ENDOCRINE SYSTEM: AN INDICATOR OF STRESS AND A MEANS OF EVALUATING ANIMAL WELFARE

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ABSTRACT
The endocrine system as an indicator of stress and a means of evaluating animal welfare has been examined in this review. Stress endocrinology is an evolving area of study with many research questions to challenge scientists. However, for the past 25 years, the welfare of domestic animals has been an important aspect of animal science. Consequently, scientists have searched for objective ways to evaluate welfare, in that the demonstration of stress indicators could provide an objective information about how well farm animals kept under production conditions have adapted to the environment. Potential indicators have been suggested, both behavioural and physiological stress indicators among others. The endocrine system may be used as indicators of stress. The primary role of hormones may be a part of the homeostatic response to a stimulus (e.g. adrenaline, corticosteroids). The amplitude of hormone response may correlate with the severity of the stimulus. Moreover, a hormone may have a key role in normal body function (e.g. reproduction) and stress may deleteriously alter the hormone, signal prevents normal function. While stress inputs may reduce over time, hormone negative feedback is a major factor reducing hormone responses. This explains a reduction in perceived stimulus severity or habituation to the stimulus and the animal deemed “less stressed” and its welfare “better”. With a better understanding of the basic biology, altered physiological processes involved in stress adaptability, it would be possible to assess and devise strategies for improving animal welfare.

Keywords: Endocrine system, indicator, stress, evaluation, animal welfare

1. INTRODUCTION
Stress endocrinology is an evolving area of study with many exciting research questions to challenge scientists (Hackney, 2006). The concept of stress and distress are integral parts of animal well-being (Clark et al., 1997). Stress is not easy to define (ILO, 2006). According to Nordqvist (2013) anything that poses a challenge or threat to well-being is a stress. Stress is a feeling an animal has when under pressure while
stressors are the things animals respond to or agents or stimuli that cause stress in the environment. Melinda Smith (2013) stated that stress is a normal physical response to events that threatened or upset an animal’s balance in some way. Generally, stress refers to a state of threatened homeostasis, but precise clinical definitions, causes and biological measurements have been controversial and confusing (Clark et al., 1997; Hackney, 2006). A persistent threat may result in new adaptation that can be detrimental or advantageous to man’s interest (Stott, 1981). According to Clark et al. (1997), a persistent threat may lead to hyperactivity of the neuroendocrine system which impairs rather than contributes to well-being. Harvey et al. (1984) posited that the natural environment is composed of various potentially stressors. According to Lee (1993), environmental stress is not limited to climatic factors but extends to nutrition, housing and any stimuli that demand a response from the animal to adapt to new circumstances. ILO (2006) documented that high noise can result in stress and contribute to cardiovascular, circulatory problems and digestive problems; psychological disturbances and symptoms such as nervousness, sleeplessness, reduced performance and changes in social behaviour in the infected. Wiepkema (1992) posited that the severity of the stress stimulus experienced by an individual is also determined by the quality of its social contacts with conspecifics and men. When stressed and an adequate solution is not available, vertebrates experience a state of uncertainty (Wiepkema, 1992). Also, Dobson and Smith (2000) stated that stress is revealed by the inability of an animal to cope with its environment, a phenomenon that is often reflected in a failure to achieve genetic potential. When individual vertebrates lose grip on their life conditions, stress symptoms appear and their welfare becomes problematic. Wiepkema and Koolhaas (1993) documented that present day research support the view that stress can originate when an organism experiences a substantial reduction of predictability and/or controllability (P/C) of relevant events. It is a basic requirement of life that the cells of an organism must be maintained within closely defined physiological limits. The maintenance of a constant interior milieu results from physiological and behavioural homeostatic adaptations. The physiological regulation of homeostasis is achieved by complex endocrine interactions (Harvey et al., 1984). The endocrine system is the collection of glands, each of which secretes different types of hormones that regulate the metabolism, growth, development, tissue function, sexual function, reproduction among other things. The word endocrine derives from the Greek words “endo” meaning within and “crinis” meaning secrete (Zimmerman, 2013). According to Boundless (2013) the endocrine system is a system of ductless glands that secrete hormones within specific organs and hormones are chemical messengers that are carried by the blood stream to different cells in the body. Harvey et al. (1984) reported that the hormones secreted from the endocrine glands principally achieve the physiological regulation of homeostasis. The endocrine system and the hormones it secretes enhance the ability of the body to respond to stressful stimuli.

Animal agriculturists are interested in improving the welfare of their animals. Without a better understanding of the basic biology, altered physiological processes involved in stress adaptability, it would not be possible to evaluate and improve animal welfare. Thus, this paper examined the endocrine system as an indicator and a means of evaluating animal welfare.

2. ANIMAL WELFARE

For the past 25 years, the welfare of domestic animals has been an important aspect of animal science (Ladewig, 2000b). “Welfare” is characterized by the absence of a number of aversive states such as pain, suffering, frustration, boredom etc (Ladewig, 2000b). Mormede (2000) documented that animal welfare is usually defined by reference to the adaptation efforts necessary to cope with its environment. “Welfare” refers to the state of an animal in relation to its environment and this can be measured (Broom, 1991). According to Ladewig and Ellendorf (2000) animal welfare relates to the animal’s ability to cope with its environment. Based on this premise, animal welfare is to be increasingly concerned with the biological needs and abilities of the animals to adapt in accordance with genetic predisposition and
multifunctional expression. Mormede (2000) stated that improvements of animal welfare should focus on the ways animal react to their environment and not only on changes in the environment, or at least they should take into account the individual diversity of adaptive responses and psychoendocrine reactivity. These reactivity traits can be selected for a better adaptation to environmental constraints, and the shaping of reactivity can also be obtained by early manipulation of the animals or specific training. According to Mormede (2000) available data show that production output and product quality may also be increased. Such a goal will be reached by a larger appraisal of animal environment interactions, combining behavioural and biological approaches and with the development of new strategies to evaluate comprehensively the endocrine mechanism of adaptation. Broom (1991) reported that both failure to cope with environment and difficulty in coping are indicators of poor welfare. Suffering and poor welfare often occur together but welfare can be poor without suffering.

3. EVALUATION OF ANIMAL WELFARE

Scientists have searched for objective ways to evaluate welfare (Ladewig, 1994; Ladewig, 2000a). According to Broom (1991) both failure to cope with environment and difficulty in coping are indicators of poor welfare. Suffering and poor welfare often occur together but welfare can be poor without suffering and welfare should not be defined solely in terms of subjective experiences. In our search for symptoms of reduced welfare, it is important to realize that just like “disease” cannot be diagnose by one or a few signs common for all types of sicknesses, so it is not possible to diagnosed reduced welfare by a few symptoms either (Ladewig, 2000a). The indicators of poor welfare include the following: reduce life expectancy, impaired growth, impaired reproduction, body damage, disease, immunosuppression, adrenal activity, behavioural anomalies, and self narcotization. As part of this evaluation, various ways to measure stress have been proposed, in that the demonstration of stress indicators could provide an objective information about how well farm animals kept under production conditions have adapted to their environment (Ladewig, 1994; Ladewig, 2000a).

(a) Indicators of Stress

Over the years, many potential indicators have been suggested, both behavioural and physiological stress indicators as well as production, fertility and disease related indicators. To guarantee the welfare of an animal, we must search for symptoms (or stress indicators). According to Wiepkema (1992), stress symptoms occur under conditions of lowered predictability and/or controllability of the environmental situation. Neuroendocrine changes associated with stress may reduce the immune and reproductive capability. Ladewig (2000b) suggested the observation of stress symptoms such as changed behaviour, altered secretion of hormones, altered heart rate, reduced fertility and many more. Ladewig (2000b) suggested that, in addition we may conduct various behaviour tests (open field test, devated plus maze test, human approach test, tonic immobility test and many more). From a model developed by Moberg (1987), it was proposed that the best indicators of animal suffering from stress is the development of a pre-pathological state, i.e., a stress related change in biological function that threatens the animal’s well-being. Examples of such pre-pathological states would be a suppression of the immune system, the loss of reproductive events critical for normal reproduction, or the development of behaviours that would lead to such undesirable acts tail-biting or excessive fighting. Although, the performance of disturbed behaviour has adaptive value, it simultaneously demonstrates an overtaxed and unhealthy state (Wiepkema, 1992). Although, determining the existence of such pre-pathological states is not convenient, their existence is currently the only defensible indicator of an animal suffering from stress (Moberg, 1987). Both the occurrence of one dramatic life event and a long lasting low predictability and/or controllability of relevant events may lead to chronic stress symptoms with a pathological character. The coherence of pre-and-post
pathological symptoms is decisive for an evaluation of individual welfare (Wiepkema and Koolhaas, 1993). According to Kumar et al. (2012) a single measure of stress might not be a reliable indicator and it is usually more informative to combine multiple indicators of stress to assess animal welfare. Popular measures of stress such as alterations in hormonal profiles can be complemented with behavioural and immunological changes. A list of stress symptoms indicate some stage of serious welfare problems. Their occurrence should not be typical of animals living in a farm. However, if at all this is the case, such system should be corrected and replaced by more appropriate system as soon as possible (Wiepkema and Koolhaas, 1993). On the other hand, if no symptoms of reduced welfare are found, we can give a limited warrantee concerning the welfare of the animal (Ladewig, 2000b).

i. Endocrine System as Indicator of Stress

Betterhealth Channel (2012) reported that the endocrine system is made up of glands that secrete chemicals called ‘hormones’ into the blood or surrounding tissues. Betterhealth Channel (2012) documented that some of the roles of the endocrine system include growth, repair, sexual reproduction, digestion and homeostasis (constant internal balance). The endocrine system is a tightly regulated system that keeps the hormones and their effects at just the right level. Throughout life, the endocrine system and the hormones it secretes enhance the ability of the body to respond to stressful internal and external stimuli. Hormones play a crucial part in regulating physical health including metabolism, sexual function and development among others (Above Stress, 2012). The adrenal cortex releases glucocorticoids (about 50 different related hormones), the adrenal medulla releases epinephrine. These two endocrine responses comprise the two primary component of the stress response. Wiepkema and Koolhaas (1993) reported that moderate stress may be necessary to optimize vigilance. The stress response is good response to acute stress but an unhealthy response to chronic stress. Wikipedia (2013) posited that physiological stress represents a wide range of physical responses that occur as a direct effect of a stressor causing an upset in the homeostasis of the body. Upon immediate disruption of either psychological or physical equilibrium, the body responds by stimulating the nervous, endocrine and immune systems. The reaction of these systems causes a number of physical changes that have both short and long term effects on the animal’s body. The endocrine system allows not only the individual organism but also the species to survive (Schwartz, 2013).

Endocrine systems may be used as indicators of stress in two ways. The primary role of a hormone may be a part of the homeostastic response to a stimulus (e.g. adrenaline, corticosteroids). The amplitude of hormone response may correlate with the severity of the stimulus and any change indicates that the body is responding (Smith and Dobson, 2002). Alternatively, a hormone may have a key role in normal body function (e.g. reproduction) and stress may deleteriously alter the hormone, signal prevents normal function. This demonstrates that the stimulus was sufficiently severe that homeostasis mechanisms were unable to maintain normal function. Stress may affect reproduction by reducing LH pulse amplitude and frequency. The LH surge may also be delayed. Several mechanisms may account for these effects, both the hypothalamus and pituitary. Corticosteroids have a broad yet fundamental, role in homeostasis and have been used as primary indicators of stress for many years. Excess corticosteroids can be detrimental, so the concentration is controlled through the Hypothalamus-Pituitary-Adrenal (HPA) axis by multi-level feedback mechanisms (Smith and Dobson, 2002). According to Betterhealth Channel (2012), one way of achieving this is through “feedback loops”. Under field and experimental conditions, after an initial large response, prolonged stimulation leads to a gradually reducing plasma corticosteroid concentrations. This has been interpreted as a reduction in perceived stimulus severity or habituation to the stimulus and the animal deemed “less stressed” and its welfare “better”. However, this reduction may be due to the intrinsic control mechanisms designed to prevent prolonged increases in corticosteroid concentrations. The stress signal at higher brain levels may still be present and the animal may still be experiencing the stimulus as aversive.
Thus, the welfare interpretation of corticosteroid concentration may differ during the time course of a stress response. A greater understanding of the mechanisms controlling corticosteroid secretion at each level of HPA is required to determine what is the correct interpretation at any one point. While stress inputs may reduce over time, hormone negative feedback is a major factor reducing hormone responses. Smith and Dobson (2002) suggested that when interpreting hormone data for animal welfare purposes, it is important not to interpret a reduction in hormone concentration due to intrinsic hormone control mechanisms as a reduction due to a decrease in the stress stimulus.

4. COPING AND ADAPTATION TO STRESS

Coping with stress is part of everyday life (Scaffer, 1996). Coping refers to the ability of the individual (animal) to control its environment and temperament that encompasses the individual variability of emotional processes (Lazarus, 1993). Animal welfare as documented by Mormede (2000) is usually defined by reference to the adaptation efforts necessary to cope with its environment. Broom (1991) reported that both failure to cope with environment and difficulty in coping are indicators of poor welfare. Suffering and poor welfare often occur together but welfare can be poor without suffering. Individual vertebrates are characterized by the flexible way they cope with stressors. Mammals and birds provide good examples of coping behaviour. Individual vertebrates appear to cope with stressors in a predominantly sympathetic or parasympathetic way (Wiepkema, 1992). The endocrine system together with the nervous and immune systems helps the body to cope with different events and stresses. Mormede (2000) reported that permanent adjustments to maintain the ‘milieu interieur within physiological limits despite variable environmental conditions are permitted by homeostatic mechanisms involving most physiological systems. However, when the pressure from the environment becomes excessive, or in case of psychological threats, new defence mechanisms are initiated, collectively referred to as stress response (Selye, 1973). According to Mormede (2000) some pioneers of adaptation/stress physiology recognized that part of stress response was the result of emotional arousal elicited by environmental stimulations, and this aspect was further given more attention (Mason, 1971).

According to Lazarus (1993), it was recognized that the brain plays a central role in adaptation/stress mechanisms. The CNS collects from the external (via sensory organs) and internal environment information necessary for the maintenance of homeostasis; it gives significance to this information in terms of danger or threat, as related to personal expectations, past experience and opportunities for control, finally, it initiates the adaptive responses, including behavioural adjustments and neuroendocrine changes to meet the energy requirements for the behavioural response and to maintain homeostasis (Mormede, 2000). Tsigos and Chrousos (2002) reported that activation of the stress system leads to behavioural and peripheral changes. The performance of highly repetitive behaviours has been shown to help animals cope with environment containing little or unvaried stimulation (Friend, 1991). According to Tsigos and Chrousos (2002), these behavioural and peripheral changes improve the ability of an animal to adjust homeostasis and increase it chances to survive. Tsigos and Chrousos (2002), further reported that the stress system coordinates the adaptive response of the animal to stressors of any kind. Schwartz (2013) reported that adaptive responses to more prolonged stresses also occur. For example, in states of starvation or malnutrition, there is reduced production of thyroid hormone, leading to a lower metabolic rate. A lower metabolic rate reduces the rate of consumption of the body’s fuel and thus reduces the rate of consumption of the remaining energy stores. This change has obvious survival value since death from starvation is deferred. Malnutrition also causes a decrease in the production of gonadotropin and sex steroids reducing the need for fuel to support reproductive processes. According to Dantzer and Mormede (1983), these concepts about adaptation and stress have long been shown to be operative for the analysis of the way farm animals deal with their environment.
5. EFFECTS OF STRESS ON THE ENDOCRINE SYSTEM AND ON ANIMAL WELFARE
Moderate stress is necessary to optimize vigilance (Wiepkema and Koolhaas, 1993). While prolonged and continuous stress which is termed chronic stress has drastic effects on the body of the animal (Bryant, 2013). Long term chronic stress disorders are serious matters which can lead on to other serious health conditions associated with the endocrine or hormonal system e.g. thyroid dysfunction (Above Stress, 2012). The three most serious common effects from long-term stress are adrenal fatigue, neurotransmitter imbalances or deficiencies and hormone imbalance. Each of these conditions leads to a list of debilitating symptoms (Perkins, 2012; Above Stress, 2012). When the endocrine system is not functioning properly, an animal cannot cope with stress effectively. This results in a vicious cycle where the weakened endocrine system creates more stress and the higher levels of stress continuously weaken the endocrine system the more. Above Stress (2012) reported that some of the most common effects of stress on the animal’s body include: aggressive behaviour, respiratory interference and these affect the well-beings of farm animals. Another of the most significant effects is that stress suppresses and weakens the immune system, leaving the animal’s body vulnerable to colds, flu and other possible health conditions. When left unchecked, it can actually aggravate existing health conditions and create new ones and exacerbate existing symptoms. The solution is to reduce as much as possible and then find ways of coping and managing the stress that cannot be removed (Perkins, 2013; Etim et al., 2013). Behavioural changes in concert with proper nutrition, appropriate veterinary services among others can aid tremendously in dealing with the deleterious effects of chronic stress exposure (Hackney, 2006).

6. CONCLUSION
The endocrine system provides an essential mechanism called homeostasis, that integrates body activities and at the same time ensures that the composition of the body fluids bathing the constituent cells remain constant. Physiological stress represents a wide range of physical responses that occur as a direct effect of a stressor causing an upset in the homeostasis of the body. Upon immediate disruption of either psychological or physical equilibrium, the body responds by stimulating the endocrine system among others. The reaction of these systems causes a number of physical changes that have both short and long-term effect on the animal’s body. Improvement of animal welfare should focus on the ways animals react to the environment and not only on changes in the environment or at least one should take into account the individual diversity of adaptive responses and psychoendocrine reactivity. These reactivity traits can be selected for a better adaptation to environment. The concepts about adaptation and stress have long been shown to be operative for the analysis of the way farm animals deal with their environment. Globally changing structure in agricultural animal husbandry has continued to bring new challenges to the science of animal welfare. One problem with determining practices that promote the best welfare for livestock is in defining and measuring physiological welfare. In future, new technologies should also be judged from the standpoint of animal welfare. Moreover, stress endocrinology is a multidisciplinary area, and there is need for more communication and interaction among fields of study.

REFERENCES


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