AGONISTIC BEHAVIOR IN FOOD ANIMALS: REVIEW OF RESEARCH AND TECHNIQUES[1,2]

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ABSTRACT

One type of social behavior—agonistic behavior—is commonly observed among food animals. Agonistic behaviors are those behaviors which cause, threaten to cause or seek to reduce physical damage. Agonistic behavior is comprised of threats, aggression and submission. While any one of these divisions of agonistic behavior may be observed alone, they usually are found, in sequence, from the start to the end of an interaction. Food animals may show interspecific or intraspecific agonistic behaviors. Interspecific agonistic behavior has not been extensively studied but it is agriculturally important because farm workers may become injured or killed by aggressive food animals. Types of intraspecific agonistic behavior are: when animals are brought together, inter-male fighting, resource defense, inter-gender fighting and aberrant aggression. Common pitfalls in research on agonistic behavior among food animals include (1) too few replicates to detect a biological difference, (2) the assumptions of the analysis are not met, (3) only aggression and not submission or other agonistic behavior components are measured, (4) incomplete description of the behaviors are reported and (5) a complete, quantitive ethogram did not form the basis for selecting behavioral measures.
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Introduction

Common food animal species are social animals, that is, they show frequent interactions among conspecifics (Maple, 1975). In addition, food animals generally are kept in environments which allow social interaction. Social behaviors include touching and licking (grooming), sexual behaviors, maternal-young interactions and agonistic behaviors. Also, several behavior patterns (such as feeding) are facilitated by group-mates.

Social behaviors, for purposes of this review, may be divided into two general categories: (1) agonistic behavior—those behaviors that cause, threaten to cause or seek to reduce physical damage and (2) those that do not have as their goal causing or preventing bodily injury. This paper deals mainly with the former category. The objective of this review is to describe previous research and acceptable methods of designing and conducting studies of agonistic behavior in food-producing animals.

Definitions

Agonistic Behavior. The definition of agonistic behavior provided by Scott and Fredericson (1951) remains acceptable today. They defined agonistic behavior as the group of behavioral adjustments associated with fighting, which includes attack, escape, threat, defense and appeasement. The simplest explanation of the concept of agonistic behavior is that it is composed of the continuum of behaviors from threat to aggression to submission.

Threat. Threats refer to those species-specific vocalizations, odors, postures, facial or body movements that signal the intent to display aggression. In stable social systems, the threat causes immediate signs of avoidance or submission. In newly formed or unstable social groups, a threat may cause the recipient to threaten or a threat may precede an outbreak of aggressive behavior. Threats are usually subtle to the human observer and therefore difficult to measure objectively.

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Aggression. Aggression is one segment of agonistic behavior. Aggressive behavior is the most formidable to define. For example, workers are aggressive in their jobs and some females and males are sexually aggressive. Neither of these uses of the word aggression applies to this discussion of social behavior. Johnson (1972), noting that aggression has so many interpretations, suggested it has lost its meaning. The definition and classification of aggression is such a semantic problem that the first five chapters of a recent book on aggression research were committed to this problem (Brain and Benton, 1981). I prefer to define aggression as those species-specific behaviors associated with attack. Attack is those behaviors whose objective is physical injury. My definition of aggression does not include threats. To put the generally subjective behaviors called threats with the more objective behaviors called aggression weakens this potentially objective measure. Some researchers include threats in the definition of aggression (e.g., Ewbank and Meese, 1971) and some researchers do not (e.g., Brain, 1981). I prefer to measure threats apart from measures of aggression.

Submission. Submissive behavior is the least studied, least understood and yet very important segment of agonistic behavior. Submissive behavior is usually exhibited following either a threat or an aggressive interaction. Therefore, while showing submission, the submitting animal is stressed (McGlone, 1985b,c). Sumission includes species-specific behaviors, vocalizations and odors that signal non-aggressiveness and reduce further attack by conspecifics. Leshner (1981) suggested most submissive behaviors are learned behaviors associated with flight (from an attack) or appeasement, and that an animal must have been attacked at some time in his life in order to show submissive behavior. Submissive behavior may be objectively measured because these behaviors always follow either aggressive behavior or a threat and because each species has specific submissive postures.

Classifications of Agonistic Behavior

Older Views. Decades ago, each behavioral system (e.g., feeding, drinking, sexual and agonistic behavior) was thought to have a unique physiological basis. While interaction of neural, endocrine and other genetic and environmental factors could be described for most behavioral systems, such a unitary theory could not be developed for aggression (threats and submission were largely not considered in the older view). Thus Moyer (1968) proposed his now-classic description of eight situations in which aggression is shown. These include predatory, inter-male, fear-induced, territorial, irritable (e.g., pain-induced), sex-related, maternal and instrumental (e.g., learned) aggression. Each type of aggression was elicited in response to different environmental stimuli and each had a different physiological basis (although much overlap exists in physiological mechanisms underlying each type of aggression). The major criticisms of Moyer's scheme were that criteria for describing environmental stimuli were arbitrary, mechanisms underlying each type overlap, an excessive number of categories was used, the plan does not differentiate between offensive and defensive attack and no mention is made of the other segments of the agonistic behavior continuum, namely, threats (sometimes included in aggression) and submission.

A More Recent View. The more recent view of agonistic behavior is based on three major criteria: physiological mechansims, motor patterns shown during agonistic behavior, and the environmental situation. Adams (1979) reviewed studies of physiological mechanisms of agonistic behavior, and he identified three components of this behavior: offensive attack, defensive attack and submission. Each was shown to have unique but integrated neural mechanisms. Each component may occur in a variety of environments. For example, intermale aggression may only have the components of offense and submission, or a predator may show offensive attack while the prey shows defensive attack . The major difference between offensive and defensive attack is that defensive attack occurs in sequence with escape, avoidance or fear behaviors. Another more recent classification of aggression types is based on bite targets used during the encounter. Blanchard et al. (1977) pioneered this approach and it has been expanded by Brain (1981). Mice apply bites to different body regions in different situations. Whether or not farm animals utilize different targets of attack in different situations remains to be demonstrated.

A Classification for Food Animals. The first logical division in a classification scheme (table 1) for food animals is between interspecific and

TABLE 1. CLASSIFICATION OF AGGRESSIVE BEHAVIORS COMMON TO FOOD ANIMALS

Behavioral category	Definition-example
Interspecific aggression	
1. Maternal defense	Mother defends young against potential predator—ewe with lamb attacks dog.
2. Defense of territory	Animal attacks intruder—grazing bull attacks human.
3. Predation	Animal attacks, kills and eats another animal—hen catches and eats an insect.
Intraspecific aggression	
4. Aggression after grouping	Previously unfamiliar animals are brought together; they fight and a social structure or heirarchy results —pigs sorted by size, they fight.
5. Inter-male fighting	Adult males generally fight to win mates or territory—rams fight during breeding season.
6. Resource defense	When resources become limited, aggression increases—cattle fight with limited feed bunk space.
7. Inter-gender fighting	Males attempt to mount non-estrous females, aggressive behavior ensues—non-estrous sows attack a boar who attempted a mount.
8. Aberrant aggression	Wool-biting in sheep, naval sucking (all mammals, especially those early-weaned), ear and tail chewing in pigs, fence and pen chewing (all mammals), cannibalism or killing of young, feather and vent picking in hens and, possibly, hen hysteria.

intraspecific agonistic behavior. Interspecific agonistic behavior is most often a management problem with larger farm animals. Aggressive male animals (particularly bulls, boars and rams) can be dangerous because they can injure or kill farm workers. Food animals may set up a territory which, when violated by a human, provokes attack (territorial defense). Aggression towards humans from females is less common, but the lactating female may be a threat to workers due to maternal aggression or defense.

Another type of interspecific aggression—predatory aggression—is more rare. While some may argue that predation is a form of feeding behavior, it is clear tht some motor patterns used during predatory attack fit the definition of aggression. Only pigs and poultry are considered omnivores and thus may, on occasion, attack and eat a small animal.

Intraspecific agonistic behavior must be managed to optimize productivity. The most common management practice that induces aggression and submission is bringing together unfamiliar animals. Intraspecific mixing of unfamiliar cattle, sheep, swine, or poultry incites high, measurable levels of agonistic behavior. The agonistic behavior shown after grouping unfamiliar animals follows the continuum from threat to aggression and submission until a period of social stability (level of aggression not statistically different from zero) is reached. During this period of social stability, only an occasional threat or attack is necessary for an animal to reinforce its dominance. If greater amounts of agonistic behavior are observed, the group may have an unstable dominance order.

Inter-male fighting is observed in normally unaggressive flocks or herds of food animals during the breeding season (e.g., Scott, 1945). This temporary increase in aggressiveness may be due to motivation to breed more females (a limited resource) or due to seasonal changes in physiology (e.g., high testosterone). Resource defense is the name of a similarly motivated type of aggression. When resources are limited (in any season), aggression increases. For example, limited feeder space causes higher levels of agonistic behavior.

Inter-gender fighting occurs in food animals during attempted sexual activity. The two common forms are when (1) a male attempts to mount a female and the male receives aggression from an anestrous female or (2) a male attacks a female in his search for a receptive female. This sex-related fighting (Brain, 1981) is not common and has not been studied in food animals.

Aberrent aggression (i.e., cannibalism and self-mutilation) is not clearly agonistic behavior. The intent seems to be to cause physical damage as in tail-biting; however, these behaviors are thought to be aberrant because they have not been reported in wild ancestors of our domestic animals. At this point, we do not know the genetic or environmental causes of aberrant aggression.

Ethograms of Agonistic Behavior

An ethogram is a complete catalogue of all behavior patterns and vocalizations occuring in a species (Banks, 1982). Banks (1982) called for the collection of ethograms for each major behavioral system. Descriptions of food animal agonistic behavior (i.e., ethograms of agonistic behavior) are essential because they: (1) lead to a better understanding of the behavior, (2) allow more accurate selection of a few critical behaviors to measure in an experiment and (3) ethograms serve as a benchmark from which changes can be identified. Quantification of behaviors and behavioral sequences will provide a basis for statistical analyses; such quantification will improve the image and scientific credibility of behavioral research, which is sometimes viewed as a descriptive rather than a quantitative science.

Sheep. Domestic sheep are often viewed as non-aggressive, gregarious animals. While sheep may not show the high frequency of agonistic encounters observed in other animals, they do show measurable levels of agonistic behavior. An early report of sheep social behavior was a largely descriptive report by Scott (1945). The aggressive behavior he described was called "fighting" and it included shoving with shoulders and running together and butting. Scott observed play-butting in young lambs and more damaging aggression in ewes and rams. Most fighting was during the fall breeding season. Considering the breadth of the literature concerning sheep agonistic behavior, pushing with the shoulders was identified as a milder type of interaction. Threats, largely undefined, were reported (Shreffler and Hohenboken, 1974; Illius, et al., 1976). Pawing at the ground, tooth grinding, lateral body presentation, sniffing, mounting, gaffing and chasing have been identified as behaviors occuring during agonistic interaction. Because a complete, quantitative ethogram of agonistic behaviors of sheep is not available, little can be said of the relative importance of these behaviors.

Aberrant aggression also has been described for sheep. Some ewes show aggression towards their lambs or alien lambs (Price et al., 1984). A better understanding of these maternal-young interactions may improve fostering and bonding techniques and may consequently enhance lamb survival.

Wool-picking (pulling wool with teeth) is more common in confinement-reared sheep. Its causes, treatment and prevention have not been scientifically elucidated.

Cattle. An early descriptive report of cattle agonistic interaction was published by Schein and Fohrman (1955). They described several pre-fight behaviors they called passive avoidance, active avoidance (leads to a fight), threat (close contact, head lowered, ready to fight) and butting or active fighting. Butting was described as a non-retaliated blow with the head, while fighting was defined as reciprocal butts, circling and pushing. The end of the fight, termed the clinch, begins with one animal showing submissive behavior. A more recent description of cattle agonistic behavior was provided by Beaver (1982).

A quantified ethogram was worked out by Bouissou (1974). This paper, written in French, may lose some of the spirit of the description in translation. Bouissou provided a sequential analysis and gave an indication of the duration of her observed interactions. Her work is necessary reading for researchers in bovine social behavior (Bouissou, 1972, 1974, 1975, 1977; Bouissou and Andrieu, 1977).

Aberrant agonistic behavior of cattle includes navel sucking, fence and pen chewing (aggression toward inanimate objects) and ear sucking. These behaviors may be signs of a "deficient environment", but this broad nonspecific cause does not provide sufficient remedies for these on-the-farm problem behaviors.

Swine. Rasmussen et al. (1962) demonstrated a dominance order in growing swine. Another early descriptive report of swine aggression was by McBride et al. (1964). Pigs show substantial levels of agonistic interactions when unfamiliar conspecifics are brought together. While pigs have been reported to show threats (Ewbank and Meese, 1971), threats are subtle and difficult to describe objectively. Jensen (1980, 1982) described head-tilt and retreat (called avoidance or chase by others) and nose-to-nose contact, which may correspond to threats. Often the best method to determine if a threat was made is to observe an avoidance response (as is done in much poultry research).

Jensen (1982) provided a quantitative ethogram of social interactions of adult female swine. He recorded both aggressive and nonaggressive interactions.

The aggressive components of agonistic behavior in the pig are composed of mainly bites and pushes. Head-thrusts (also called levering by some researchers) and a type of pushing where the pig usually pushes its opponent's head up. Head-thrusts, in combination with bites and shoulder pushes, represent the phase of the interaction that seems most intense.

Submissive behavior is shown by the subordinate pig turning its body and either running away or remaining stationary and presenting its rump (Arnone and Dantzer, 1980; McGlone, 1985b). Submission may also be signalled by a lowering of the head (McBride et al., 1964) or a squeal (Signoret et al., 1975).

Abnormal or aberrant agonistic behaviors are found in swine. Sows, on occasion, kill their piglets and growing pigs bite tails and chew ears. While research in this area has been attempted, results have been contradictory (van Putten, 1969; Ewbank, 1973). It seems the following factors may exacerbate tail biting and ear chewing: high concentrations of atmospheric ammonia, dietary factors, floor type and lack of bedding. Because this syndrome is difficult to reproduce experimentally, it is difficult to determine its cause and find a solution.

Chickens. Social behavior of the chicken was the subject of the first reports on social behavior and has a long and colorful history in the United States beginning with Allee's laboratory in Chicago, which operated mostly from the 1930's to the 1950's. Research on chickens is so extensive that I only made a cursory review because it was covered by now-classic earlier reviews (Guhl, 1953; Wood-Gush, 1956).

The behaviors shown by chickens in the contiuum from threat to aggression to submission are well-defined. Readers are directed to Schjelderup-Ebbe's (1922), Guhl's (1953) and Wood-Gush's (1956) research, which all described chicken agonistic interactions. Any modern description of chicken social behavior is far less colorful. Chickens show threats commonly that are associated with sparring, leaping and wing-flapping. The major aggressive act is the peck. Most researchers in the last decade have used the categories threat-avoidance, pecks with or without avoidance and avoidances alone. Also, postural changes occur during the fight (Foreman and Allee, 1959). Submissive behaviors have been described as retreat and full-retreat by Wood-Gush, (1956). While excellent descriptive reports are available, a thorough quantitative ethogram of chicken agonistic behavior has not yet been reported.

Aberrant behavior can be found among confined chickens. While diet and management procedures that influence cannibalism have been investigated, the behavior has been described poorly or not at all.

Deciding on a Type of Measurement

Frequency or Duration. As is evident from table 2, the most common type of measurement is frequency of encounter, not duration of encounter. This is probably because less-sophisticated and less-costly equipment is needed to measure frequency. But does frequency of encounters tell the whole story? Generally, I do not think so. Only the chicken, and perhaps sheep, have discrete fighting units (peck and butt, respectively) which can be easily recorded by an observer. The other two species utilize long, variable-duration bouts of pushing (as may sheep) coupled with interspersed bites or butts (swine and cattle, respectively). Researchers may use frequency of behavior when behaviors are of relatively constant duration (such as a bite). For swine, the correlation between frequency and duration of bites is very high (r=.99; Kelley et al., 1980). However, the correlation between frequency of bites and duration of attack (bites with interspersed pushes) was lower (r=.83; Kelley et al., 1980). The complexity of the problem is illustrated in figure 1. A single bout has many components. The bout, in this case, is a period of behavior followed by a period of at least 30 s of not showing that behavior. A single bite takes about .5 s. Because the duration of a bite is relatively constant, frequency and duration of biting should be highly correlated. However, when the pigs begin to bite and push (alternating between the two behaviors rapidly),

TABLE 2. SUMMARY OF NUMBERS OF STUDIES UTILIZING VARIOUS TYPES OF MEASURES BY AUTHORS STUDYING AGONISTIC BEHAVIOR[a]

	Measures of agonistic behavior				
Species	No quantification	Frequency	Duration	Behavior scores	Dominance value
Sheep	1	9	0	1	9
Cattle	2	14	2	1	18
Swine	2	22	7	4	4
Chickens	0	31	0	3	6

[a]A complete annotated bibliography is available from the author upon request.

problems arise because pushes are of variable duration. Because pushing is of variable duration, a complete picture must have at least the duration of each behavior. Cattle agonistic behavior has a similar scenario. Bouissou (1974) described one pair of cattle interaction that lasted off-and-on for over 50 min. In addition, some authors utilize a behavior score or intensity score. These scores are subjective and more difficult to measure similarly by different researchers.

Investigations which measure social behavior fall into two categories. Those projects that seek a better understanding of agonistic behavior per se need to record more detailed data (i.e., frequency, duration and possible sequences of behavior). Other studies may have a primary objective that is non-behavioral (e.g., improving productivity). For these studies, the weight of literature favors measuring frequency of discrete behaviors (e.g., bite, butt or peck). Selection of discrete behaviors to measure should be based on at least a complete descriptive account, or preferably, a quantitative ethogram of agonistic behaviors.

Measuring Agonistic Behavior

Sampling and Equipment. Decisions must be made about techniques for sampling behavior. Ideally, we hope to record every instance of every behavior. In reality, time does not permit the recording of every second of every behavior for each animal in an experiment. So, just as physiologists may take a blood sample each 10 min over several hours, behavioral scientists employ techniques to sample behavior.

Excellent and complete descriptions of techniques to sample behavior were provided by Altmann (1974) and Lehner (1979). Validation of sampling techniques are often lacking in behavioral studies. If a researcher uses nutritional or physiological assays, sampling and assay techniques must be validated. Likewise, behavioral researchers should validate intra- and inter-observer reliability, repeatability of measuring particular behaviors, sampling and recording techniques (Lehner, 1979).

A wide range of photographic and electronic equipment is available for collecting behavioral data (Lehner, 1979; Banks, 1982). Much

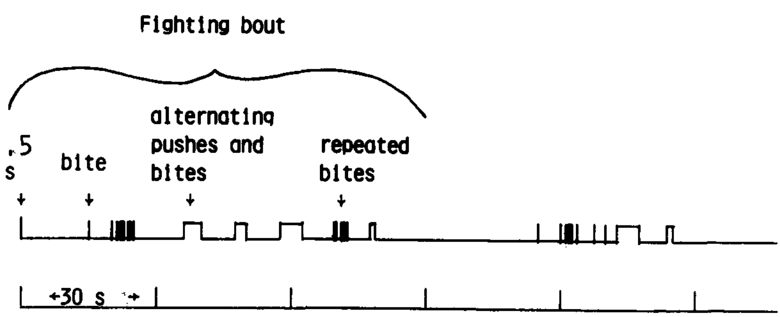

Figure 1. An example of behavioral events over time.

TABLE 3. COMPARISON OF PIG DATA (MIN/H) FOR THREE BEHAVIORS SAMPLED FOR THREE TIMES[a]

	60 min/h		20 min/h			5 min/h		
Behavior	$\bar{X}$	SE	$\bar{X}$	SE	r^b	$\bar{X}$	SE	r^b
Attack	3.30	.81	5.54*	1.37	.80	2.81	.87	.52
Feeding	6.60	1.27	6.83	1.88	.81	6.17	2.16	.43
Drinking	1.89	.87	.91	.32	.44	1.01	.33	.17

[a]Adapted from Arnold-Meeks and McGlone (1986).

[b]Correlations are between 60 min/h values and subsample data.

*P<.05.

behavioral data may be accurately recorded by observers using either pad and paper or sophisticated computer equipment. The advanced electronic equipment only serves to save data collection and summary time.

Live Observations—With Subsampling. More papers have been published using live observations of behavior than from recordings. However, this trend is reversing. Typically, observers record data on paper or into a tape recorder. With a pencil and paper, only the frequency of each act can be recorded. A number of behavioral durations can be recorded if the observer has a time reference. Usually this involves a stopwatch, an event recorder or a computer.

Generally, live observations are superior in the quality of behavior that may be observed. No type of photography can exactly mimic the live animal. However, photography or video recording is essential if animals move faster than the eye-hand system can record simple movements or if several events are observed at the same moment. A variety of techniques have been employed to sample behavior (Altmann, 1974). Observers attempt to record behavior in the least amount of time. Sampling procedures should yield data comparable to observing and recording the behavior of every animal at every moment. To reduce the required time, observes are tempted only to observe a given group of animals for a fraction of an hour (a form of scan-sampling). Thus, in order to observe behavior in three animal pens, the observer may record each pen for 20 min (or less) each hour. Given in table 3 are means and standard errors for young pig behavior over three sampling periods: 60 min/h (a full observation), 20 min/h and 5 min/h for each of three behaviors: attack (alternating biting and pushing), feeding (head in the feeder) and drinking (mouth around nipple waterer) duration. Each mean represents data from 10 1-h segments of video tape. Individual behaviors were recorded for 20 pigs (five pens of four pigs each). Sampling data were adjusted to a full-hour value (i.e., the 20 min/h value was multiplied by three for each observation). The mean attack value subsampled at 20 min/h was overestimated (P<.05), although correlations with the full-hour observation were moderatley high (r=.80). Sampling only 5 min/h gave unacceptable correlation coefficients (I consider only r>.90 to be acceptable for this type of assay). Sampling 20 min/h was grossly unacceptable for drinking behavior. In conclusion, sampling less than the full period (for these pig data) provides inaccuracies that only less-than-precise researchers would accept.

Recordings Varying Play-Back Speed. The modern ethologist has at his or her disposal sensitive photographic and video equipment (reviewed by Lehner, 1979 and Banks, 1982). The addition of event recorders or computer-linked data aquisition and summary systems (McGlone, 1985a) will greatly speed data collection and should remove some inaccuracies (especially in transcribing data).

Recorded behavior can be analyzed in slow motion as in recroding individual pig bites, or at faster speed as in recording general activity such as time spent standing. Any manipulation of time must be done with caution because sampling problems may exist. A savings of time similar to that of scan sampling may be realized by viewing the recording faster than real-time. In terms of data-collection time required, playing back the recordings at four times real-time speed would require one-fourth as much time for data collection. Means, standard errors and correlations between real-time and faster play-back speeds are presented in table 4. Only drinking was underestimated at the very fast speed (24 times); the correlation with

TABLE 4. COMPARISON OF PIG DATA (MIN/H) FOR THREE BEHAVIORS PLAYED BACK AT THREE SPEEDS[a]

	Real-time		Four times			24 times		
Behavior	$\bar{X}$	SE	$\bar{X}$	SE	r[b]	$\bar{X}$	SE	r[b]
Attack	3.67	.82	3.50	.81	.99	3.87	1.02	.87
Feeding	6.55	1.23	6.58	1.26	.99	5.03	1.07	.95
Drinking	.74	.15	.71	.14	.90	.48*	.14	.57

[a]Adapted from Arnold-Meeks and McGlone (1986).

[b]Correlations are between real-time and faster speeds of collection.

*P<.05.

real-time data was unacceptable. Viewing these behaviors at four times real-time speed provided acceptable correlaions and means compared with real-time data. In addition, feeding behavior could be summarized at the fastest speed (24 times real-time).

In conclusion, recording from video (and probably photographic) records made in time-lapse and played back at a faster speed (1) saves observer time (2) does not compromise accuracy if performed properly and (3) is a more accurate alternative to sampling less than the full period. Observers of animal behavior also must gear sampling techniques toward diurnal and seasonal variations in behavior.

Experimental Design

Minimum Number of Replicates. Researchers who study behavior (as well as other researchers) must ask themselves: what is the minimum number of replicates required to detect a biological difference in mean values? To answer this question we must know the grand mean, the difference that is considered biologically significant, an estimate of the population variance, and accepted error rates (e.g., P<.05).

Presented in table 5 are selected papers from each species covered in this review. I estimate that a 25% or greater change in agonistic behavior is biologically important. Compared with performance data (e.g., average daily gain) where a 10% difference is very important, agonistic behavior seems to require a much greater change to be biologically important. This is due to greater variation. Whereas performance data generally have coefficients of variation (CV) around 30%, the CV for agonistic behavior is usually 60% or greater.

When a standard Student's t-test is applied to data in table 5, and treatment mean is 25% greater than control mean value, one can estimate the minimum number of replicates that would just make that difference significant at the 5% level. However, given these assumptions the experiment will have a 50% chance of making a Type II error. Generally five to ten replicates per treatment are needed to detect a 25% difference in means given the standard deviations presented. This rule-of-thumb (five to ten replicates) must be increased as the variance increases and may be decreased if the mean differences are greater than 25%. Of course, with fewer replicates, data are more susceptible to random artifacts.

Assumptions of Analysis. This segment is provided as a reminder that parametric tests of significance have certain assumptions that should be examined, especially for behavioral data. Briefly, these are a normal distribution of error variances, homogeneity of variance within treatments and experimental errors within treatments are assumed to be random and independent. Often a simple transformation of raw data can make the analysis (and assumptions) valid. In many cases, especially when dealing with frequency measures, data require a nonparametric test of significance.

Common Designs. There are two common experimental designs for the study of agonistic behavior. The first is the within-pen design. In this design, considering two treatments, one-half of the animals receive one treatment and the other half receive some control treatment. Animals are mixed; threats, aggression, submission and dominance-subordinate relations are recorded. In the second design, one pen of animals receives one treatment and another pen receives the control treatment. Animals are mixed; threats, aggression and submission are recorded. Additional measures of performance or health may be made in either design.

Design 1 requires fewer animals and generally reduces some variation (pen-to-pen variation

TABLE 5. ESTIMATED NUMBER OF REPLICATES REQUIRED FOR AGONISTIC BEHAVIOR STUDIES

Source, animal	Name	Type	$\bar{X}$	SD	CV, %	Minimum number of replicates needed to detect a 25% difference, P<.05
Kelley et al. (1980), swine	Biting	Duration, s	68.3	43.1	63.1	7
	Biting	Frequency	36.6	19.9	54.4	5
Bhagwat and Craig (1979), hens	Peck-avoidances	Frequency	2.6	1.79	68.8	8
Collis et al. (1979), dairy cattle	Aggression	Frequency	147.5	79.2	53.7	5
Illius et al. (1976), rams	Hit	Frequency	31.8	24.1	75.9	10

can be removed as blocks). Also, only with design 1 can treatment effects on dominance be identified. Design 1 has the disadvantage of close contact of treated and control animals. Some drug treatments may contaminate control pigs in design 1 because they would have contact during agonistic behavior. Finally, design 2 is the only way to test housing systems, pen designs and many management practices. Livestock producers manage groups of animals and they seek techniques to reduce aggression in all animals.

Common Pitfalls. There are at least five pitfalls common to research on agonistic behavior. They have already been addressed but they bear repeating:

(1) Too few replicates to detect a biological difference.

(2) Assumptions of the analysis are not met.

(3) Other measures of agonistic behavior (threats, submission) are not recorded.

(4) Incomplete descriptions of the behavior are reported.

(5) A complete, quantitative ethogram did not form the basis for selecting behavior measures.

Food Animals are not Rodents. A final message is needed for this review. The volume of literature on agonistic behavior contains mostly studies of rats and mice. The environments that induce attack for rodents and farm animals are different. Research mice, in particular, have been bred to be aggressive. Little research has been done to select aggressive or non-aggressive farm animals (except for chickens, where the heritability of aggressiveness is about .20). Animals found on farms have not been intentionally selected for or against aggressiveness. Some techniques used to incite attack in rodents (shock, genetic strains, isolation) are not necessary to incite attack in farm animals. In fact, isolated pigs did not fight any more than non-isolates (Fraser, 1978). And finally, when the objective is to reduce social stress on-the-farm, farm-like experimental designs should be used. Farm-like conditions usually include large group sizes (i.e., more than a pair of animals) and commercial-type pens, feeders, waterers and management practices.

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