Chapter

Introductory Chapter: Applications of Stress Endocrinology in Wildlife Conservation and Livestock Science

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1. Introduction

Animals have contributed towards the progress of mankind in many ways such as through biomedicine, scientific research, domestication and farming, zoo animals and aquaculture [1–5]. The key concept of animal welfare underpins the quality of life of an animal while living under human management [6]. Animal welfare is a complex subject which takes into account the environmental and management factors that influence the physiological, behavioural and emotional (well-being or affective) state of animals [7, 8].

Animals such as elephants, dolphins, birds and dogs can display complex cognitive ability guided by processes such as perception, learning, memory and decision-making [9, 10]. Emotion in animals involves complex physiological, behavioural, immune, cognitive and morphological responses that enable them to generate behaviours to cope against stressors [11]. There are specific physiological markers of pain and stress that enable researchers to evaluate the welfare of animals from a quantitative viewpoint and relate the data to understand how the animal perceives its environment [12, 13].

2. Stress endocrine response

Disruption to an animal's homeostasis initiates activation of the hypothalamic-pituitary-adrenal (HPA) axis (**Figure 1**), the result of which generally prepares the body for some form of exertion [14, 15]. The hypothalamus releases corticotrophin-releasing hormone (CRH) [15], signalling the anterior pituitary to release adreno-corticotrophic hormone (ACTH) [15], which circulates in the blood resulting in an increased output of glucocorticoids from the adrenal cortex. Glucocorticoids, in which cortisol is pivotal to larger vertebrates and fishes, while corticosterone occurs mainly in birds, amphibians and reptiles, act to partition energy through gluconeogenesis, in preparation for a physical challenge, by diverting storage of glucose away from glycogen/fat and mobilising glucose from stored glycogen. Following the stress response, cortisol acts to initiate PH balance, as a blocker within a negative feedback process to CRH secretion, and motivates the animal to replenish energy stores and to restore homeostasis [16].

Under chronic stress, prolonged activation of the stress response will have deleterious downstream effects including the inhibition of normal reproductive function, suppression of the immune system, tissue atrophy and inhibition or abnormal growth rate (**Figure 1**). It can also lead to abnormal behaviours such as stereotypies [17].

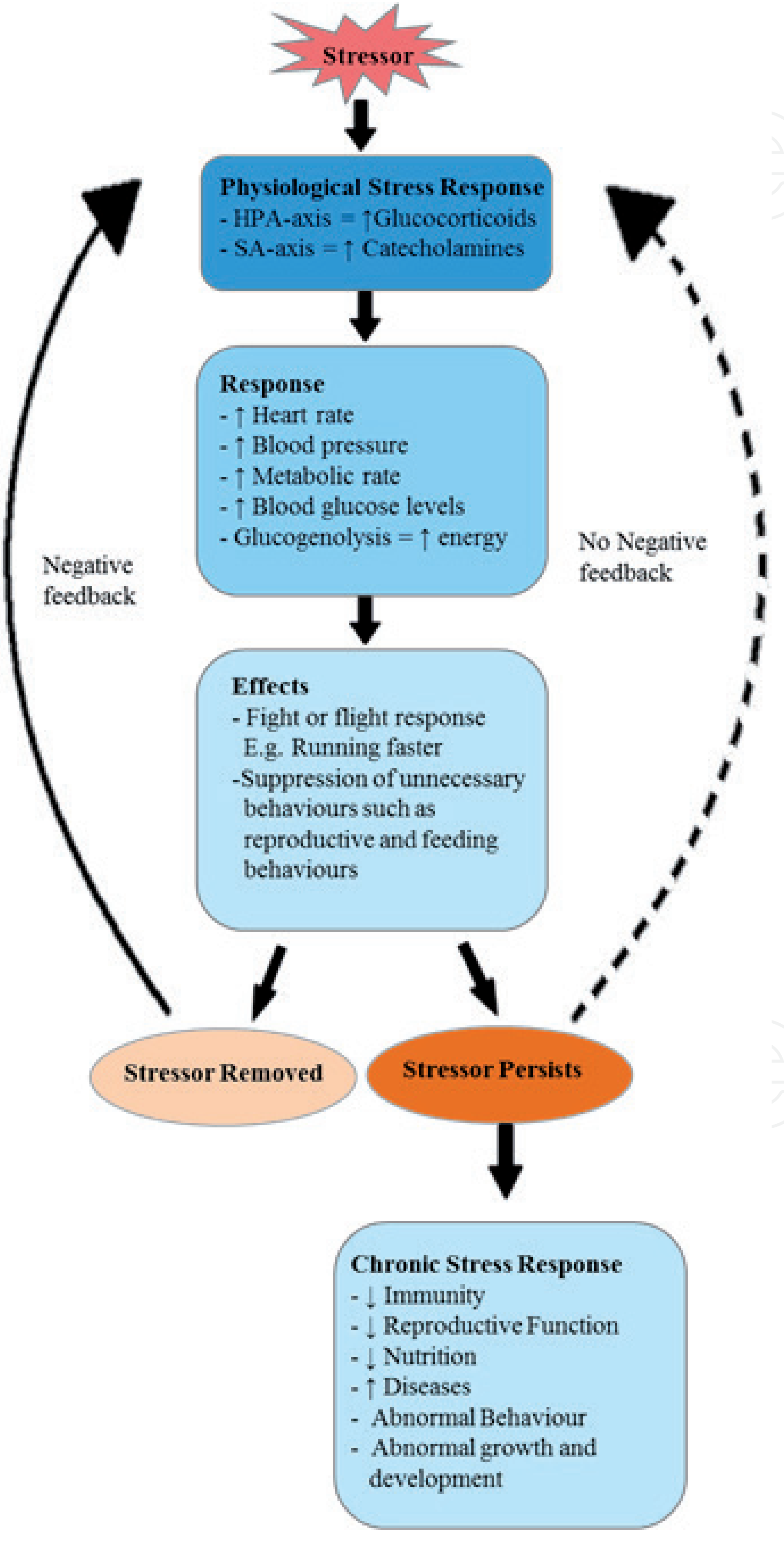

Figure 1.
Diagram demonstrating the generation of stress response under acute and chronic stress. Feedback loop for the HPA axis deactivation is shown using arrows.

3. Applications of stress hormone measurements

The present book has been focused on the applications of endocrine data in animal studies using examples from wildlife and production animals. Below I have provided examples of the stress hormone monitoring applied in wildlife and production animal research.

3.1 Wildlife translocation

Translocation programmes and captive breeding programmes are keys to species recovery [18]. Minimising the impact of multiple stressors on animals should be a major consideration when translocating animals from the wild into captivity and when maintaining animals in captivity [19]. Stress is a vital factor to consider when assessing animal welfare both in captivity and in the wild. Captive translocated animals are faced with a variety of stressors (i.e., factors that tend to change homeostasis) such as capture, transportation to release sites and captivity that may affect the settling of the animal into their new environment [20]. Short holding periods of animals can cause significant short-term stress responses, which may last for several days, weeks or months depending on the adaptive capacity of the species and the individual animals [21].

For example, the Fijian ground frogs (*Platymantis vitianus*) which IUCN listed as "endangered" species were translocated from their wild habitat into a captive breeding programme. As shown in **Figure 2**, the levels of stress hormone (corticosterone-indexed using urinary corticosterone metabolites) were elevated within 6 h post-translocation and remained elevated for up to 15 days before returning to pre-translocation levels.

3.2 Evaluation of stress in zoo wildlife

Animals in zoos encounter various environmental stimuli which may initiate a stress response such as noise, human interactions and climate [22, 23]. Stress hormone monitoring provides a quick and reliable quantitative way of assessing the stress responses of animals in zoos. An example is a study by the IUCN that listed marsupial,

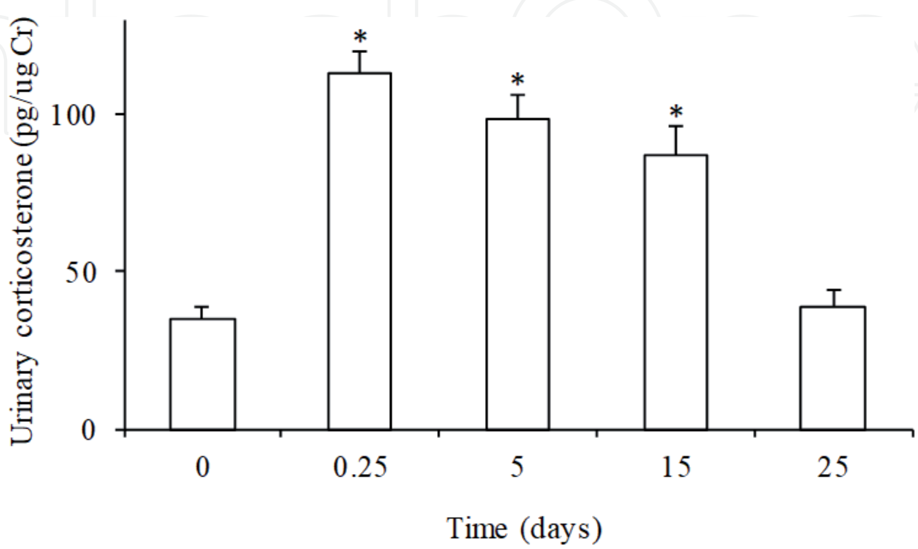

Figure 2.
Mean (+S.E.) urinary corticosterone in Fijian ground frogs. Sample sizes are N = 40 (for baseline urinary corticosterone), N = 10 per group for urinary corticosterone during transportation (6 h) and captivity at 5, 15 and 25 days.

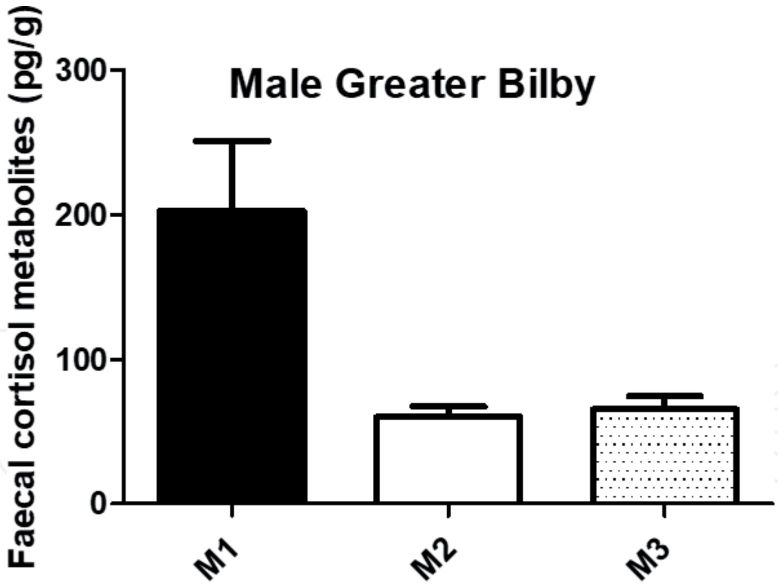

Figure 3.
Macrotis lagotis. Mean (±SEM) faecal cortisol metabolite profiles of male (N = 3) greater bilbies over the 21-day sampling period.

the greater bilby (*Macrotis lagotis*), as a "vulnerable" species. Using stress hormone monitoring through quantification of faecal glucocorticoid metabolites (FGMs) provided new knowledge on the stress responses of the bilbies to zoo activities and management interventions. As shown in **Figure 3**, the male bilbies showed variation in the levels of FGMs which was related to their health status and activity data.

Male 1 had chronic arthritis; however, males 2 and 3 showed no signs of illness or injury. Male 2 took part in activities such as shows, while male 3 did not. However, their mean FGM levels were apparently very similar (**Figure 3**).

3.3 Stress evaluation in farm animals

Stress can impact on the quality of livestock through effects on production traits such as growth and development, reproduction, meat quality, milk production and body condition [24–28]. Robust and sensitive non-invasive physiological tests that can detect subtle changes in the HPA axis activity to acute physical or psychological stressors in livestock are the focus of our research programme. Currently animals with the red meat, dark cutters are not identified until carcase assessment post-slaughter. The industry is seeking a preslaughter method to identify animals that are likely to produce dark meat (DC), which could allow either preslaughter intervention such as drafting out and preventative treatment of individuals or post-slaughter intervention.

A number of possible technologies exist, such as non-invasive faecal cortisol monitoring. Cortisol testing is considered paramount to the behavioural stress response because studies have found a good degree of positive association between traditional measurements of fear behaviour, body temperature and blood cortisol profiles in cattle [29]. Furthermore, individual differences in stress responses at slaughter may explain differences in rate or extent of pH decline between animals from a similar genetic and rearing background, slaughtered under similar conditions.

Dark-cutting or non-compliant beef is defined from the loin muscle (longissimus thoracis) having an ultimate pH (pHu) >5.7 or an AUSMEAT colour score >3 (Meat Standards Australia (MSA)). The major determinant of pHu is the concentration of muscle glycogen (muscle sugar) at slaughter. In the muscle post-mortem, glycogen forms lactic acid, which is correlated with the pH decline that occurs at

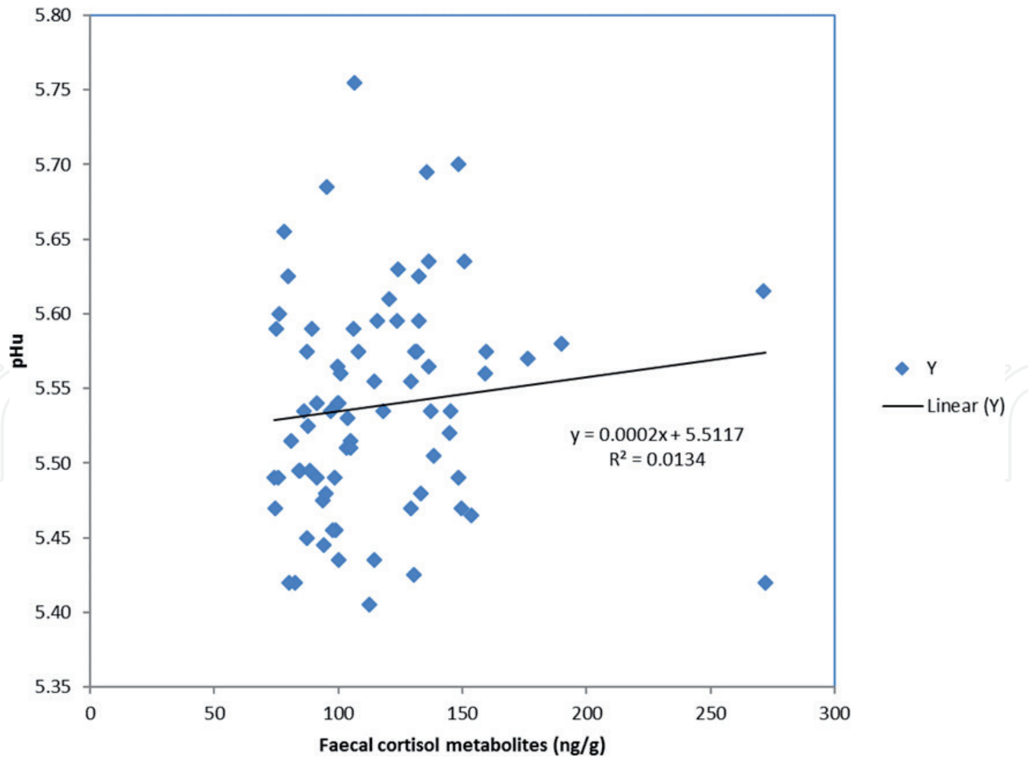

Figure 4.
Correlation between stress and ultimate pH of red meat using example of second-cross lambs. Both traits measured post-slaughter.

post-mortem. Lactic acid is one of the major contributors of lowered pH of the muscle from a pH of around 7, which is standard in a living animal, down to a pHu of around 5.4–5.7 within 24 h. If there is an insufficient muscle glycogen concentration at slaughter, there is limited formation of lactic acid, resulting in a high pHu and dark meat. Consumers do not like the appearance of dark beef, and high pH meat has shorter shelf-life and is unsuitable for vacuum packaging due to high susceptibility of spoilage [30].

Research with second-cross lambs demonstrated strong correlation between post-slaughter faecal cortisol metabolites and lamb meat quality traits, such as pHu—an indicator of dark-cutting (**Figure 4**). This positive correlation indicates that input of more stress on the farm could reduce meat quality through increased pH of red meat.

4. Conclusion

The above case studies demonstrate the wider applications of stress endocrinology in wildlife and production animal science. Hormone monitoring provides a useful tool for evaluating the health and welfare of animals when used in combination with health, behaviour and other relevant husbandry information.

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