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The effect of agonistic interactions on the heart rate of group-housed sows

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Abstract

Inter-sow aggression can be a major welfare problem in group-housing systems and can also affect productivity. This experiment investigated the effect of different types of agonistic interaction using heart rate as an indicator of physiological response. The heart rates of nine Large White × Landrace sows housed in a large group with an electronic sow feeder system, were monitored during agonistic interactions. Interactions were categorised into: (1) interactions involving physical contact, (2) non-physical interactions involving threat only. Both were recorded as win or loss, giving a total of four encounter types. The data were analysed to give the peak heart rate value during the encounter and also the increase from the pre-encounter mean to the peak value. Although there were some statistical difficulties presented by small sample size, sows involved in physical encounters had a greater increase in heart rate and a higher peak value (+59.1 beats per min (bpm), 137.0 bpm) than sows involved in threat encounters (+31.6 bpm, 107.3 bpm). Sows which lost a physical encounter tended to have the highest heart rates (+85.7 bpm, 157.7 bpm). The results demonstrate that all sows involved in agonistic encounters show an acute and transient response indicated by a rise in heart rate; however, the rise is greatest for sows which lose a physical encounter.

Keywords: Pigs; Heart rate; Social behaviour; Aggression

1. Introduction

For many species, including the domestic pig, welfare problems arise when they are subjected to an environment which is unpredictable or uncontrollable (Fraser and Broom,

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1990; Wiepkema and Koolhaas, 1992). A major problem reported by many commercial producers keeping sows in group housing systems, is that of inter-sow aggression and bullying, due to the establishment and maintenance of a social hierarchy. An inability to prevent attack by another sow can itself lead to poor welfare, in addition to any effects of injury or pain caused by the attack. A sow's ability to control its social environment can not only affect its access to resources (Edwards et al., 1993), but also its physiological state and productivity (Mendl et al., 1992).

Even in stalls and tethers, inter-neighbour aggression can be high (Vestergaard and Hansen, 1984; Barnett et al., 1987; Broom et al., 1995), but the physical consequences for the sow receiving the aggression are negligible, due to the lack of opportunity for physical contact. In a group situation, aggression can have a severe effect both in terms of physical injury and also production and appears to be particularly prevalent during two periods, i.e. (1) during and after mixing of sows back into the herd following farrowing and service, and (2) around the time of feeding. The consequences for production can be highly detrimental at both these times. Sows subjected to high levels of aggression on mixing may suffer hormonal upset leading to failure of embryo implantation and return to service (Maclean, 1969; Hansen and Vestergaard, 1984). Sows subjected to aggression at feeding may be deprived of sufficient ration (Csermely and Wood-Gush, 1986; Edwards et al., 1993) and hence lose condition and give birth to litters with low viability. Aggression is especially likely where simultaneous group feeding systems, such as "dump" feeding or trough feeding, are practised (Edwards et al., 1993) which do not afford sows any protection from displacement by dominant sows.

The aim of this experiment was to determine the effects that different intensities and degrees of success of agonistic social interaction have on the heart rate of sows, which can be a useful measure of the emotional response of an individual to short-term problems such as social challenge.

2. Methods

2.1. Subjects, housing and care

The subjects were nine Large White × Landrace sows (Masterbreeders UK Ltd, Tring, UK) of similar parity (mean 5.7 ± 0.2) and weight (mean 228.3 ± 4.4 kg), housed in a group of 37 sows in a single large pen (16.5×5.5 m^2). The pen was divided into a strawed lying area (7.5×5.5 m^2) and a dunging area (9.0×5.5 m^2). Part of the dunging area was occupied by an Electronic Sow Feeder (ESF) system with rear entrance and front exit gates (crate manufactured by Quality Equipment, Bury St. Edmunds, UK and electronics by Nedap Poiesz, Hengelo, Netherlands), in which the sows were fed one at a time. The feeding cycle started at 15:00 h and all sows were fed 2.2 kg per day throughout the period of study. Water was available ad libitum from nipple drinkers and a water trough situated in the dunging area. The housing system was ventilated by two thermostatically controlled 900 rev. min^{-1} 45-cm fans and was lit both by natural daylight and artificial lighting with lights switched on at 06:00 h and off at 22:00 h. The dunging area was cleaned daily and straw added to the lying area at regular intervals.

2.2. Heart rate monitoring equipment

The heart rate monitor used was the Polar Sport Tester (Polar Electro Oy, Finland), consisting of an electrode belt, a clip-on transmitter and a wrist-watch receiver. The receiver has a memory function and stores data from the transmitter, averaging heart rate over 5-s, 15-s or 60-s intervals. In this study, the interval was set at 5 s for maximum detail, which gave a total memory capacity of 2 h 40 min.

The electrode belt was fitted around the thorax of the sow without modification. ECG Gel (Camcare, Cambmac Instruments Ltd., Cambridge, UK) was applied to the electrode surfaces and, after ensuring that the skin surface was clean and dry, the electrode belt was placed around the thorax of the sow caudal to the forelimbs. One electrode was positioned in the ventral midline and the other located on the left side of the thorax in line with the olecranon process of the forelimb. The signal was tested using the receiver and where necessary, the belt was adjusted about 10 cm ventrally or dorsally until the signal was consistent. The receiver was then fastened around the belt, positioned on the dorsal midline and activated to start recording.

After completion of data collection, the equipment was removed and the receiver downloaded by ''wire-free'' contact via a Polar Interface (Polar Electro Oy, Finland) onto an Apple Macintosh. The data was displayed in graphical and numerical form using Polar Heart Rate Analysis Software, Version 3.00 (Polar Electro Oy, Finland) and analysed for statistical comparisons.

2.3. Experimental protocol

The sows were chosen on basis of order of going to the feeder as recorded on the ESF computer over the previous 7 days. The heart rate monitors were fitted 30 min prior to the computer cycle switch over at 15:00 h. The sows' behaviour was continuously recorded by direct observation together with video-recorder backup of behaviour at the feeder entrance. The time on the monitor receivers and on the video clock were synchronised in order to be able to relate behavioural events with the heart rate data. Agonistic social interactions were categorised into two types: Type 1—agonistic social encounter involving threat only. As two sows approach each other, loser moves away and avoids physical confrontation with winner. Type 2—agonistic social encounter involving physical contact. Loser moves away only after bite or knock from winner. This therefore gave four classifications of agonistic encounters: (1) Winner–Threat encounter; (2) Loser–Threat encounter; (3) Winner–Physical encounter; (4) Loser–Physical encounter.

Heart rate data were also collected during other specified behaviours. These behaviours were walking, rooting whilst walking, lying with eyes open and lying with eyes closed.

2.4. Statistical analysis

Results were averaged from six recordings of each encounter classification in which the sow participated. The behavioural and graphical heart rate data were examined together and subsequent numerical heart rate data analysed to give peak heart rate during an encounter and increase in heart rate from pre-encounter mean to peak value. The pre-encounter mean was the mean heart rate value calculated over 1 min before the encounter occurred. It was not possible to calculate a mean heart rate during agonistic encounters because of the extremely short time period over which they occurred.

Not all sows monitored gave results for all four classifications because of different positions held in the social hierarchy. Some sows never lost an encounter, and some never won. Thus, although nine sows were monitored, the total number of sows within each classification was either six or seven and the number of sows involved in all four encounter types was only three. If the results are analysed without taking this fact into consideration, some sows appear in both categories whereas others appear only in one. This could result in an artificially high or low value if a sow which only appears in one category has an unusually high or low heart rate due to, for example, stage of gestation. Therefore, comparisons between two treatments, i.e. win vs. lose and physical vs. threat, were carried out using Wilcoxon Signed Rank test which omitted unpaired values and hence, for these tests, $N=6$ or 7. Comparison between the four encounter types was carried out using a Friedman two-way ANOVA, which again omitted any unpaired values and hence, $N=3$.

The results for the heart rate during specified behaviours were also averaged from six recordings of each behaviour type and were the mean heart rates calculated over a continuous 30-s bout of that behaviour. All nine sows gave results for all four specified behaviours and these were compared using a Freidman two-way ANOVA in which $N=9$. Comparisons with encounter heart rates were carried out using Wilcoxon Signed Rank tests in which $N=6$ or 7.

3. Results

When results for both types of encounter were combined (see Table 1), there were no significant differences in peak heart rate or change in heart rate between winners and losers. Sows involved in a physical or Type 2 encounter had higher peak heart rate and greater change in heart rate than sows involved in a non-physical or Type 1 encounter.

When the results are analysed in terms of all four classifications with all values included (see Table 2), the sows showed an increase in heart rate ranging from between +36.3 to +85.7 beats per minute, when participating in an agonistic encounter. Sows tended to have the highest peak values and greatest change in heart rate when losing a physical agonistic encounter.

Table 1
Wilcoxon Signed Rank analysis of mean heart rate (HR) response (beats per minute) to social encounters compared by encounter outcome and encounter type

Parameter	Win Encounter	Lose Encounter	z-value	N	P-value
Peak HR	114.7 (4.5)	127.5 (9.2)	−1.37	6	0.172
HR Change	+42.2 (4.5)	+53.3 (8.5)	−0.95	6	0.344
	Physical Encounter	Threat Encounter			
Peak HR	137.0 (5.5)	107.3 (3.7)	−2.37	7	0.018
HR Change	+59.1 (6.7)	+31.6 (4.7)	−2.37	7	0.018

Values in parantheses are standard errors of the mean.

Table 2
Freidman analysis of mean heart rate (HR) response (beats per minute) to social encounters, by encounter classification (Only sows with values in all four classifications included $N=3$, df$=3$)

Measure	Encounter classification				χr^2	P-value
	Win Physical	Win Threat	Lose Physical	Lose Threat		
Peak HR	128.7 (15.3)	104.0 (9.5)	157.7 (8.7)	125.0 (12.0)	7.00	0.072
Change	+50.7 (8.5)	+36.3 (6.3)	+85.7 (7.4)	+45.7 (6.9)	7.76	0.051

Values in parantheses are standard errors of the mean.

Table 3
Freidman analysis of mean heart rate (HR; beats per minute) during specified behaviours ($N=9$, df$=3$)

Measure	Specific behaviour				χr^2	P-values
	Root + walk	Walk	Lie (eyes open)	Lie (eyes closed)		
Mean HR	81.2 (2.5)	79.0 (2.3)	58.0 (1.8)	52.1 (0.9)	24.07	0.001

Values in parantheses are standard errors of the mean.

Table 4
Wilcoxon Signed Rank analysis of mean heart rate (HR) response (beats per minute) to social encounters with mean heart rate during rooting with walking

Encounter classification	Encounter HR	Root + Walk HR	z-Value	N	P-value
Win Physical	125.3 (7.1)	82.9 (3.6)	−2.20	6	0.027
Win Threat	104.7 (4.4)	83.5 (3.5)	−2.20	6	0.027
Lose Physical	150.2 (6.0)	79.1 (1.4)	−2.20	6	0.027
Lose Threat	105.9 (9.0)	79.5 (1.0)	−2.19	7	0.028

Values in parantheses are standard errors of the mean.

For the specified behaviours, mean heart rates were significantly higher during walking and rooting whilst walking behaviours (see Table 3) than when lying down with eyes open or with eyes closed. However, the heart rate during an agonistic encounter was significantly greater than the mean heart rate during rooting whilst walking, regardless of encounter classification (see Table 4).

4. Discussion

The results demonstrate that sows show a physiological response to social encounters, indicated by a rise in heart rate above baseline locomotory levels, regardless of whether or not the encounter involves physical contact, or whether the encounter is won or lost. This emphasises the importance of the ''psychological'' aspect of social stress. Threats can cause elevations in heart rate without any physical contact being necessary. In open housing systems, sows can escape from aggression and thus, the time period over which heart rate is increased may be short. However, in confined housing systems such as stalls and tethers, and in feeding stalls, there is no possibility of escape and the psychological stress experienced by the receiver of aggression must be considerable.

The results obtained for sows participating in physical encounters certainly contain an element of increased locomotory activity compared with threat encounters, and it could be argued that the rise seen in sows which lose physical encounters is wholly due to greater physical exertion than winners. However, sympathetic nervous stimulation of the heart during exercise shows a slow response, with heart rate acceleration beginning 1–2 s after exercise commences and reaching a plateau after 30–60 s. The heart rate increases seen in this experiment were instantaneous and very short-lived. Therefore, the large rise in heart rate for the sows which lost an aggressive interaction is probably indicative of greater sympathetic–adrenal medullary activity. Social interactions have been shown to increase plasma catecholamine levels in guinea pigs (Sachser, 1987; Sachser and Lick, 1989), especially in those defeated in fights. Increases in heart rate in response to approach by an unfamiliar person, which have been noted in sheep (Baldock and Sibly, 1990) and red deer (Price et al., 1993) without any increase in locomotory activity, may be similarly explained.

The fact that sows who lose agonistic encounters appear to show the highest elevations in sympathetic–adrenal medullary activity may help to explain why pigs which responded to agonistic interactions in different ways in a previous study, varied in measures of their long-term stress (Mendl et al., 1992). Three broad categories of gilts were identified in terms of relative success in agonistic interactions. High Success animals were able to displace more pigs than could displace them, Low Success animals were displaced by more pigs than they were able to displace, and No Success pigs were never observed to displace any other pigs. The data showed that No Success pigs were the most inactive, tended to be involved in fewest agonistic and non-agonistic interactions and used aggression least often. The Low Success pigs were most active, used more aggression during agonistic interactions and, most notably, experienced the highest levels of aggression and greatest number of displacements from other pigs. The Low Success pigs also had the highest baseline cortisol levels and the highest peak cortisol level in response to ACTH challenge and they produced the lowest total weight of piglets born alive (Mendl et al., 1992). This relationship between stress and reproductive success has been observed in other species (Bowman et al., 1978; Abbott et al., 1988).

The present study suggests one possible reason for why Low Success pigs experienced greater indices of long-term stress than other pigs. Repeated experience of defeat in agonistic interactions (a characteristic of the Low Success group) is likely to be associated with regular bursts of sympathetic–adrenal medullary activity. We hypothesise that repeated elevations in sympathetic–adrenal medullary activity over time are accompanied by transient increases in hypothalamic–pituitary–adrenal (HPA) activity and it may then be this short-term activity that leads to longer-term HPA responses to stress of the sort seen in Low Success pigs. Mice, rats and guinea pigs involved in fights have all been shown to have elevated plasma glucocorticoids (Henry and Stephens, 1977; Koolhaas et al., 1983; Sachser, 1987). Alternatively, the behavioural strategy which pigs select may itself be influenced by experience of short-term physiological stress. This hypothesis would predict that No Success pigs initially experienced high levels of defeat by others and so opted for a ''stress-free'' avoidance type of strategy. Different behavioural strategies for coping with failure in agonistic interactions have also been identified in tree shrews (Von Holst et al., 1983), rats (Fokkema, 1985) and mice (Benus, 1988).

In summary, inter-sow aggression will always be present where sows are exposed to each other, although the incidence of aggression will be influenced by such factors as housing system, stocking density, feeding method and method of mixing sows. The results demonstrate that an agonistic interaction will elicit an acute response indicated by an increase in heart rate and that the magnitude of the response will be influenced by the type of interaction and the degree of success in resolving that interaction.

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