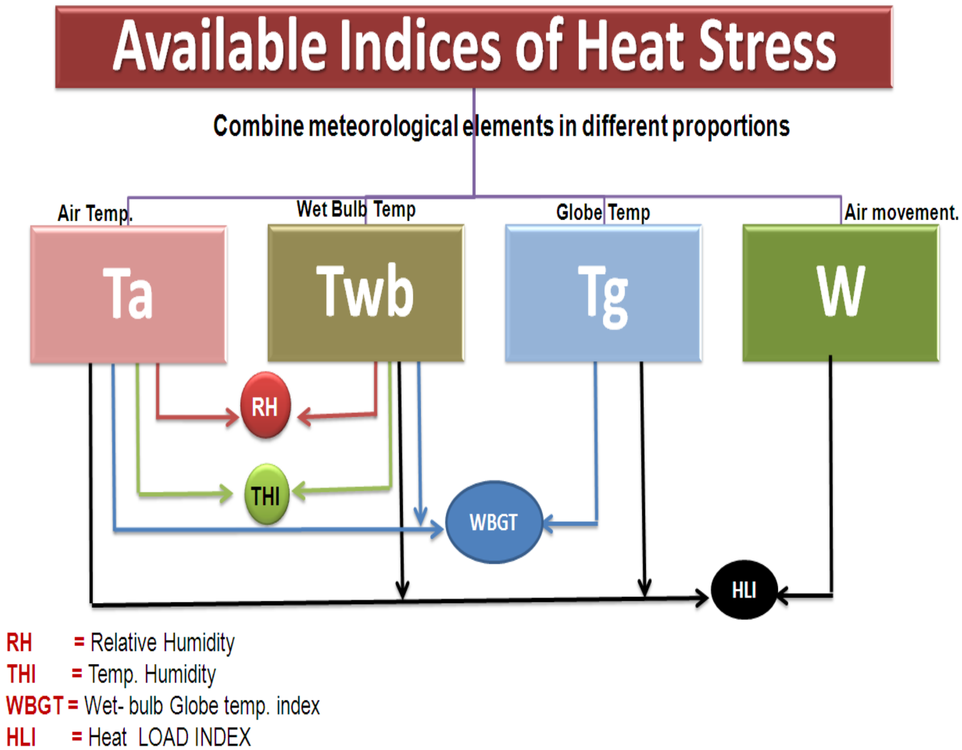
Figure (1). Illustration of compensatory responses to various levels of heat stress (modified from Yousef, 1988).



II. Indices for environmental heat load

For many decades, scientists have been unsuccessful to develop a universally accepted index for environmental heat load . A benchmark for estimation of how" stressful" or "Comfortable" an environment is complicated (Yousef, 1990; Gaughan *et al*, 2012). In general , any heat load index is based on accurate measurements of the various elements of the physical thermal environment (Figure 2).

Figure (2). Illustration of combining various meteorological elements to form available heat load indices.



No single meteorological element (air temperature Ta; relative humidity; RH; Wind ; W; radiation) can reflect environmental warmth. Therefore to develop an index for heat loads, one must combine as many as possible of the meteorological elements in different proportions using mathematical equations to form one number to reflect warmth of the environment (Fig. 2). Each index shown in Fig. 2, has its limitations. However, in the med-west region of the USA, the temperature - humidity index "THI" is commonly used. Furthermore, the forecasted THI is used as an early warning system to farmers (Table 1).

Table (1). THI as an early warning system to farmers

THI Limits	Managerial Action
< 72	No Stress, ?no action
73-78	Alert (Critical) , No significant action required
79-83	Danger (action is necessary)
>84	Emergency (action is mandated)

Based on the THI, and/or any heat load assessment , an advice is given to farmers to take the required and appropriate managerial intervention to reduce heat stress. It should be recognized that the THI is suitable only for certain regions where wind and solar radiation are of minimal effect on warmth of the environment. Also HTI limits are not the same for animals species. THI limits for a given species are affected by production levels and the physiological status of the animals. The combination of more meteorological elements in development of the heat load index, the higher the success of its use as an early warning system for producers. The development of such an index will provide a good tool to predict intensity of heat stress.

III. Measurements of threshold limits for ULCR as an early warning system to farmers

Responses of animals to heat stress have been traditionally measured by various physiological and/or biochemical deviations from normal levels (i.e, body temperature , respiration rate , heart rate , blood analysis, …..etc).This approach was criticized by Moberg (1985) who proposed that researchers should measure parameters such as reproductive performance , production level , growth rate ….etc or other functions which constitute a multiple endpoint and seve as indicators of animal well-being . Now is the time to give the Moberg alternative serious consideration in measuring the compensatory responses. Such approach gives a good signal to the economics of animal production.

In some cases , when heat stress is removed , animal performance could exceed the normal level , i. e. over shoot , and / or quickly return to its normal level (Fig 1). Thus, if one examine the economic loss of productivity during the entire cycle of stress and recovery, the outcome may be minimal losses. To avoid production losses, we need to determine the threshold heat load level above which economic losses will occur. Identification of this threshold should be used as an early warning system to producers to modify the level of heat stress severity to obtain optimum animal performance and guard animal health, safety and well-being. Furthermore, it helps producers to know when and how to interfere for mitigations of heat stress using a proactive plan ahead of time rather than reacting too late after the start of heat stress . In other words, prevention of substantial losses in animal performance must be the key to manage heat stress. Various tactical measures to reduce the negative consequences of heat stress were summarized recently by Daader *et al*. (2016).

Conclusively, measuring compensatory responses using a multiple end-points criterion to evaluate animal performance such as growth rate, reproductive levels, production, ….etc rather than measuring discrete physiological and/or biochemical responses to heat stress; would provide a better understanding to develop management strategies to acquire optimum animal productivity. Furthermore, availability of such data would seve as a base to develop an early warning system for producers to do a plan ahead of time to reduce the potential threat of heat stress, and productivity.

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