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The Effects of Ethostasis on Farm Animal Behavior: A Theoretical Overview

A.F. Fraser
and
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The solution of animal problems that occur on the farm requires a holistic and multidisciplinary orientation and analysis, as well as the acquisition of new investigatory tools by both veterinarians and animal scientists. Field studies may be modeled under more controlled laboratory conditions, but the most relevant investigations must take place on the farm, and the first level of analysis should be ethological. Domestic animal behavior can be monitored and quantified like any other factor in the animals' environment; yet it has been virtually ignored in the development of new livestock husbandry systems.

The relationships between husbandry systems, disease problems, and behavioral factors are extremely complex but are known to be interrelated and interdependent. It is postulated that severely constricting husbandry practices can generate anomalous behavior — a phenomenon termed ethostasis. Applied ethology now has a vital and central role to play in investigating the problems that have been created by modern intensive livestock production.

The purpose of this overview, therefore, is to delineate some of the husbandry factors that can give rise to behavioral anomalies, and to describe various categories of anomalous behavior that are of diagnostic value in clinical appraisals of stressful husbandry. Ready identification may facilitate recognition and correction of problems that may lead to lowered productivity, diseases, and economic losses; it may also foster concern for the animals' welfare from an ethical, as well as an economic, perspective. These circumstances highlight some of the contemporary animal husbandry problems that warrant further research and quantitative analysis.

Zusammenfassung

Die Lösung von Problemen mit landwirtschaftlichen Nutztieren erfordert eine holistische und multidisziplinäre Orientierung und Analyse sowie den Einsatz von neuen Untersuchungsmethoden durch Veterinäre und Wissenschaftler im tierischen Bereich. Untersuchungen ausserhalb von Laboratorien können nun an Hand von Modellen unter kontrollierten Bedingungen innerhalb von Laboratorien durchgeführt werden, aber die hauptsächlichsten Untersuchungen müssen auf der Farm stattfinden, und der erste Schritt in der Analyse sollte ethologischer Natur sein. Das Verhalten eines landwirtschaftlichen Nutztieres kann wie jeder andere Faktor in der Umwelt eines Tieres beobachtet und quantifiziert werden; dies wurde jedoch in den modernen Viehhaltungssystemen praktisch ignoriert.

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Die Beziehungen zwischen Viehhaltungssystemen, Krankheitsproblemen und Verhaltensfaktoren sind äusserst komplex, man weiss jedoch, dass sie miteinander verknüpft und voneinander abhängig sind. In diesem Artikel wird gezeigt, dass besonders einschränkende Viehhaltungspraktiken zu abnormalem Verhalten führen—ein Phänomen, das als *Ethostasis* bezeichnet werden kann. Die angewandte Ethologie spielt heute eine vitale und zentrale Rolle in der Untersuchung der Probleme, welche die moderne intensive Tierhaltung mit sich bringt.

Zweck der folgenden Ausführungen ist es, einige der Faktoren in der Tierhaltung aufzuzeigen, die zu abnormalem Verhalten führen können, und die verschiedenen Kategorien von abnormalem Verhalten zu beschreiben, die von diagnostischem Wert sind in der klinischen Erfassung von Stress in der Tierzucht. Rechtzeitige Identifizierung ermöglicht das Erkennen und die Korrektur von Problemen, die zu verminderter Produktivität, Krankheiten und wirtschaftlichen Verlusten führen können; dies mag auch die Rücksicht auf die Wohlfahrt der Tiere stärken sowohl vom ethischen wie auch vom ökonomischen Gesichtspunkt aus. Diese Umstände werfen ein Licht auf die gegenwärtigen Viehzuchtprobleme, welche eine weitergehende Forschung und quantitative Analyse rechtfertigen.

Introduction

Interpretation

Classical ethology has frequently hesitated to pursue the interpretive aspects of behavior studies, taking instead a relatively narrow, objective approach, and concentrating on restrained examinations of observed behavior. Ultimately, however, as behavioral information accumulates, it begs some broader interpretation. This is particularly true in the case of ethology as it is applied to domesticated animals, whose behavior is extremely dependent upon the complexities of the control involved in their husbandry, especially when confinement and constraint are the main features. Veterinary ethologists, in particular, cannot escape the responsibility of interpreting some of the behavior patterns they study as dependent variables resulting from such control. Then, applied ethologists must begin to place these interpretations within a broader perspective. This article is an attempt to make some progress toward this goal.

The Role of Ethology and Its Limits

One important element in achieving a broader perspective involves the use of our intuition and sense of empathy. These can be valuable subjective tools in observing and understanding animal behavior, although they are often inhibited in the name of a quasi-scientific "objectivity." While objective description remains the essential ingredient of good science, a mechanistic and often reductionistic approach to ethology may lead to a very narrow or biased understanding of observations. Intuition and empathy are also valuable assets in practicing good animal husbandry and veterinary medicine. Use of these faculties does not mean the adoption of a simplistic anthropomorphic attitude toward animals but, rather, a willingness to place some trust in our sensitivity to animals, in order to facilitate the work of the ethologist, veterinarian, and animal husbandryman, as well as to benefit the animals under their care or investigation.

While it is not the intention here to examine the merits and limitations of the behavioral sciences, certain other values and attitudes relevant to applied ethology should be addressed. With farm animals, concentration on purely economic concerns and narrow utilitarian values can severely limit the capacity for responsible compassion, which is the primary ethical ingredient of good animal husbandry. The attitudes of the stockman and related variables should always be considered in any study of farm animal behavior.

Husbandry Systems

With the advent of new intensive methods of animal husbandry, many new behavior problems and new diseases have appeared, while others have become more common. In terms of economic losses and animal welfare, the need to learn the causes and best methods for control of diseases in farm livestock remains a major concern. Therefore, there is an even greater need for some comprehensive way of interpreting animal behavior. Husbandry systems that are now in widespread use require rigorous reappraisal in terms of their effects on behavior. However, because of economic constraints, it is virtually impossible to mimic field conditions under even ideal laboratory conditions. Thus, many systems are put into use without adequate field testing. It is our belief that severely restrictive husbandry leads to behavioral abnormalities; this phenomenon has been referred to as "ethostasis." Further, recognition of this phenomenon may comprise the essence of any appraisal of the acceptability of innovative animal husbandry.

Concepts and Terminology

Among ethologists, there has often been some hesitancy to define the general terminology of their subject, but a common understanding of the meanings

of these terms nevertheless does exist. Definitions of certain broad terms are required and are given in this review to serve as a basis for clear and orderly comprehension, to provide a sound base for exercises on interpretative ethology, in particular.

In applied ethology, *behavior* can be given a two-tier definition as follows. (1) Behavior is the overt form of the composite neurophysiological functions of animals, individually and collectively. (2) Behavior is, itself, the function by which the animal mediates dynamically with its environment. Normally, therefore, behavior is an adaptive response to some change in the internal (physiological) or external (physical/social) environment. The adaptive role of behavior will be discussed below.

There are numerous behavior patterns in animals. Each functional pattern has recognizable similarities in appropriate contexts of mediation. These similarities constitute the *norms* of behavior, for a given species and a particular environment, considering both the physical and social elements of that environment. However, departures from the established norms in behavior do occur.

Littlejohn (1969) has noted that since *normal* behavior can be shown to relate to relevant and complex circumstances, it must be possible to show that *abnormal* forms of behavior relate to their own specific circumstances as well. Littlejohn emphasized the need to recognize, in a systematic fashion, this relationship between abnormal behavior and its principal physical causes. In his work, he made exclusive reference to organic factors such as specific diseases.

Behavioral abnormalities can be considered to fall into three categories.

1. Idiosyncratic Behavior

Certain highly individualized forms of unusual behavior patterns can occur in some animals. Some examples include bulls adopting "dog-sitting" postures,

cows rolling their tongues, and horses knocking stable doors with their forefeet. These manifestations are analogous to vacuum activities, which become habits over time. Characteristically, they lack clinical or subclinical significance since they are entirely coexistent with other evidence of normal environmental mediation.

2. Clinical Behavior

In the manifestly sick animal, the array of signs and symptoms of illness or dysfunction frequently includes significant alterations of behavior. Such clinically aberrant behavior assists in drawing attention to the dysfunction and also aids in its precise identification. Clinical and subclinical behavioral signs combine organic (*i.e.*, infectious or nutritional) sickness and abnormal behavior. A subclinical nutritional deficiency, for example, may lead to cannibalistic behavior or pica.

3. Anomalous Behavior

Medical irregularities are termed *anomalies*. Irregular forms of behavior occur in animals that are not manifestly clinically ill. These behavioral anomalies exist in characteristic forms, each of which is an ethological entity with its own mediative significance.

The more commonly recognized forms of anomalies in veterinary science are physical, but behavioral anomalies can be classed as etho-anomalies. Some forms of anomalous behavior can be grouped into major syndromes. Such etho-anomalies occur, characteristically, in animals that have been placed under controlled environments, either in high-density groups at one extreme, or in a state of solitary confinement at the other (Bryant, 1972; Jackson, 1976; Wood-Gush, 1973).

Ethostasis

The term *ethostasis* (Fraser, 1974) has recently come into use to describe the circumstances in which management practices, by preventing or restricting the major behavioral patterns inherent

in animals, can generate various types of abnormal behavior.

Stressful Factors

Many ambient factors can be seen to affect behavior by producing adaptive responses and, as such, are potential stressors (Table 1). The ambient factors that can cause abnormal behavior must be individually identified if they are to be appreciated and controlled. The cause-and-effect relationship between environmental stressors in chronic control conditions and anomalous behavior have already been investigated by applied ethologists who have worked independently, although along essentially parallel lines (Kiley-Worthington, 1977; Ewbank, 1978; Fraser, 1980; Fraser and Fox, 1978; Sambras, 1981). These investigators have found that some forms of husbandry evidently create many stressors.

Stress Criteria

Formerly, it was generally considered that the presence of stress was difficult to determine in animals. However, a report delineating the valid use of the term *stress* in a veterinary context, by Fraser *et al.* (1975), has been so widely accepted that we can conclude that this problem has been satisfactorily addressed. That report states:

We cannot hope to delineate any single biological phenomenon or principle by defining the term stress, but we do require that the term be defined sufficiently that it can be used in a tangible way in discussing a variety of veterinary problems. The term should be used where there are extremes of bodily states, but should not imply any measurable parameter which necessarily summates various reactions to adversity. Furthermore, the term should encompass states of coping as well as those of collapse, and states involving disturbed behavior as well as those involving altered physiological function.

TABLE 1 Variety of Environmental Stressors Associated with Chronic Control of Livestock That May Act Cumulatively on Animals

| Stressor origin | Stressor item |
|-----------------|--|
| Management | Improvident welfare Nutritional levels Husbandry standards Environmental variables Hygienic standards Noise levels Attritive management policies |
| Space | Social density Peck order status Group size Permitted movement Area per head Isolation |
| Constraint | Hardware controls (Stalls, Tethers, Races, Crushes) Special suppressive devices Restrictive housing systems |

With these considerations in mind, we offer the following definition: An animal can be said to be in a state of stress if it is required to make abnormal or extreme adjustments in its physiology or behavior in order to cope with adverse aspects of its environment and management. Extreme behavioral adjustments (*i.e.*, dysstatic rather than homeostatic) can only be corrected by removing the animal from the pathogenic environment or by adjusting those factors in the environment that were responsible for creating the ethostatis (Table 2). Therefore we can say that a husbandry system can be considered stressful if it makes abnormal or extreme demands on the animal and thereby sets up a condition of ethostasis. Finally, an individual factor, such as an extreme of temperature, may be called a stressor if it contributes to the stressful nature of a particular system of husbandry. Social homeostasis, such as crowding together to keep warm, is adaptive, but a practice like this may have negative or maladaptive consequences if it interferes with food intake or other normal functions.

Accumulated observations now clearly show that appraisal and recognition of etho-anomalies comprise a sound and logical means whereby stress in animals can be identified. Furthermore, it is clear that biochemical or physiological data alone may be misleading or inconclusive (Anchel, 1976). It has been found, in studying anomalous behavior within various husbandry systems that, although stressors can be cumulative (Craig, 1981), animals are capable of tolerating a sum of stressors, up to a certain level. This critical level for combined stressors shows variability among individuals.

Confinement Husbandry Systems

Modern forms of animal husbandry are progressively developing into systems that usually increase the density of animals held in groups (Dougherty, 1976). Although some farm animal ethologists have begun to examine these newer methods of husbandry, there is inadequate knowledge about the responses of the animals kept under such management systems (Ewbank, 1969; Loew, 1972; Duncan, 1974; Kiley-Worthington, 1977; Sambras, 1981). Some examples of restric-

tive husbandry practices currently in use are listed below:

1. Prolonged enclosure within narrow stalls is a common feature in some forms of modern swine husbandry.

2. In association with (1), some swine practices also utilize a chain tether, which affixes a harness around the pig by a chain to a point on the floor.

3. Isolated stalls are used for the husbandry of calves in systems of veal production.

4. The flock densities of birds in enclosure systems now being used for laying hens in the poultry industry have reached an extreme level. Frequently, three birds are contained within one cage of spatial dimensions originally designed for one bird.

5. Fattening swine are frequently held in dense groups during the later stages of their growing periods.

6. Feeding cattle are kept in groups, the densities of which are still increasing.

7. Many dairy cattle operations now keep the animals in an indoor system, with set daily routines of movement from holding quarters to milking quarters and back.

8. Recreational horses are frequently maintained in separate stalls and are not given the same quantity and quality of work and exercise that they were formerly afforded.

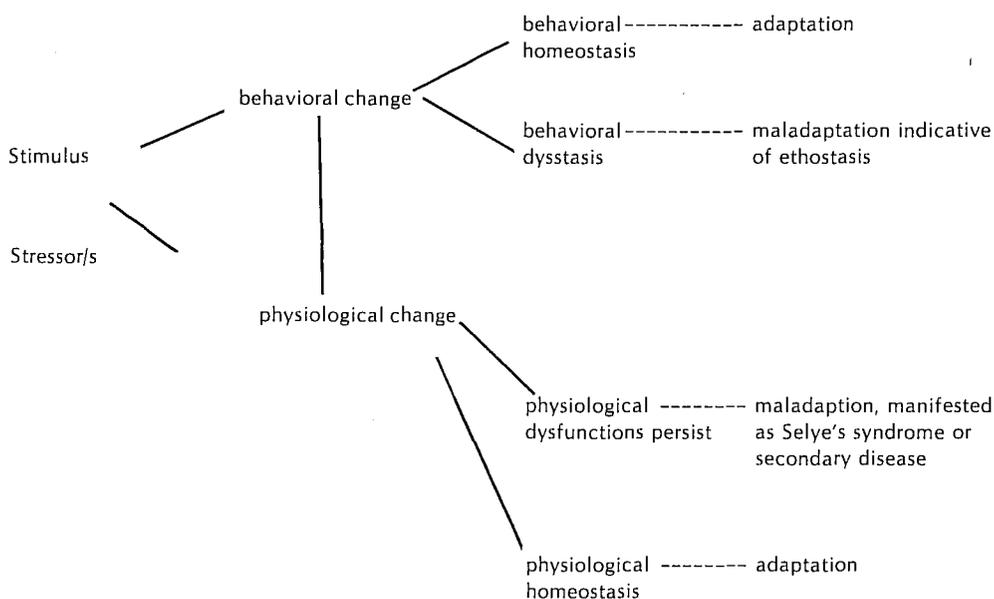
9. Sheep are permanently restricted indoors in certain new husbandry systems.

These and many other examples of ethostatic circumstances may not appear to be particularly noxious events but, given frequent repetition over time, they can become significantly stressful (Fox, 1977).

Crowding

When population density reaches a level that produces etho-anomalies, it can be termed *crowding* (Davis, 1971). Even those species of domestic animals

TABLE 2 Possible Consequences of Environmental Stimuli/Stressors



that have become very adaptable to tightly packed conditions have a limited ability to adjust to population densities that are sufficiently high so as to prohibit social hierarchical systems from operating satisfactorily. For example, the form of aggression exhibited between animals to maintain a stable peck-order under lower-density conditions is usually no more than a gesture. But when the subordinate animal does not have adequate space to avoid the aggressor's gesture, the aggressor will begin to display true agonistic behavior. Space is required for avoidance. As soon as injuries result, subordinate animals that are marked by them become subjected to increased aggressive attention. Within a comparatively short time, injuries from agonistic encounters can be found on several of the animals in an affected group.

Observations

Species Forms of Etho-Anomalies

Swine. When confined within stalls such as feeding or farrowing stalls for extended periods of time, swine frequently exhibit anomalous behavior that takes the form of habitual mouthing of stall parts. Confined sows will indulge in chewing upon stall nipple-type automatic waterers for long periods of time. They will also engage in extended bar biting behavior on the metal piping at the front of their stalls. Further, swine crowded in pens will frequently show tail biting.

Cattle. In cattle, numerous forms of anomalous behavior can be seen in those systems of management that feature close confinement. Intersucking behavior can be observed in groups of young calves kept under crowded conditions within pens. Growing calves kept in confinement frequently display excessive self-grooming. They may also lick a pen fixture excessively, forming pools of saliva on the floor beneath such fixtures. Ex-

cessive grooming in calves can lead to the formation of hair balls in the alimentary canal, with such clinical consequences as acute obstruction and rumen ulceration.

Another form of anomalous oral behavior has been observed more recently in adult dairy cattle that are closely confined in pens during non-lactating periods. This etho-anomaly appears as "tongue-rolling," which involves extending the tongue and rolling it within the mouth (Fraser, 1980).

"Orthostasis" in calves is a further behavioral problem in which the calf spends a large proportion of its time each day in a static standing position. When newborn calves are confined in isolation, particularly when they are unable to see others and are confined on unsuitable or uncomfortable flooring, the total quantity of time spent each day in lying down is markedly reduced, compared with the norm. Orthostatic calves are subject to fatigue and, in due course, this fatigue predisposes them to neonatal disorders such as diarrhea (Fox, pers. comm., 1981).

Sheep. Among breeding ewes in experimental husbandry systems that involve chronic confinement within rows of pens of limited size, anomalous behavior, in the form of "wool-picking" or "wool-pulling," has been observed. The sheep pull with their mouths on the strands of wool on the backs of the sheep near them. Ultimately, subordinate sheep in the affected group lose their long-fiber wool over the back or even over the entire body (Fig. 1).

Poultry. The anomalous behaviors associated with crowding among poultry have become common knowledge. The principal one is cannibalism, a less drastic form of which is feather-picking. Cannibalism can be seen in adult poultry; it can also be seen in young poultry at the brooding and rearing stages. This behavior pattern has led to the widespread



FIGURE 1 Wool pulling in sheep. The sheep on the left still has its full fleece; that in the center has been almost completely "fleece"; that on the right is partially fleeced.

and routine debeaking of young birds, which serves to obscure this anomalous behavior. Broiler poultry kept on deep litter may develop serious problems from ingesting large quantities of the litter. Boredom, social facilitation, and nutritional deficiency pica may be involved in this behavior.

Various forms of displacement activities in poultry have also been reported by Duncan and Wood-Gush (1974). These displacement activities, when increased in intensity and incidence, can become etho-anomalies.

Horses. Among domestic animals, the stable vices of horses probably constitute the most well-recognized form of anomalous behavior. These have recently been well reviewed by Houpt (1981). They are understood to be consequences of boredom that result when horses are kept in stables for long periods of time without the provision of adequate exercise or activity. The most common forms of such etho-anomalies include cribbing and wind-sucking. A horse is described

as a cribber when it habitually sets its upper incisor teeth on a firm object such as a manger and sucks in air, usually making a characteristic grunting sound at the same time. In time, this aerophagia has a chronic adverse effect on the animal's health. Wind-sucking is simply a form of cribbing in which the horse does not need to bite onto an object while the air is being sucked in.

Weaving in horses is another form of stereotyped behavior. Stereotypes, previously documented by Fox (1971), can become etho-anomalies when their intensity and incidence become excessive. In weaving, the horse rocks from one side to the other. A similar etho-anomaly is stall-walking—when the animal moves back and forth in a repetitive, precise type of movement that usually involves stepping actions of the forefeet. This may be sustained for such long periods of time that the progressive drain on the animal's energy becomes significant. In these cases, the animal's physical condition deteriorates. Another etho-anomaly is commonly known as "sourness." The temperament of a sour horse

deteriorates as it passes feces that contain a significant proportion of undigested material. Then, it will participate only reluctantly in activities for which it has previously been adequately trained.

General Etho-Anomalous Entities

Many of those who are investigating etho-anomalies in farm animals suspect that animal producers are not sufficiently aware that their animals need quality and variety in the environment. Inadequate attention to either of these conditions can increase the stressful character of some forms of controlled environments to the point where etho-anomalies become inevitable. The range of etho-anomalies that can appear in this kind of situation is much greater than those described in the previous section and includes:

Freezing— This indicates tonic immobility or catatonic behavior. It can occasionally be observed in ruminants when an animal has been subjected to aversive stimulation in circumstances from which it is unable to escape. The behavior has various manifestations, but they are all characterized by a generalized hypotonic state that resembles conscious collapse.

Coprophagia— The eating of feces may be normal behavior in very young animals, but not in adults. In adult horses, it is usually observed in individuals that are kept under chronic control and are not provided with adequate exercise or diversionary activities. It occurs, together with "anal massage," in swine kept under intensive husbandry (Sambraus, 1979).

The Orosthena Syndrome

Mouth-based stereotypies constitute a complex syndrome that covers a variety of manifestations of pathologically excessive mouthing behavior in animals. Several manifestations have already been described by Kiley-Worthington (1977). Most forms of orosthenia are associated with the simultaneous occurrence of chronic control, on the one hand, and hypostimulation (reduced stimulation), on the other. Examples of these kinds of

behavior are shown in Table 3.

Discussion

The environmental circumstances, given here as forms of chronic control or chronic restriction, impose two main deficiencies in the physiology of perception, namely, hypostimulation and hypokines-thesia (diminished sense of body movement).

It is important to differentiate between *stimuli* and *stimulation*. Stimuli are perceptible external factors, whereas stimulation is the excitation process that occurs within the sensorium of the perceiving animal. The quantity of stimuli can affect the type of stimulation that results. Stimuli of the same type eventually lose their potential value for further stimulation, but a deficit in one type of stimulus can be compensated by an increase in another, alternative stimulus, i.e., by variability. Stimuli contribute quantitatively to the quality of pooled stimulation through variability. Environmental quality, therefore, can be assessed on the basis of its potential for stimulus variability. In the absence of stimulus variability, it appears that anxious states can become established in an animal. These states then become manifested as etho-anomalies.

Abnormally decreased mobility and abnormally decreased motor function or activity are termed *hypokinesia*. This condition has multiple causes. The critical effect of this state is a marked reduction in the animal's sensation of its own movement.

The various forms of sense organs (in tendons, joints, and muscles) that respond to mechanical action, movement, position, touch, and pressure constitute a major source of the sensory input of animals. Among these kinds of input is gravity, which acts on the body variably, according to its movement and position. The sense of muscular effort that accompanies a voluntary motion of the body is termed kinesthesia. Dysfunctions of the

TABLE 3 Manifestations of Orosthena Syndrome and Associated Clinical Sequelae

| Examples of orosthena | Clinical sequelae |
|---|--|
| Crib biting and aerophagia in horses | Deterioration of physical condition; occasional colic |
| Tail biting in swine | Deterioration of physical condition; abscessed hindquarters |
| Bar biting in swine | Reduced production and subfertility in sows |
| Intersucking in calves | Hair ball in calves |
| Excess grooming in calves | Hair ball in calves |
| Wool pulling in sheep | Loss of fleece and impairment of physical condition |
| Tongue rolling in cattle | Unknown—possibly deterioration in physical condition |
| Feather pecking in poultry | Loss of feather cover; trauma |
| Excessive water drinking in confined horses, sheep (polydipsia nervosa) | Excessive water intake to 2 to 3 times normal quantity; bloating; possible bowel torsion |

sensory system resulting from reduced sensory input are evidently capable of causing adverse effects on environmental mediation, and anomalous forms of behavior are the result.

It is evident that altered behavior is one of the principal dysfunctions revealing stress, as it has been defined here. Altered behavior of this sort is manifested as frank anomalies. While it is generally recognized that stress alters behavior, the precise dose-response relationships remain to be elucidated. Thus, although many environmental features are clearly recognized as evident stressors, others are only putative stressors. This inconclusiveness is due to inadequate study of the subtle dose-responsiveness between stressors and behavior. For examples, noise *per se* is not necessarily a stressor, but an increase in this stimulus, in either volume or duration, will eventually lead to gross behavioral and physiological pathologies (Ekesbo, 1977).

However, we can say that the chronological sequence observed in many of the anomalous conditions described above

shows such a close, well-defined temporal relationship between stressor and anomaly that the connection between the two has been clearly demonstrated. Establishing this temporal relationship must be considered a primary requirement for "proving" a cause-and-effect relationship between certain stressors and anomalous responses. It is believed by some investigators that a considerable number of as yet unidentified etho-anomalies still await our recognition, definition, and report (Campbell, 1975).

Conclusion

It is postulated here that behavioral anomalies in animals are products of a phenomenon of ethostasis and that they can be assumed to conform to certain laws.

Five primary postulates concerning etho-anomalies can be stated as follows:

1. Beyond a critical sum, stressors generate forms of anomalous animal behavior that are specific and peculiar in their manifestations.

2. Etho-anomalies characteristically persist once they become established. The frequency of their manifestation is affected by remissions and exacerbations of the associated causal factors.

3. Etho-anomalies are "enzootic" in nature; they are limited to given circumstances and transmissible by mimickry.

4. Anomalous behavior in animals is inconsistent with the attainment of optimum health, welfare, and production.

5. Etho-anomalies constitute *prima facie* evidence of stress in an individual, or within a group of represented animals.

In the final analysis, humane treatment, animal health, and financial profits are more interdependent than they are mutually exclusive (Fraser, 1973). As Brantas (1975) states "Welfare is a relative concept. Profit is a matter related to welfare [cited in Anon., *Poultry Welfare Report*, 1981]. Determining the relationship between welfare and profit is an ethical matter." Applied ethology, in addressing the behavioral needs of the animal that must be taken into consideration to promote optimal health, can create the essential bridge between ethics (and animal rights) and profits.

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