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Animal welfare: A measurable science

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Introduction

There has been a dramatic rise in the interest of animal welfare from the general public, producers, extension educators, veterinarians, and scientists. This interest in animal welfare results from the fact that consumers are becoming increasingly aware of how their animal products are produced and are demanding high standards of animal welfare. The issue of animal welfare has been a major force that has impacted animal agriculture in Europe and will do so in North America in the near future.

Pork producers have a moral obligation to provide good welfare for the animals in their care. Good animal welfare starts with factors such as the following:

- Correct nutritional requirements
- Correct pen and feeding space allowance
- Ad libitum water supply
- An environment free from cruelty and abuse
- Correct medication and treatment or euthanasia of sick and injured animals

These issues should be a key component for any efficient animal production system.[1,2]

There is a great degree of variability among societies, cultures, and among individuals on the issue of animal welfare. However, moral positions on animal welfare have changed as people have come to know more about the complexity of animal organization, the sophistication of animal behavior, and the degree of similarity between farm animal species and humans. Both research and the subsequent media coverage of this research has contributed to this change of attitude.[1] If we assume that domestic animals have rights, but humans have a right to use domestic animals (e.g., in agriculture, for companionship, and for experimentation), then most of us are faced with the following question: What are the appropriate standards of welfare that we should provide our animals? Judgment of animal welfare should not be made by relating animal welfare to one's personal philosophy or to the expectations of the society. Animal welfare should be measured objectively and scientifically. The assessment of welfare can be conducted in an objective and scientific way, which is independent of any moral considerations. It is then, once the welfare is assessed, that a society or an individual should integrate moral views with biological facts and sanction or condemn a particular activity or animal production practice.[1,2,3]

A definition of stress

Stress is a difficult term to define because, unlike a disease, stress has no specific etiology or outcome. Individual animals differ in the way that they respond to the same stressful situations.[4] Several definitions of stress have been presented in the literature, but a useful one is the following by Moberg: "Stress is the biological response to an event that the individual perceives as a threat to its homeostasis. That event which is perceived as a threat is defined as the stressor."[4]

Homeostasis refers to the maintenance of a body variable in a steady state by means of physiological or behavioral regulatory actions.[2] Therefore, stress involves both a disruption of homeostasis and the process initiated to re-establish homeostasis.[5] Selye observed a general, non-specific biological response when animals were subjected to a number of stressors, which he eventually defined as the general adaptation syndrome (GAS). The first stage of the GAS is the activation of the hypothalamic-pituitary adrenal (HPA) axis. The second stage consists of the animal physiologically coping with the stressor (resistance stage) and, finally, the third stage refers to the animal no longer coping and adapting to the challenge of the stressor.[6] A stressor is the stimulus that causes disruption of homeostasis, and it can be physical, psychological or physiological.[7] Stressors in animal production include crowding, weaning, mixing unfamiliar animals, transportation, dehorning, tail docking, and unfamiliar environments.[7-11]

The stress response

The stress response is the process whereby the animal alters behavior and physiological functions in order to maintain homeostasis. There are a series of biological responses that are available to the animal once a stressor is perceived. These responses are behavioral, autonomic, and neuroendocrine. Animals have evolved these biological responses to enable them to ensure that they have the best chance of survival in the wild.[4]

The behavioral response is the most effective mechanism that the animal has in coping with stressors. For instance, if there is insufficient space for the animal, it may simply remove itself from the location or situation. However, behavioral responses may not be appropriate or effective for all situations.[12] For example, in animal production, the behavioral response may be insufficient since confinement may restrict the behaviors necessary to cope with the situation.[4] Nevertheless, Hemsworth and Barnett concluded that some component of behavior is likely to be involved in every stress response.[13]

In addition to the behavioral responses, the physiological responses that are used by the animal when faced with a stressor are elicited in three series of events, with the full elicitation of these physiological responses dependent on the time that the animal is exposed to the stressor and the success of the biological responses in coping with the challenge.[5] The first of these biological responses is the autonomic response, which is often referred to as the response of the sympathetic adrenal medulla (SAM) axis. When an animal is exposed to a stressful situation, a primary "fight-flight" reaction occurs and the SAM axis is activated.[14] This response may include escape or avoidance responses and the secretion of catecholamines such as adrenaline (epinephrine) released from the adrenal medulla and noradrenaline (norepinephrine) released from the adrenal medulla and the nerve endings from the sympathetic nervous system.[13] As a consequence, further physiological responses occur, such as an increase in the heart rate, higher blood pressure, contraction of the stomach and sphincters, suppression of intestinal movements and activity, glandular stimulation and glycogenolysis.[15-17] Glycogenolysis, the utilization of muscle and liver glycogen, provides an energy source for the animal (glucose) and prepares the animal to react quickly to a threatening situation.[14] The catecholamines have a half-life of only several minutes.[1] This initial reaction to the stressor is short-lived, and if the stressor is not removed. a second series of physiological reactions occurs.[13]

This second series of physiological reactions involve the stimulation of the HPA axis. The second series is often called an acute stress response and is part of the GAS and is a corticosteroid-dependent mechanism. The first stage of the response of the HPA axis is the release of corticotrophin-releasing factor (CRF) from the hypothalamus via interleukin 1B.[1,17] This results in the release of adrenocorticotrophic hormone (ACTH) from the adenohypophysis (anterior pituitary). There are various hormones that modulate the release of ACTH, such as arginine vasopressin (AVP) and oxytocin.[17] ACTH is released into circulation within 2 to 5 minutes of a stressor and reaches peak concentrations 5 to 20 minutes after stimulation.[18] ACTH is transported to the adrenal cortex via the blood and stimulates the secretions of cortisol and corticosterone. These glucocorticoids promote gluconeogenesis, the conversion of protein to carbohydrates (glucose or glycogen) which is used as an energy source for the increase in metabolic requirements. Therefore, during this stage, homeostasis is achieved in which the increased demand for energy is met by increased metabolic performance. This physiological state of stress generally disappears when the stress is removed and has no major effects on the welfare of the animal other than depletion of energy reserves. There are some situations when an acute stress response could have detrimental effects on animal production. These include effects on meat quality[19] and reproduction.[15,18] The acute stress response is effective in allowing the animal to adapt to changes in its environment.[13]

A third series of physiological events occur if the stressor continues and this response is the chronic stress response.[20] This is corticosteroid-dependent and comes at a physiological cost to the animal. In order to assess the biological cost of stress and to assess long-term welfare problems, Moberg developed a model of animal stress. The stress response is considered in three main stages. The first stage involves the animal's perception of a threat to homeostasis; the second involves the animal's response, and the third involves the consequence for the animal.[23]

Stress in the short-term, i.e., activation of the SAM and HPA axes, has only a minor biological cost to the animal. However, a chronic stress response, i.e., a prolonged activation of the HPA axis, results in significant change in biological function. It is at this stage when the animal enters the prepathological state and is vulnerable to infectious disease and depressions in growth and reproduction.[4]

Functioning-based or homeostasis approach to welfare assessment

The welfare of an animal is its state as regards to its attempts to cope with its environment.[24] When animals are faced with conditions in which they cannot cope, their individual fitness may be reduced as a consequence of physiological and behavioral responses. Attempts to cope include the functioning of the body repair system, physiological stress responses, immunological defenses, and behavioral responses.[3] The welfare of the animal can, therefore, be assessed in a scientific way that is independent of moral considerations.[1]

Using the definition of Broom, welfare risks can be studied at two levels: the behavioral and physiological responses of the animal to the challenge and, secondly, the consequent biological cost to the animal (reduced biological fitness).[24] The behavioral and physiological stress responses of the animal to the environment are the responses that the animal is using to return to homeostasis. Substantial and prolonged behavioral and physiological responses can have effects on biological fitness by affecting growth performance, reproduction, injury, health, and survival.[1,13]

It should, however, be recognized that there are some limitations with this approach in assessing animal welfare. Our current knowledge may not allow detection of less serious risks to animal welfare; however, more subtle risks to animal welfare should be reflected in changes in the biological fitness of the animal and the magnitude of the behavioral and physiological response.[3,13]

In utilizing this approach to welfare assessment, the following behavioral and physiological measures can be used:

Behavioral measures of welfare

If an animal perceives a threat to its homeostasis, it will change its behavior accordingly. Behavioral measures are useful indicators of long-term problems for an animal.[1] The simplest of the behavioral measures is the measurement of problems with movement—for example, if the environment prohibits the animal from moving, e.g., a slippery floor, the animal is lame, or the animal is closely confined. Behavioral measures such as locomotion, vocalization, and avoidance have been used to measure acute stress in animals. Other short-term behavioral responses include orientation reactions, startle responses, and defensive or flight reactions. Redirected behaviors and stereotypes are examples of the behavioral change that may be indicative of long-term welfare challenges. Pigs living in an environment without adequate environmental stimulation may develop aggressive behavior and may engage in tail biting.[2] These behaviors may be a consequence of a lack of resource, or some specific frustration. There is considerable diversity both within and among species in behavioral responses when animals are confronted with a stressor; however, a feature of all these situations is the animal's lack of control of its interactions with environment.[1]

Physiological measures of welfare

The measurement of the activity of the SAM and HPA axes are amongst the most useful in assessing how difficult it is for the animal to cope with short- and long-term problems.

Heart rate

Measurement of the heart rate is a useful measure of a short-term physiological response to a stressor, provided that the measurement itself does not cause too much disturbance to the animal. Handling by affecting movement increases the metabolic rate and will affect the heart rate of the animal. Activation of the SAM axis increases the heart rate and the activation of the HPA axis decreases the heart rate.[1] Thus, heart rate should not be used as the only measurement of the stress response.

Blood pressure

Measurement of blood pressure can be a useful indicator of long-term welfare problems. Blood pressure measurements must be carefully interpreted as the procedure can have an effect on the animal.[1]

The adrenal axis

It is difficult to measure changes in the SAM axis (catecholamines) due to rapid and varied responses.[23] Catecholamines may be a useful measure of the acute stress response if they are sampled within one minute of exposure to the stressor in catheterized animals.[1] The primary measurement of the stress response has been the measurement of adrenal corticosteroids.[23] These corticosteroids inhibit ACTH secretion; therefore, it is difficult to measure ACTH as it is removed from the blood so quickly. Blood sampling may be used to measure activity of the SAM and HPA axes. Care must be taken as the procedure used to sample may evoke increased release of ACTH and corticosteroids. Concentrations of corticosteroids rise two minutes after the stress occurs; therefore, blood sampled within a two-minute window via an indwelling catheter or via jugular venipuncture may be used.[1]

Alternative sources for cortisol assessment have also been investigated. In saliva, cortisol exists in its free form and therefore reflects the biologically active, unbound fraction in cortisol.[25-27] Salivary cortisol has been used as a measure of acute stress response in pigs by Parrott and Misson, Ruis et al., Bradshaw et al., de Jong et al., and Geverink et al.[28-32] In order to minimize the effect of handling and sampling on salivary cortisol, it is necessary to train animals to be accustomed to the procedure.

Fecal cortisol is an alternative to saliva and has been assessed in other species. In general, increases in fecal cortisol are apparent within 48 hours of exposure to a stressor. Concentrations of cortisol in fecal samples have been found to increase within 24 to 50 hours of exposure to a stressor such as an ACTH challenge. Fecal cortisol would therefore be indicative of a chronic and not an acute stress response.[33,34]

Urinary corticosteroids have been assessed as an alternative to plasma corticosteroids in pigs by Hay and Mormede.[35] In urine, cortisol is found in its free form. The free cortisol from the plasma enters the urine via glomerular filtration of blood by the kidneys. The plasma cortisol thus accumulates in the urine so that the voided urine represents the average free cortisol circulating between urinations.[36] In order to use urine or feces as alternatives to plasma cortisol, it is important to be able to determine the time over which the urine or fecal sample was produced and the frequency of urination and defecation, and to ensure that urine or feces were the major routes of corticosteroid excretion.[37]

ACTH challenge

An ACTH challenge may be conducted to assess the adrenal function of the animal. If an animal is chronically stressed, the adrenal gland is chronically hyperstimulated by ACTH. The adrenal gland under stress undergoes hyperplasia (increases in size and weight), and the capacity of the gland to secrete cortisol increases.[1] Adrenal gland responsiveness in pigs can be assessed on the basis of the cortisol response to an intramuscular injection of 50 IU ACTH. Blood samples taken 60 minutes after an ACTH injection were found to reflect maximal response by Hennessy et al.[38] An ACTH challenge is a useful measure of activation of the HPA axis in pigs.

"Biological fitness" measures of welfare

Prolonged elevated concentrations of corticosteroids affect reproduction,[12,18] immune function,[21] metabolism, and growth performance.[22] Therefore, abnormal function of these systems is an indication of a welfare problem with the particular animal.[4] Therefore "biological fitness" variables such as reproductive success, life expectancy, and weight changes are important indicators of animal welfare.

Conclusion

In conclusion, the functioning-based or homeostasis approach offers scientists the best assessment of animal welfare with our current state of knowledge. These scientific measures of animal welfare can be used to assess the welfare of an animal and then, finally, moral views can be incorporated with biological facts to assess whether the welfare of an animal is at risk.

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