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Wilson G. Pond • Alan W. Bell

Adaptation and Stress: Animal State of Being

Stanley E. Curtis
University of Illinois, Urbana, Illinois, U.S.A.

INTRODUCTION

Sound animal husbandry depends on application of scientific knowledge of many aspects of the biology of the animals we keep. Environmental aspects of animal care are based on application of principles of animal ecology in design, operation, troubleshooting, and correcting deficiencies. They are crucial to both economical animal production and responsible animal stewardship.

ADAPTATION

Any environment has factors that threaten to overwhelm its inhabitants. Animals are driven to adapt to their environments, and thereby remain fit. Adaptation is an animal's adjustment to its environment, especially a nonideal one, so its life and species can continue.

Realistic Expectations

Animals sometimes fail to adapt; they experience stresses of various kinds. So they may feel well, fair, or ill (described later). We should expect an animal to experience well-being mostly, fair-being sometimes, ill-being once in a while. When an animal shows signs of failing to adapt, correcting the problem may not be easy.

Animal Responses

An animal's environment consists of a complex of elements, each of which varies over time, across space, in intensity. Most combine in additive fashion as they affect an animal.

Internal steady state

An animal normally maintains steady states over time in the various aspects of its internal environment. This mechanism homeokinesis is the general basis of environmental adaptation. When an animal perceives a threat or actual shift in some internal or external feature, it reacts to preempt or counteract that change. It attempts to keep an internal steady state, and thereby to survive and thrive. The essence of an animal's homeokinetic mechanisms is similar to that of a home's simple thermostat: a negative-feedback control loop.

Coping

An environmental adaptation refers to any behavioral, functional, immune, or structural trait that favors an animal's fitness its ability to survive and reproduce under given (especially adverse) conditions. When an animal successfully keeps or regains control of its bodily integrity and psychic stability, it is said to have coped.

A given stimulus complex provokes different responses by different animals, and even by the same animal from time to time. Tactics vary. Its response depends on the individual's inherent adaptability, accumulated life experiences, current adaptation status, and current ability to muster extraordinary responses.

STRESS

Failure to Adapt

Stress occurs when the stimulation an animal is experiencing goes beyond that individual's ability to adapt. Environmental stress may ensue when the environment changes, adaptation status changes, or an animal is moved to another environment. When an animal has coped, its response is an adaptive response. But there always are limits to adaptability. When attempts to adapt fail, the response is a stress response, the stimulus a stressor.

Failure to adapt stress has negative consequences for animal state of being. Understanding untoward consequences of such breakdowns for bodily integrity is relatively clear-cut. But psychic disturbance or collapse is often not even recognized. It is now believed that humans can survive stress only to the extent we can cope

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psychologically. Likewise, Ian J. H. Duncan[1] thinks that animal state of being has to do with animal feelings.

COPING

The numerous possible strategies and tactics for counteracting stimuli an animal usually has at its disposal imbue flexibility and power to the animal's adaptive responses when it faces an adverse environment. But when an animal responds to environmental stimuli, it is not necessarily under stress or distress. Responding to stimuli is a normal biological feat routinely carried out by every normal, unstressed creature that lives. Typical scenarios of environmental stimuli and animal responses run a wide gamut. Modified versions of nine schemes created by Donald M. Broom and Kenneth G. Johnson[2] follow:

1. In the face of stimuli, internal steady state is maintained with ordinary basal responses. State of being is very well.
2. Complete adaptation achieved with minor extraordinary response. Stimuli provoke adaptation. Fitness and performance may be briefly compromised, but wellness promptly returns.
3. Sometimes, animal response to stimuli over time is neither extraordinary nor adequate. For so long as the impingement continues, fitness and performance may be reduced minor stress and fairness ensue but after that, wellness returns.
4. Stimuli elicit some minor extraordinary response, but over time this is inadequate for complete adaptation. Both fitness and performance decrease awhile (fairness), after which wellness returns. Stress is present at scheme 4 and above.
5. An animal's extraordinary response over a long period achieves only incomplete adaptation. Although fitness remains relatively high, performance is reduced. The animal experiences overall fair-being.
6. To completely adapt, an animal sometimes must mount an extreme response. During adaptation and recovery periods, fitness and performance decline. The animal is only fair.
7. Despite some extraordinary response to stimuli, complete adaptation is not achieved long term. Fitness and performance decline; the animal becomes ill.
8. In some cases, an extreme response does not result in complete adaptation even long term reducing the ill animal's fitness and performance.
9. An environmental stimulus may be so enormous and swift that the animal succumbs before it can respond.

Measuring Impacts

Impacts of environmental impingements are estimated by measuring their effects on the animal. The same environment that would quickly chill to death a newborn piglet might be well-tolerated by the sow. Differences in thermal adaptabilities of the two put the same environment in the piglet's cold zone, the sow's neutral zone.

Tolerance Limits, Collapse, and Death

An animal ordinarily is confronted by more than one stimulus at a time. Stimuli also impinge sequentially. Animals in practical settings generally need to cope with multiple stimuli.

A range of tolerance sets limits for an environmental factors within which an animal can readily cope, thrive, reproduce, survive i.e., experience wellness. Outside this range are the upper and lower ranges of resistance. If an animal resides long enough outside its tolerance range, it eventually will die due to environmental stress.

Kinds of Stress Response

There are four kinds of stress response. Some reduce an animal's state of being; others enhance it. *Understress* occurs in simple environments that lack certain features (social companions, play items) (stimulus underload). Sometimes animals give behavioral signs of understress (lethargy; exaggerated, repetitive activity apparently devoid of purpose (stereotypy); some other disturbed behavior). *Eustress* (good stress): situations of extraordinary responses, but which the animal finds tolerable or even enjoyable. *Overstress*: environmental situations that provoke minor stress responses. *Distress* (bad stress): circumstances that provoke major stress responses. Judging from signs of negative emotions (anxiety, fear, frustration, pain), distress causes an animal to suffer, but to what extent is not yet known.

STATE OF BEING

An animal's state of being is determined by any response the environment requires and the extent to which the animal is coping. When readily adapting, the animal is well. When having some difficulty, it is fair. When frankly unable to cope, it is ill. In reality, environments that make animals ill are not uncommon. But it is our moral responsibility to minimize such occasions and correct them to the extent possible.

Scientific Assessment

Our understanding of an animal's state of being depends on generally accepted observations, scientific laws and theories, and unique individual experiences. In 1983, Marian Stamp Dawkins and Ian J. H. Duncan believed that the terms ''well-being'' and ''suffering'' would be very difficult to define.[3] That remains the case two decades later. Until more is known, it is unlikely that kept animals will enjoy more of the objectively defined well-being for which we all should hope. Following are some questions to be asked in assessing animal state of being.[4] Is the animal

- Having its actual needs met, achieving internal integrity and psychic stability, coping, adapting?
- Showing frank signs of sickness, injury, trauma, emotional disturbance?
- As free of suffering as possible, experiencing mostly neutral and positive emotional states?
- To some extent able to control its environment, predict it, live harmoniously in it?
- Performing growing, reproducing, lactating, competing, working at a high level?
- Showing signs of imminent illness or being in a vulnerable state?

Animal Needs

When an animal *actually* needs something it does not have, it is experiencing a deficiency. At any moment, an animal has specific needs based on its heredity; life experiences; bodily, psychic, and environmental conditions. Given its needs at a given point, then, the biological, chemical, and physical elements of its environment determine whether those needs are being fulfilled.

Functional Priorities Under Stress

A performing animal is one that is producing some product, progeny, or work or performing some activity useful to humans. The rate of performance of a constitutionally fit animal usually is the best single indicator of that animal's state of being.[5] When its performance wanes, the animal probably is not as well is it could be.

When bodily resources become limiting as often happens during stress some processes must be downplayed so others more vital at the moment can ascend. The goals of individual survival (maintenance) and species perpetuation (reproduction) in that order are an animal's top priorities. Other performance processes may not be critical to an individual's survival or reproduction, so they are least protected and least spared.

When an animal responds to any stimulus, its maintenance needs invariably increase. Resource expenditures in support of maintenance processes increase progressively along with stress intensity, so the animal's potential performance capabilities progressively decrease.

How Animal Responses Affect Performance

Environmental stimuli provoke an animal to respond, which in turn can influence performance processes in five ways.[5] Responses:

1. Alter internal functions. As an unintentional consequence, certain stress hormones secreted as part of long-term adaptive or stress responses can reduce a foal's growth rate.
2. Divert nutrients from other maintenance processes and performance. A nursling piglet that increases metabolic rate simply to keep its body warm in a chilly environment will have fewer nutrients left for disease resistance and growth.
3. Directly reduce animal productivity. Thermoregulatory responses to hot environments sometimes include reducing internal heat production. Eggs laid by heat-stressed hens weigh less than normal, due partly to decreased feed intake, partly to a homeokinetic reduction in egg synthesis (which gives off heat).
4. Impair disease resistance. As a consequence, e.g., individual feedlot cattle under social stress due to aggressive group mates are more likely to become infected and diseased.
5. Increase variation in animal performance. Individual animals differ in responses to stimuli and therefore in performance even when residing in the same adverse environment. Stress increases individual variation in performance.

Other Considerations

Other environmental aspects of animal care include the concepts of optimal stimulation, enrichment, predictability, controllability, frustration, and helplessness.[6]

CONCLUSION

Foundations of success in environmental aspects of animal care are the fundamental principles of animal

ecology and their application. Every situation is complex and unique. There are no general recipes in these matters. The fundamental principles have been set forth here.

REFERENCES

1. Duncan, I.J.H. Feelings of Animals. In *Encyclopedia of Animal Rights and Animal Welfare*; Bekoff, M., Meaney, C.A., Eds.; Greenwood Press: Westport, CT, 1998.
2. Broom, D.M.; Johnson, K.G. *Stress and Animal Welfare*; Kluwer Academic Publishing: Amsterdam, 1993.
3. Duncan, I.J.H.; Dawkins, M.S. The Problem of Assessing ''Well Being'' and ''Suffering'' in Farm Animals. In *Indicators Relevant to Farm Animal Welfare*; Smidt, D., Ed.; Martinus Nijhoff Publishers: Boston, 1983.
4. CAST. *The Well being of Agricultural Animals*; Curtis, S.E., Ed.; Council on Agricultural Science and Technol ogy: Ames, IA, 1997.
5. Curtis, S.E.; Widowski, T.M.; Johnson, R.W.; Dahl, G.E.; McFarlane, J.M. *Environmental Aspects of Animal Care*; Blackwell Publishing Professional: Ames, IA, 2005.
6. *The Biology of Animal Stress: Basic Principles and Implications for Animal Welfare*; Moberg, G.P., Mench, J.A., Eds.; CABI Publishers: New York, 2000.