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The accumulation of skin lesions and their use as a predictor of individual aggressiveness in pigs☆

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Abstract

Post-mixing aggression in commercially housed pigs can be intense and often results in the accumulation of skin lesions. The number of lesions (lesion score, LS) has often been used as a proxy indicator of post-mixing aggression. There has been no previous attempt to quantify the role of different behaviours in the accumulation of lesions. The objective of this work was to investigate the factors that contribute to LS in order to assess the validity of LS as a measure of individual aggressiveness. After mixing into new groups of 12, the durations of reciprocal fighting and bullying, the proportions of fights initiated, won and lost and physical attributes of the pigs were investigated for their impact on LS using multiple regression on a sample of 342 growing pigs. Pig liveweight was the single greatest determinant of LS. The duration spent in reciprocal fighting and being bullied were also significant determinants of the LS and contributed to the total LS in proportions of 0.17 and 0.14, respectively. The proportion of

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fights initiated, won and lost did not influence the LS for pigs of a given weight. On an individual pig basis, it was impossible to establish the relative importance of reciprocal fighting and the receipt of bullying to the accumulation of lesions by reference to the total LS alone. Engagement in reciprocal fighting was found to result in lesions to the anterior third of the body, whilst the receipt of bullying resulted in lesions accruing on the caudal third of the body. Reference to the location of lesions, in addition to their number, is a refinement of the methodology that potentially allows discrimination of pigs that accumulate lesions as a result of reciprocal fighting or receipt of bulling. A partial replication of the experiment at a second unit ($n = 84$ pigs) with different genotypic, environmental and husbandry conditions confirmed that the duration spent in reciprocal fighting and being bullied were significant determinants of the LS and that the LS approach is applicable across units. Liveweight was not recorded at Unit 2. These results suggest that the LS methodology provides a rapid means of estimating aggressive behavioural phenotypes when reference is made to both the number and location of lesions and pig weight and pen identity effects are accounted for.

Keywords: Pig; Mixing-related aggression; Lesion score; Fighting; Bullying

1. Introduction

Under wild conditions, the ancestors of the domestic pig cohabit in small, genetically related matriarchal groups. Outside of the mating season, aggression between individuals is infrequent and rarely injurious; a feature common to domestic pigs housed in an extensive enclosure (Stolba and Wood-Gush, 1984, 1989; Mendl, 1995). Group social stability is facilitated by the infrequent and gradual integration of new members to the group (Mauget, 1981), close kinship, the preservation of individual space and the use of threats and non-aggressive behaviour to maintain dominance relationships (Mendl, 1995). In contrast, many commercial pigs are repeatedly exposed to sudden mixing episodes with unrelated animals in an environment that limits effective dispersal and the display of appropriate submissive behaviour. Under these conditions, post-mixing aggression is intense during the first 24 h after mixing (Meese and Ewbank, 1973), but varies considerably between members of the group (Mount and Seabrook, 1993; Erhard et al., 1997).

Whilst fighting, pigs attempt to target the head, neck and ears of their opponent using bites and slashes from the canine teeth (McGlone, 1985; Luescher et al., 1990; Geverink et al., 1996; Weary and Fraser, 1999). This results in the accumulation of superficial skin lesions predominantly to the front third of the body, but also to the flanks when delivered in a reverse parallel posture (McGlone, 1985; Fraser and Rushen, 1987).

Intra-specific aggression in the pig poses a significant challenge to animal welfare and productivity (Arey and Edwards, 1998; O'Connell and Beattie, 1999). Whereas the problem of pig aggression has received much attention, detailed studies of aggressive behaviour have largely been confined to staged paired encounters or small group sizes. We have identified the need for an approach to rapidly and reliably quantify individual differences in aggressiveness within the context of the social mixing that occurs on farms.

The number of skin lesions (lesion score, LS) has frequently been used as a proxy indicator of the extent of post-mixing aggressive behaviour. This approach offers a rapid means of assessing aggressiveness of a large number of pigs and has been used commonly when investigating the development of aggression over several days or weeks or when using large social group sizes (e.g. Francis et al., 1996; Erhard et al., 1997; Spoolder et al., 1999; Turner et al., 1999, 2000, 2002). Typically, group mean lesion scores have been used to compare treatment effects on aggression. A limited number of experiments have compared the LS of categories of pigs within the same social group (e.g. Erhard et al., 1997; Turner et al., 2000), but no studies have fully examined the behaviours which contribute to the accumulation of lesions at the level of the individual pig. Limited evidence exists which demonstrates that the LS does relate to aspects of reciprocal fighting behaviour (Olesen et al., 1996; Erhard et al., 1997), but these two indices have not always been measured over the same time scale and the importance of bullying or physical damage from the environment in the accumulation of lesions have not been considered.

This study formed part of a larger analysis investigating the heritability of aggressiveness in pigs and its relationship to economically important production traits. These findings will be reported in a separate publication. The use of lesion scores was identified as a potential means of rapidly assessing individual aggressiveness of a large sample of pigs when mixed under commercial conditions. The aim of this study was to provide a behavioural validation for the use of LS as a proxy measure of individual aggressiveness. We approached this in the present study by measuring LS post-mixing on two farms differing in genotype, housing and management. We simultaneously collected behavioural records of aggressive behaviour in addition to physical attributes of the pigs and the surrounding environment. We then used multiple regression to analyse the contributions of physical and social environmental covariates and behaviour to the accumulation of lesions.

2. Methods

2.1. Experimental design

The principal experiment was performed on one unit (Unit 1) where the effects of a range of physical and environmental covariates on LS were assessed and a behavioural validation of the LS methodology performed. A partial replication on a second farm (Unit 2) allowed the LS method to be validated under different genotypic, environmental and management conditions. Both units were managed as commercial farms. A full replication of the experiment at Unit 2 was not possible and a smaller range of environmental variables was quantifiable at this unit.

2.1.1. Unit 1

2.1.1.1. Physical and environmental covariates determining LS. The total sample of 1132 purebred pigs (Large White, $n = 597$; 207 males, 390 females and Landrace, $n = 535$; 166 males, 369 females) were mixed into new social groups to investigate the effects of pig liveweight, gender, genetic line, birth litter size, experimental group size and ambient temperature on LS 24 h after mixing.

2.1.1.2. Behavioural validation. The overt post-mixing aggressive behaviour of a sub-sample of 342 of the 1132 pigs (Large White, $n = 186$; 71 males, 115 females and Landrace, $n = 156$; 49 males, 107 females) was observed in detail using the protocol described below. All pigs mixed between two arbitrary dates spanning the middle of the experimental period were used to form this sub-sample. The housing and mixing procedure was the same for both the sub-sample of 342 and the remaining 790 pigs.

2.1.2. Unit 2

2.1.2.1. Behavioural validation. It was not possible to investigate the physical and environmental covariates determining LS at Unit 2. To replicate the behavioural observations performed on the sub-sample of 342 pigs at Unit 1, the aggressive behaviour of 84 crossbred pigs (Large White × Landrace, 36 males, 48 females) was observed when mixed at Unit 2.

2.2. Animals and housing

2.2.1. Unit 1

Pigs were farrowed in standard farrowing pens (mean total litter size at birth = 13.1 - S.E.M. 0.09 pigs) and weaned at 4 weeks of age into first stage pens with fully perforated plastic floors in mixed-sex groups of 45 S.E.M. 2.4 individuals. Floor space allowance was 0.34 m^2/pig. At 27.9 S.E.M. 0.14 kg, experimental pigs were moved and mixed into the experimental accommodation (96 pens) according to the protocol described below. The pens comprised of a fully slatted concrete floor and a wet feeding trough of 4.5 m length. Home-mixed feed was delivered on a four-hourly regime beginning at 07:00 h and ending at 19:00 h. The median group size was 12 with a range of 10–13. The median floor space allowance was 0.93 m^2/pig (range 0.86–1.12 m^2/pig) and the mean ambient temperature was 20.9 S.E.M. 0.22 °C.

2.2.2. Unit 2

The farrowing accommodation and weaning procedure was similar to Unit 1. First stage accommodation comprised of fully perforated, plastic-floored pens and group sizes of either 16 or 32 individuals. Floor space allowance in the first stage accommodation was 0.22 m^2/pig. Pigs were observed at mixing into the second stage pens (seven pens) at 18–25 kg. The pens housed 16 pigs at a floor space allowance of 0.36 m^2/pig had fully slatted concrete floors and dry pelleted food was offered ad libitum.

2.3. Experimental mixing protocol

2.3.1. Units 1 and 2

Where possible, an equal number of pigs were selected from each of two non-adjacent first stage pens to form a single-sex experimental group. Where an even number of pigs was unavailable, a maximum of one additional pig was selected from one pen than from the other. Mixing occurred between 09:00 and 12:00 h and all pigs were introduced simultaneously into the clean second stage pen. Immediately before mixing into the experimental pens, the unique ear tag number, pig liveweight, gender, genetic line and experimental group size were recorded (Unit 1 only). Ambient temperature was recorded

24 h after mixing at Unit 1. Only 12 pigs per pen of 16 were observed for the purposes of the experiment at Unit 2 as this was the maximum number of individual spray paint marks which could be reliably identified at that site. Six pigs from each of the two first stage pens were selected at random to provide these 12 experimental pigs.

2.4. Lesion score recording protocol

2.4.1. Units 1 and 2

Immediately before entry into the experimental pen, a pre-mixing LS was recorded for each pig and a spray mark, unique within the experimental group, was applied to all pigs. Twenty-four hours after mixing, the LS was again recorded from which the pre-mixing LS was subtracted to provide the number of lesions resulting from the 24 h post-mixing period. This period was suggested by pilot studies as the point at which lesions could most accurately be counted and encompasses the period when the majority of mixing-induced aggression is believed to occur (Meese and Ewbank, 1973).

The lesion scores used in the analyses were recorded by one observer, but to quantify the extent of inter-observer reliability in LS recording, a second observer also independently lesion scored the first 48 animals in the study at Unit 1. Each observer was blind to the scores allocated by the other individual. The scores recorded by the two observers were closely correlated (Pearson correlation, $r = 0.91$, intercept 12.03, slope 0.79, $P < 0.001$).

To facilitate counting, the body was divided into three regions: front (head, neck, shoulders and front legs), middle (flanks and back) and rear (rump, hind legs and tail). The number of fresh lesions was recorded but weighting was not given to the length or diameter of lesions. Freshness was judged subjectively by lesion colour and the estimated age of scabbing.

2.5. Behavioural observations

Overt aggressive behaviour was recorded by one observer for the sub-sample of 342 pigs at Unit 1 and 84 pigs at Unit 2, using continuous observation of the 24 h post-mixing period with the aid of time-lapse video equipment. The duration, to the nearest second, of all bouts of reciprocated or non-reciprocated aggression were recorded using the definitions provided in Table 1. Only aggressive behaviour which was likely to result in injury was recorded. Aggression was recorded when bites were delivered at an approximate rate of $\geq$1 per 3 s. The same ethogram was used on both farms. The identity of the initiator, winner and loser were noted if this was clear.

2.6. Statistical analysis

The non-reciprocal behaviour categories ‘resting during fight’ and ‘withdrawal at end of fight’ occurred very infrequently and for short durations at both units. For the purposes of analysis, the records from these two categories and those from the third category ‘attack not associated with a fight’ were pooled and given the collective term ‘bullying/bullied’ dependent on the direction of the aggression.

Table 1
Ethogram of aggressive behaviours

Damaging aggression	Periods of interaction during which bites were delivered at an approximate rate of ≥1 per 3 s. This defines the severity of aggression recorded under 'reciprocal fighting' and 'non-reciprocated aggression' described below
Reciprocal fight	Reciprocal damaging aggression lasting ≥1 s
Fight initiation	
Initiator	Identity of the pig which delivered the first bite
Unclear initiator	Antagonists bit each other apparently simultaneously with <1 s between attack and retaliation
Fight outcome	
Loser	Identity of the pig which retreated ≥1 m from the winner and was pursued over this distance. The loser did not show re-newed damaging aggression towards the winner for ≥3 s
Winner	Identity of the pig which pursued a retreating pig over a distance of ≥1 m. The winner did not receive re-newed damaging aggression from the loser for ≥3 s
Unclear winner	Neither pig retreated for ≥1 m or was pursued over this distance at the end of a fight
Non-reciprocated aggression	
Rest during fight	Damaging aggression was given/received whilst the recipient was resting for ≥3 s during a reciprocal fight. The recipient did not show damaging aggression during this period
Withdrawal at end of fight	Damaging aggression was given/received whilst the recipient was withdrawing at the end of a reciprocal fight. The recipient did not show damaging aggression during this period
Attack not associated with a fight	Damaging aggression was given/received without the recipient showing damaging aggression during, or for ≥3 s before or after, the attack

In order to estimate the effects of physical and environmental covariates on LS and for the behavioural validation, the data were examined for their approximation to the normal distribution and log transformed where necessary.

The effect of a range of physical and environmental covariates on LS was examined at Unit 1 ($n = 1132$) by incorporating pig liveweight, group size and litter size as fixed effects, pen and genetic line as random effects and ambient temperature as a factor in a residual maximum likelihood (REML; Gilmour et al., 2000) model to determine the effects on LS. As litter and gender were confounded with pen identity, the inclusion of pen as a random effect allowed gender and litter effects to be estimated by comparisons among pen mean scores.

A multiple regression analysis which accounted for differences between pens was used to generate a model to estimate the LS at Unit 1 using six variables based on the behavioural data (durations of reciprocal fighting, bullying and being bullied, and the proportion of reciprocal fights initiated, won and lost). Pig liveweight was also included as a variable in the model. The strength of within-pen correlations between individual variables was examined for both units using Pearson product moment correlations after log transformation of the data where necessary and subtraction of between-pen effects. All relationships are therefore presented as within-pen correlation coefficients after differences resulting from pen effects were removed.

3. Results

3.1. Phenotypic variability in aggressive behaviour and LS

At both units, pigs spent a shorter duration being bullied and bullying other individuals than engaging in reciprocal aggression (Table 2). All three behavioural variables and the LS had frequency distributions with a positive skew (Table 2; Fig. 1(a and b)).

3.2. Physical and environmental covariates determining LS

Within the ranges studied at Unit 1, the impact of a variety of animal and environmental covariates on the expression of the LS trait were quantified using the total sample of 1132 pigs. Factors group size (10–13 pigs/pen), ambient temperature (16–23 °C), total litter size at birth (4–21 pigs), gender and genetic line had no significant effect on LS. The correlation of pig liveweight with LS was highly significant ($P < 0.001$). On the logarithmic scale, the slope of the relationship was 0.019 S.E.M. 0.0056. On the untransformed scale, this corresponds to approximately a 2% increase in LS for each additional kilogram of body weight. Pen identity was also found to significantly influence the LS when included as a random effect.

3.3. LS estimation from behavioural variates and pig attributes

3.3.1. Unit 1

A multiple regression analysis which accounted for differences between pens was used to generate a model to estimate the LS using data from Unit 1 only. The initial model incorporated the durations engaged in reciprocal fighting, being bullied and bullying other pigs, the proportion of reciprocal fights initiated, won and lost and pig liveweight. Of these seven variables, only the duration engaged in reciprocal fighting, the duration spent being bullied and pig liveweight significantly affected the LS. The remaining variables were removed from the model. Transformation did not normalise the data and a similar

Table 2
Durations (s/pig) spent being bullied, bullying and engaged in reciprocal fighting and the lesion score (LS) of pigs on Units 1 and 2

	Unit 1			Unit 2		
	Median	Range	Skewness	Median	Range	Skewness
Bullied	3.0	0–84	3.43	0.0	0–17	2.39
Bullying	0.0	0–183	5.37	0.0	0–29	3.64
Reciprocal aggression	11.0	0–705	3.38	2.0	0–165	2.84
LS	28.0	1–140	1.34	24.0	0–112	1.45

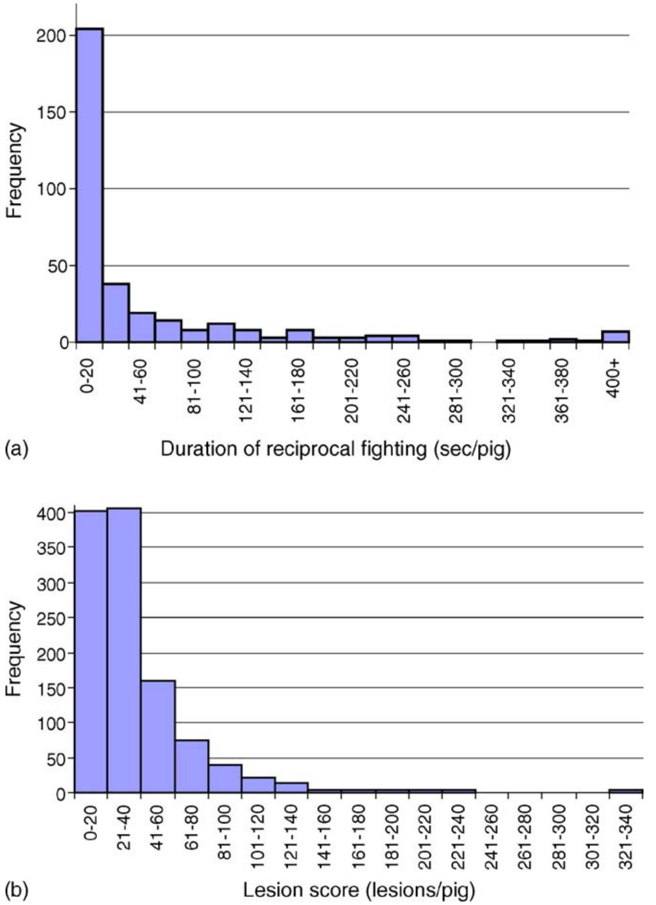

Fig. 1. (a) Frequency distribution of duration engaged in reciprocal fighting at Unit 1 ($n = 342$) and (b) frequency distribution of lesion score (LS) at Unit 1 ($n = 1132$).

prediction equation was generated using untransformed data. For ease of presentation, untransformed data were used to generate equation (1). The duration spent bullying other pigs, whilst being significantly correlated to LS ($r = 0.283$, $P < 0.001$), was also closely correlated to the duration spent in reciprocal fighting ($r = 0.520$, $P < 0.001$). Inclusion of the duration spent bullying therefore did not further improve the model's ability to predict the LS and equation (1) was best able to predict the LS from the available data.

$$\mathrm{LS} = 9.430 + 0.110 \times (\text{time in reciprocal fighting}) + 0.699 \times (\text{time bullied}) + 0.523 \times (\text{liveweight}) \quad (1)$$

The partial correlation coefficients between LS and time in reciprocal fighting and time bullied were $r = 0.488$ ($P < 0.001$) and $r = 0.248$ ($P < 0.001$), respectively.

3.3.2. Unit 2

The inability to record pig liveweight at Unit 2 and the small sample size constrained the full replication of the multiple regression analysis performed at Unit 1. It was possible, however, to examine the impact of each of the behavioural variables on LS independently. Significant correlations were found between the LS and the duration in reciprocal fighting ($r = 0.251$, $P < 0.05$) and between the LS and the duration of time spent being bullied ($r = 0.195$, $P < 0.05$). No significant correlations were detected between the LS and the duration spent bullying other pigs, or between the LS and the proportion of reciprocal fights initiated, won or lost. A significant correlation was found between the duration spent in reciprocal fighting and the duration spent bullying other pigs ($r = 0.493$, $P < 0.001$).

3.4. Relationship between LS and other characteristics of reciprocal fighting

LS was significantly correlated with the frequency of reciprocal fights (Unit 1, $r = 0.397$, $P < 0.001$; Unit 2, $r = 0.221$, $P < 0.05$) and with the mean fighting bout length (Unit 1, $r = 0.388$, $P < 0.001$; Unit 2, $r = 0.253$, tendency, $P < 0.1$). These two behavioural variables were significantly correlated at Unit 1 ($r = 0.360$, $P < 0.001$), indicating that a high duration spent in reciprocal fighting was often a combined consequence of a high frequency of fights and a high mean fighting bout length. No significant correlation between fight frequency and length was apparent at Unit 2. Pigs with a high LS also fought a greater proportion of group members at both units (Unit 1, $r = 0.379$, $P < 0.001$; Unit 2, $r = 0.231$, $P < 0.05$).

The proportion of reciprocal fights which were initiated, won or lost did not correlate with LS at either unit. There was evidence, however, that pigs which spent a high duration in reciprocal fighting tended to initiate (Unit 1, $r = 0.128$, $P < 0.05$; Unit 2, $r = 0.289$, tendency, $P < 0.1$) and win (Unit 1, $r = 0.314$, $P < 0.001$; Unit 2, $r = 0.266$, tendency, $P < 0.1$) a higher proportion of these encounters. Independently, the proportion of fights which were initiated and won were significantly correlated (Unit 1, $r = 0.377$, $P < 0.001$; Unit 2, $r = 0.582$, $P < 0.001$). No significant relationship was found at either unit between the duration engaged in reciprocal fighting and the proportion of fights lost.

3.5. Relationship between fighting behaviour and liveweight at Unit 1

There was no significant correlation between the duration engaged in reciprocal fighting and liveweight. However, there was a significant negative correlation between the duration spent being bullied and liveweight ($r = -0.218$, $P < 0.001$).

3.6. Relationship between reciprocal fighting and being bullied

There was a significant and positive correlation between the duration spent in reciprocal fighting and the duration being bullied at Unit 1 ($r = 0.167$, $P < 0.005$). Whilst this relationship is statistically significant, the correlation coefficient accounts for little of the total variance and no significant correlation was found between these two variables at Unit 2. It is likely that, whilst some pigs did accrue a high LS from being both heavily bullied and being involved in a lot of reciprocal fighting, pigs were also able to acquire a high LS through only one of these routes.

3.7. Location of lesions accrued during reciprocal fighting and when bullied

The location of lesions was examined as a possible indicator of the contribution made to the LS by reciprocal fighting and the receipt of bullying. The pig's body was divided into three areas comprising front (head, neck, shoulders and front legs), middle (flanks and back) and rear (rump, hind legs and tail). The durations of (i) reciprocal fighting and (ii) being bullied were expressed as a proportion of the total time spent in both behaviours (reciprocal fighting + being bullied). The correlation, accounting for between-pen effects, between the proportion of time spent in either of these two behaviours and the proportion of the LS located on each of the three body areas was examined. At Unit 1, a significant positive correlation was found between the proportion of lesions located on the front third of the body and the proportion of time spent in reciprocal fighting ($r = 0.152$, $P < 0.01$). The regression equation for this relationship was:

$$\text{Proportion of lesions located on the front} \\ = 0.409 + 0.081\ \text{proportion of reciprocal fighting}$$

Also at Unit 1, a significant positive correlation was found between the proportion of lesions located on the rear third of the body and the proportion of time spent being bullied ($r = 0.148$, $P < 0.01$), with the following regression equation:

$$\text{Proportion of lesions located on the rear} \\ = 0.208 + 0.040\ \text{proportion of time being bullied}$$

The proportion of lesions located on the middle region was not significantly influence by the proportion of time spent in reciprocal fighting or being bullied.

These analyses were based on a sample size of 320 after removal of pigs from the dataset which had either (a) received no lesions or (b) engaged in no reciprocal fighting and been the recipient of no bullying.

When these analyses were repeated at Unit 2 with a sample size of 60 pigs, no significant relationship was found between pig behaviour and lesion location.

4. Discussion

In commercial group housing systems, pigs exhibit wide-ranging individual behavioural differences, which persist over time, in response to a variety of challenging situations (Lawrence et al., 1991; Forkman et al., 1995; Erhard and Mendl, 1999; van Erp-van der Kooij et al., 2002) and there is evidence that this variability extends to the propensity to show aggressive behaviour (Erhard et al., 1997). The current data would support the presence of wide phenotypic variability in aggressiveness. The two populations were characterised by a majority of pigs which showed small to moderate amounts of reciprocal fighting and a minority which engaged in a disproportionately large amount of fighting. Erhard and Mendl (1997) found a similar tendency for a large part of the population to show a low propensity towards aggressiveness, as measured by attack behaviour in a standardised resident/intruder paradigm.

Lesion score is a measure of the outcome of aggression. If it is to be used as a proxy measure of individual aggressiveness it is necessary to demonstrate which behaviours contribute to the accumulation of lesions, and to identify which factors of the environment are significant determinants of this trait. Both engagement in reciprocal fighting and being bullied were found to be significant determinants of the LS at 24 h post-mixing. At Unit 1, the mean durations per pig for the two variables was 53.6 and 7.1 s, respectively. A typical pig accrued approximately the same quantity of lesions (5.91 lesions/pig versus 4.96 lesions/pig) from these two routes. Despite the disparity in the total observed durations of these behaviours, they both contributed to the total LS in similar proportions (proportionately 0.167 versus 0.140 of the total LS, respectively). Consequently, the number of lesions received per second of being bullied was over six times greater than that received from the same duration of reciprocal fighting.

The LS approach readily identifies pigs which had successfully avoided engagement in reciprocal fighting and the receipt of bullying, due to their low LS. Whilst the correlation between the duration engaged in reciprocal fighting and being bullied was positive and statistically significant at Unit 1, a large residual variance remained and the relationship between these variables did not approach statistical significance at Unit 2. It is likely that many pigs received lesions disproportionately from one of these routes. It is difficult to quantify the relative contribution of reciprocal fighting and the receipt of bullying to the accumulation of injuries based on an individual's LS alone. The use of lesion location may allow the importance of these two routes to be identified at the level of the individual pig.

During reciprocal fights, bites are targeted primarily at the head, neck and shoulders of the opponent (McGlone, 1985; Weary and Fraser, 1999) and lesions accumulate predominantly in this area (Rundgren and Löfquist, 1989). Pigs which engage predominantly in reciprocal fighting, but which receive little bullying, would be expected to receive a greater proportion of their total LS around the front third of the body. The larger dataset from Unit 1supports this proposition as a significant positive correlation was identified between the LS to the front of the body and the proportion of time spent in reciprocal fighting. Conversely, during retreat (a prerequisite for bullying as defined in Table 1), bites are targeted at the rump of the retreating animal (Meese and Ewbank, 1973) and a significant positive correlation was identified at Unit 1 between the proportion of lesions located around the rear of the body and the proportion of time spent in receipt of bullying. Whilst these relationships were statistically significant, the correlation coefficients were not large, indicating that lesions were not received exclusively to the front region during reciprocal fighting or to the rear region when bullied.

As the duration engaged in reciprocal fighting was a significant determinant of the LS, it is worth considering what characteristics of reciprocal fighting differed between individuals which showed little or much of this behaviour. A high duration in reciprocal aggression was the product of both a high frequency of fights and a long mean fighting bout length. As the total duration engaged in reciprocal fighting is a composite measure of these two variables, its use would appear to offer the best single measure of reciprocal fighting behaviour investigated in this study. A high LS resulting from reciprocal fighting was unlikely to be attributable to a single prolonged fight with one individual opponent but appears to reflect a more generally aggressive temperament. Pigs which won a high proportion of reciprocal fights tended to initiate them and to engage in a high duration of fighting overall. Evidence from many taxa suggests that the experience of recent success or defeat influences an individual's subsequent willingness to engage in fighting and the outcome of those fights (Rushen, 1988; Chase et al., 1994; Cloutier et al., 1995; Hsu and Wolf, 1999). For the pigs studied, the experience of winning or losing encounters immediately after mixing appears to have influenced the assessment of their likelihood of success in subsequent encounters. However, Rushen (1988) observed that, until the end of the encounter, the eventual losers of fights between pigs tended to fight with the same vigour as eventual winners, which may explain the lack of a direct effect of fight success on LS in the current experiment.

Within the limits of the environment, age and genetic background of the pigs and husbandry practices used in this study at Unit 1, the total litter size at birth, gender and genetic line of the pig and the group size and ambient temperature in the experimental accommodation had no significant effect on LS. Before application of the LS approach in an environment which differs from that studied, or when using pigs with a different genetic or social history, the impact of these covariates on the LS may need to be reassessed. An effect of the group on LS is a clear result from this work. As lesions accrue through social interactions with other pigs, it is not surprising that the behaviour of the group influences the LS of its individual members. However, after accounting for between-pen effects, considerable within-pen variation in LS was still apparent which correlated to aspects of aggressive behaviour.

A significant factor in this group-level effect was likely to be the group mean liveweight. At the within-pen level, liveweight of the individual pig proved to be the single most important determinant of the LS, accounting for proportionately 0.42 of the total LS at Unit 1. A positive correlation between liveweight and aggression has been demonstrated in pigs before (Olesen et al., 1996; Pitts et al., 2000) and a considerable sexual dymorphism in aggression occurs around the time of puberty, characterised by an increase in aggression in intact males (Cronin et al., 2003). However, in the current experiment, the increased LS of heavier pigs could not be attributed to a longer duration of reciprocal fighting or being bullied. As the duration and intensity of fighting is greatest between pigs of closely matched weight (Parker, 1974; Rushen, 1988), it is probable that heavy weight pigs predominantly fought other heavy weight pigs. The weight-related increase in LS may simply reflect the greater level of injury possible when heavier pigs, with greater strength and larger canine teeth fight, rather than an increase in aggressive temperament per se.

5. Conclusions and practical implications

This study has concentrated on the expression of physically injurious aggression. Other aspects of aggressive behaviour which do not lead to physical injury, such as pushing, are not quantifiable using this approach but could be perceived as a significant stressor by the pig. Additionally, using the LS approach, it is not possible to investigate whether individuals which expressed a high level of injurious aggression also performed a large amount of non-injurious aggression. However, this work does suggest that the lesion score approach can be used to provide a measure of the durations of physically injurious aggression.

A wide phenotypic variability in overt aggressive behaviour and lesion scores has been demonstrated, in which a disproportionate amount of lesions are received by a minority of the population. The LS in this study was determined by the duration of time engaged in reciprocal fighting, the duration of time being bullied and pig liveweight. The success in reciprocal encounters did not significantly determine the LS. The LS approach readily identifies pigs which had neither engaged in prolonged reciprocal fighting nor been the recipients of prolonged bullying, due to the low number of lesions received. For other pigs, it is more difficult, based on lesion number alone, to determine the contributions made by reciprocal fighting and the receipt of bullying to the LS. Statistically, it is possible to use the location of lesions to infer how they were accrued, since bites received during reciprocal fighting are predominantly targeted towards the front third of the body and those received when bullied typically accumulate on the rear. However, by making reference to both lesion number and location, a large amount of error still remains unexplained. The LS approach allows measurements to be efficiently made on a large sample size. The benefits of the approach need to be considered in light of its limitations and when observations of aggressive behaviour are feasible they should be used in preference to the LS approach. Used with caution, however, the LS methodology can provide some insights into the aggressive behaviour of large numbers of individual animals where other approaches would be impossible.

When used in future studies it will be necessary to account for differences in individual pig liveweight and between-pen effects, and also the impact of environmental variables should be quantified if out-with the range studied in the present experiment. The findings from the two units showed close agreement and indicate that the LS methodology is not unit-specific but ought to be generally applicable when used at a liveweight of 20–30 kg.

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