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Do pigs form preferential associations?

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Abstract

This investigation examined whether pigs form long-term preferential associations or 'friendships' and factors that may influence the formation of these relationships. Thirty-three pigs from 16 litters were housed together from 4 weeks of age. At 10 weeks they were split into two groups of 16 and 17 pigs and each introduced into 3.05 m × 3.66 m observation pens (1st pen). At 17 weeks the two groups swapped pens (2nd pen). The lying patterns of each group were recorded over 3 weeks in both the 1st and 2nd pens. To identify dyads with preferential associations, association indices were calculated for each pair based on their lying patterns and analysed using SOCPROG1.3 and the permutation method [Whitehead, H., 1999. Programs for analysing social structure. SOCPROG 1.2, http://is.dal.cal/∼whitelab/index.htm]. Dyads with high association indices for at least 2 out of 3 weeks in either pen, i.e. ≥0.10 (twice the mean), were classed as having preferential associations. Mantel tests were used to examine the relationship between the relative sex, weight, familiarity and relatedness of a dyad and their level of association and to examine consistency of associations between pens. The existence of preferential associations was identified in both groups, since the standard deviations for the observed half-weight association index means were significantly higher than for the randomly permuted half-weight association index means ($P < 0.001$). Of the 33 pigs observed, 32 formed preferential associations with one or more pigs in their group, resulting in 50 dyads. Only six dyads (12 pigs) formed preferential associations in both pens, suggesting that the remaining dyads either formed short-term associations only or were simply displaying a shared preference for the same lying location. Levels of association between pens showed no significant correlation. The relative sex, weight, familiarity and relatedness of dyad members also showed no significant correlation with their level of association. These findings suggest that unrelated pigs are capable of forming preferential associations. However, it is unclear whether such associations are widespread or important to pigs, since most dyads' preferential associations were not consistent between pens.

Keywords: Behaviour; Friendship; Pigs; Preferential association

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1. Introduction

Some species of domestic farm animals, such as cows (e.g. Reinhardt and Reinhardt, 1981) and sheep (e.g. Arnold et al., 1981), have been shown to form preferential associations or ‘friendships’, where certain pairs appear to prefer each other’s company over other animals in their group. Pigs have been shown to prefer associating with certain groups of pigs over others, for example their mother and littermates over other group members (e.g. Peterson et al., 1989; Jensen and Strangel, 1992) or other pigs introduced into an established group at the same time as them (e.g. Durrell, 2003). However, few studies have properly examined whether long-term preferential associations or ‘friendships’ are formed between pairs of pigs within a group. That is, whether two pigs within a group associate more with each other than with other group members. For example, Kuipers and Whatson (1979) examined sleeping patterns in piglets and reported ‘no consistency in the position or orientation of piglets with respect to each other and no selection of neighbours’. However, no formal record of lying partners was made and piglets were only observed during one 90 min period each week. Stookey and Gonyou (1998), in contrast, did find preferences for specific lying partners amongst 80% of the piglets in their study. However, lying scans were only carried out during one 6 h period on pigs kept in small groups of five. This may be too small a sample period and also quite a limited group size for identifying lying partner preferences.

Newberry and Wood-Gush (1986), on the other hand, carried out a more extensive investigation into association between littermate pairs kept in a semi-natural environment. They recorded various measures of association, including lying together, behavioural synchrony, social interaction and nearest neighbour, during the piglets’ first 13 weeks of life. They found that some littermate pairs had stronger relationships based on several of the measures, but that these were not consistent between the two age periods, 0–4 and 4–14 weeks. However, there were several limitations to this study. Firstly, the method they used to select ‘friendly’ pairs was exclusive, in that pigs could only be joined to one other pig for each measure and could, therefore, only have one ‘friendship’. Littermate pairs that had relationships that were strong but not the strongest were, therefore, not classed as ‘friends’ and this could explain why ‘friendships’ did not appear to be consistent over the two age periods. Secondly, pigs were classed as lying together if they were lying in the same group or nest, even if they were some distance apart. No distinction was made, therefore, between pigs that consistently lay together in physical contact and those that did not lie in contact but simply shared the same nest with other pigs.

In environments where space allowance is limited and pigs forced into close proximity, some of the measures used by Newberry and Wood-Gush (1986) in a semi-natural environment are of little value and instead information on the identities of animals lying in physical contact tend to have been used (Stookey and Gonyou, 1998; Durrell, 2003). It is well known that pigs spend a large proportion of their day lying together and previous observations suggest (Signoret et al., 1975; Stolba, 1982) that the social relationships of pigs may be best indicated by their choice of lying partners (Newberry and Wood-Gush, 1986).

The aim of this investigation was to determine whether pigs form long-term preferential associations, based on lying partner preferences, and to examine factors that may influence the formation of these associations. Unlike previous studies, observations were carried out for long periods over several weeks and pigs could be included in more than one preferential association.

2. Method

2.1. Design

Forty Large White x Landrace pigs from 16 litters were weaned at 4 weeks of age and housed together as a single group. At 7 weeks of age, this group was randomly split into two groups of 20 pigs. Some pigs had to be removed from each group at this time due to injuries sustained, leaving 6 gilts and 11 boars in one group (group 1) and 6 gilts and 10 boars in the other group (group 2). At 10 weeks of age each group was moved into an observation pen (1st pen) and video recordings were obtained over 3 weeks from 11 to 14 weeks of age. At 17 weeks each group was moved into the observation pen previously housing the other group (2nd pen) and video recordings were obtained over 3 weeks from 18 to 21 weeks of age. Pigs were introduced into two separate observation pens to control for pigs having shared preferences for certain lying locations within the pens. By moving pigs into a different observation pen, it was hoped that this would force them to change their preferred lying location. If two pigs were found to associate highly in both pens this would suggest this was due to a preferential association rather than to a shared preferred lying location.

2.2. Housing

Each group of pigs were housed in two 3.05 m × 3.66 m pens, located on either side of an aisle. Each pen contained a fully slatted floor and a nipple drinker on either side of a head to head shelf feeder, from which food was offered ad libitum. The total space allowance in the pens was 11.16 m^2 providing 0.70 m^2/pig for the group of 16 pigs and 0.66 m^2/pig for the group of 17 pigs.

2.3. Measures

From 11 weeks of age (1st pen) and again from 18 weeks of age (2nd pen), each group was video recorded over 3 weeks using 24 h time-lapse 3 days per week. The lying patterns of pigs were recorded from these video recordings using group scan sampling (Altmann, 1974) at 15 min intervals from 12:30 h until 18:30 h each observation day. The following information was recorded during each scan: (1) the identities of all pairs lying together (some pigs were recorded within more than one pair); and (2) the identities of all pigs lying alone. A pair of pigs was classed as lying together if they were lying with their bodies in physical contact or lying in very close parallel contact, except where at least one of the pig's only source of contact was its head, rear or limbs. To identify individuals, each pig was assigned a different spray-marking and prior to each 24 h video recording pigs were spray-marked accordingly on both their backs and sides.

For each individual pig the following information was recorded: sex, weight at 10 weeks (prior to introduction into observation pens), identity of dam, identity of sire and, if adopted at birth, the identity of the adoptive dam.

2.4. Statistical analysis: lying partner preferences

The raw data from each 15 min interval scan were presented in a 0:1 'raw association matrix', with all dyads assigned a value of 1 if they were recorded as lying together or 0 if they were not. Estimates of the proportion of time pigs spent lying together were calculated for all dyads using the half-weight association index (HWI) (Cairns and Schwager, 1987; Ginsberg and Young, 1992) and indices for each dyad were presented in an 'observed association matrix'.

$$\mathrm{HWI} = \frac{x}{(n_a + n_b)/2}.$$

where x the number of scans in which individuals a and b are recorded as lying together, n_a the total number of scans in which individual a is recorded as lying and. n_b the total number of scans in which individual b is recorded as lying.

To determine whether individuals within a group associated randomly, a large number of randomly permuted association matrices were created and the random data values produced were used for comparison with the observed data values. This was conducted by carrying out permutations on the raw association matrices following the Monte Carlo method described by Bejder et al. (1998) and Manly (1995) with some modifications by Whitehead (1999b). This involves randomly selecting row and column pairs within the raw association matrices and inverting association values between rows, so '1' is changed to '0' and vice versa. This procedure leaves the number of individuals recorded as lying and the number of associations involving each individual unchanged. The number of permutations required to obtain accurate P-values is higher than for standard Monte Carlo methods, as each permutation is sequential and thus not independent. The number required was determined by increasing the number of permutations until the P-values stabilized at 250,000 (Bejder et al., 1998). For each random permutation, a new random association matrix was formulated. Analyses were performed using SOCPROG1.3 (Whitehead, 1999a) in MATLAB 5.1 (The Math Works, Inc. Natick, MA, USA, 1999), which provided means, standard deviations and P-values to compare the observed and random association matrices. Separate analyses were carried out for each group (1 and 2) in each pen (1st and 2nd pens). The existence of significant high associations between individuals was identified where the standard deviation for an observed association matrix was greater than 95% of the standard deviations for its accompanying random association matrices.

Separate association matrices were produced for each group (1 and 2) during each observation week (weeks 1–6). A dyad was identified as having a preferential association where its association index was $\geq$0.10 during at least two of the three weeks in either the 1st or 2nd pen. This arbitrary value of 0.10 was chosen because it was approximately twice the mean association index. High associations during one week only in either pen were ignored, since these were most likely due to two pigs lying together for a long duration during a single observation day. However, it is possible that preferential associations in evidence in one pen only may or may not have been due to pigs sharing the same preferred lying location(s). High associations for at least two weeks in each of the two pens were, therefore, viewed as more reliable indicators of a preferential association. A worked example is now provided to aid the reader. Each pig was scanned 24 times a day for 3 days a week, which adds up to 72 scans per week. Pigs in this study tended to be recorded lying approximately 75% of scans, which works out as 54 of the 72 scans. If this was the case for a particular pig, this would make the denominator of the HWI come out as $(54 + 54)/2$, which is 54. For the HWI to come out at ≥ 0.1, this pig would need to be seen lying with another pig for at least 6 scans during a particular week. Whilst 6 out of 54 scans may seem rather low, it must be noted that in order to show a pair had a long-term preferential association, the pair would need to be seen lying together for this number of scans for at least 2 weeks in both pens. In addition, there are many factors that account for a 'friendly' pair not being seen lying together during a scan. Firstly, the pair is unlikely to have been inactive always at the same time. Secondly, other resting pigs may have blocked the pair's access to one another. Finally, the pair may have wished to lie alone or with other pigs in the group, especially if they had more than one preferential association.

2.5. Statistical analysis: relative characteristics of dyads with preferential associations

Mantel tests (see Schnell et al., 1985) were carried out to determine whether there were differences in association when the same group of pigs was moved to a different pen. For each test, two square symmetric matrices of the same size and indexed by the same animals were compared, one with association data for the 1st pen and the other with association data for the 2nd pen. For each matrix, dyads were given a score of '1' if they showed a preferential association within that pen (i.e. they had association indices ≥ 0.10 for at least 2 out of the 3 weeks in the pen) and '0' if they did not. Mantel tests and matrix correlation coefficient between the elements of each matrix were calculated and the statistical significance of these tested by means of a Monte Carlo test using 1000 random permutations (see Schnell et al., 1985).

2.6. Statistical analysis: relative characteristics of dyads with preferential associations

Mantel tests were carried out in the same way to determine whether there were differences in association depending on a dyad's relative: (1) sex (both boars or both gilts versus opposite sex); (2) weight (both light or both heavy versus light–heavy); (3) familiarity (reared together from birth versus reared together from 4 weeks); and (4) relatedness (same dam and/or sire versus unrelated). The median of the weights for all the pigs was used as an approximate dividing line for assigning pigs to the 'light' or 'heavy' weight category. Pigs weighing less than 30 kg were assigned to the 'light' weight category and pigs weighing more than 30 kg were assigned to the 'heavy' weight category. For each test, a matrix with association data for each dyad was compared with another matrix with sex, weight, familiarity or relatedness data for each dyad. For the association matrix, each dyad was given a score of 0–2 depending on the number of 3-week periods in which they had high association indices for at least 2 out of the 3 weeks. Similarly, for the other matrices, dyads were given a score of 0–1 depending on their relative characteristics (e.g. '0' for same sex, '1' for opposite sex).

Table 1
Observed and random association values for two groups of growing pigs

Group	Pen	Observed HWI[a]	Randomised HWI[a]	P[b]
1	1st	0.06 ± 0.029	0.06 ± 0.020	<0.001
	2nd	0.05 ± 0.028	0.05 ± 0.019	<0.001
2	1st	0.06 ± 0.038	0.06 ± 0.026	<0.001
	2nd	0.05 ± 0.035	0.05 ± 0.023	<0.001

[a] Mean ± SD.
[b] From SD of observed and randomised means.

3. Results

3.1. Existence of significantly high associations (permutation tests)

The existence of significantly high associations was identified for both groups of pigs in both pens, since the standard deviations for the observed HWI means were significantly higher than for the randomly permuted HWI means ($P < 0.001$, Table 1).

3.2. Dyads with preferential associations (permutation tests)

All but one of the 33 pigs formed preferential associations in evidence in at least one pen, i.e. they had association indices ≥0.10 with the same pig for at least 2 weeks in one or both pens. Twelve pigs formed preferential associations in evidence in both pens (Tables 2 and 3). A total of 50 dyads with preferential associations were identified out of a possible 256 dyads (Group 1 = 17 × 16/2 = 136; Group 2 = 16 × 15/2 = 120), with 44 having associations in evidence in one pen and 6 having associations in evidence in both pens (Tables 2 and 3). This included 19 dyads in group 1 and 22 dyads in group 2 with preferential associations for 2 weeks in one pen, two dyads in group 1 and one dyad in group 2 with preferential associations for 3 weeks in one pen and two dyads in group 1 and two dyad in group 2 with preferential associations for 2 weeks in both pens and finally two dyads in group 2 with preferential associations for 2 weeks in one pen and 3 weeks in the other pen (Tables 2 and 3). The mean indices for these dyads (including indices <0.10 and excluding indices in pens where no preferential association were in evidence) were 0.11 (ranging from 0 to 0.36).

3.3. Associations between pens (Mantel tests)

Mantel tests revealed no significant relationship between associations for dyads in the 1st pen and the 2nd pen. This was the case for both group 1 (mantel test = 1.62; matrix correlation = 0.140; P = n.s.) and group 2 (mantel test = 1.67; matrix correlation = 0.154; P = n.s.).

3.4. Relative characteristics of dyads with preferential associations (Mantel tests)

Mantel tests revealed no significant relationship between the number of 3-week periods dyads showed preferential associations and their level of familiarity (together from birth;

Table 2
Dyads in group 1 with high association indices (≥0.10) for at least two out of three weeks in the 1st pen and/or the 2nd pen

Group	Dyad (sex)		1st pen			2nd pen		
			w1 (HWI)	w2 (HWI)	w3 (HWI)	w1 (HWI)	w2 (HWI)	w3 (HWI)
1	b5s (m)	r1t (m)	0.10	0.07	0.13	0.12	0.07	0.10
1	bx (m)	r5s (m)	0.12	0.13	0.05	0.17	0.03	0.17
1	r1d (f)	r3sx (f)	0.11	0.10	0.12	0.00	0.08	0.11
1	b1s (m)	b3s (m)	0.11	0.00	0.16	0.00	0.20	0.00
1	b1s (m)	b5s (m)	0.15	0.02	0.11	0.00	0.02	0.10
1	b1s (m)	r5s (m)	0.06	0.12	0.11	0.04	0.02	0.02
1	b1d (f)	bhs (f)	0.13	0.14	0.02	0.02	0.05	0.02
1	b1d (f)	bx (m)	0.12	0.00	0.10	0.00	0.05	0.07
1	b1d (f)	r5s (m)	0.12	0.00	0.17	0.02	0.09	0.14
1	b1d (f)	r2d (m)	0.05	0.13	0.14	0.04	0.00	0.05
1	b3s (m)	bhs (f)	0.06	0.10	0.10	0.02	0.09	0.08
1	b3s (m)	r2d (m)	0.16	0.04	0.14	0.00	0.04	0.22
1	b2d (m)	r1s (f)	0.12	0.08	0.12	0.02	0.00	0.09
1	bx (m)	r1s (f)	0.10	0.10	0.08	0.07	0.07	0.00
1	bx (m)	r3sx (f)	0.17	0.15	0.06	0.02	0.18	0.08
1	r1d (f)	rx (f)	0.11	0.12	0.09	0.06	0.07	0.07
1	r1t (m)	r5s (m)	0.18	0.12	0.00	0.02	0.05	0.04
1	r1t (m)	r5s (m)	0.11	0.10	0.00	0.02	0.05	0.11
1	r3s (m)	rhs (m)	0.14	0.02	0.18	0.08	0.04	0.11
1	bx (m)	rhs (m)	0.05	0.11	0.10	0.08	0.21	0.05
1	b3s (m)	r3sx (f)	0.04	0.02	0.00	0.16	0.10	0.24
1	b1d (f)	r1d (f)	0.07	0.06	0.02	0.00	0.13	0.10
1	b3s (m)	b2d (m)	0.06	0.09	0.00	0.17	0.11	0.04

together from 4 weeks), relatedness (same dam and/or sire; unrelated), relative sex (both boars; both gilts; opposite sex) and relative weight (both light; both heavy; opposite weight) (Table 4).

4. Discussion

4.1. Existence of preferential associations

The main aim of this investigation was to determine whether pigs form preferential associations, that is whether some pigs prefer the company of one pig over other pigs in their group. This was measured by recording the pigs' lying partners over time. Results show that each group contained dyads with significantly higher association indices than one would expect by chance. This suggests that some pairs formed preferential associations. However, it is possible that association indices calculated over each entire 3-week period may have been inflated by long bouts of lying together during a single observation day. To control for this, only dyads with high association indices for at least 2 separate weeks during one or both of the 3-week observation periods were classed as showing a 'preferential association'.

Table 3
Dyads in group 2 with high association indices (≥0.10) for at least two out of three weeks in the 1st pen and/or the 2nd pen

Group	Dyad (sex)		1st pen			2nd pen		
			w1 (HWI)	w2 (HWI)	w3 (HWI)	w1 (HWI)	w2 (HWI)	w3 (HWI)
2	b1s (m)	b1d (f)	0.12	0.05	0.26	0.13	0.14	0.17
2	bx (m)	r1d (m)	0.12	0.05	0.24	0.11	0.15	0.16
2	r2s (m)	r5s (m)	0.10	0.11	0.00	0.04	0.17	0.10
2	r2d (m)	rhs (m)	0.10	0.08	0.12	0.21	0.09	0.15
2	b5s (m)	rhs (m)	0.11	0.28	0.18	0.08	0.04	0.00
2	b1s (m)	rhs (m)	0.05	0.14	0.10	0.02	0.00	0.04
2	b1d (f)	rx (m)	0.02	0.11	0.14	0.00	0.06	0.00
2	b3s (f)	r1s (f)	0.13	0.11	0.08	0.08	0.11	0.07
2	b3s (f)	r3s (f)	0.13	0.11	0.08	0.08	0.11	0.07
2	b3s (f)	r2d (m)	0.10	0.11	0.00	0.00	0.02	0.09
2	b5s (m)	r1s (f)	0.10	0.00	0.13	0.04	0.11	0.00
2	bhs (f)	r1d (m)	0.00	0.17	0.16	0.00	0.08	0.02
2	r1s (f)	r1t (f)	0.04	0.22	0.11	0.00	0.00	0.00
2	r1t (f)	rx (m)	0.16	0.03	0.10	0.04	0.00	0.00
2	r2s (m)	rhs (m)	0.13	0.06	0.11	0.00	0.02	0.14
2	r3s (f)	r5s (m)	0.10	0.08	0.19	0.07	0.04	0.02
2	r3sx (m)	rhs (m)	0.29	0.08	0.36	0.09	0.02	0.14
2	rhs (m)	rx (m)	0.04	0.25	0.16	0.02	0.08	0.02
2	b1s (m)	r3s (f)	0.00	0.02	0.12	0.10	0.09	0.11
2	b3s (f)	r1t (f)	0.10	0.00	0.00	0.00	0.25	0.19
2	b5s (m)	rx (m)	0.07	0.00	0.16	0.15	0.18	0.06
2	bhs (f)	r5s (m)	0.00	0.00	0.10	0.02	0.15	0.11
2	bx (m)	r1t (f)	0.06	0.00	0.07	0.19	0.24	0.02
2	bx (m)	rhs (m)	0.09	0.03	0.03	0.17	0.17	0.04
2	r2s (m)	r3sx (m)	0.00	0.00	0.05	0.10	0.09	0.19
2	r2s (m)	rx (m)	0.02	0.00	0.04	0.13	0.07	0.12
2	r3s (f)	r2d (m)	0.04	0.06	0.07	0.10	0.10	0.07

Association indices equal to or greater than 0.10 were classed as high. This is an arbitrary figure, but was chosen because it is approximately twice the mean association index. In other words, it is approximately twice the index one would expect if there was no difference in association patterns between dyads.

Table 4
Association between the number of 3-week periods dyads showed preferential associations and their relative familiarity, relatedness, sex and weight: results of Mantel tests (*t*), matrix correlations (*r*) and significance levels using 1000 random permutations (*P*); n.s. = $P > 0.05$

Group	Familiarity			Relatedness			Sex			Weight		
	t	*r*	*P*	*t*	*r*	*P*	*t*	*r*	*P*	*t*	*r*	*P*
Group 1	−1.08	−0.093	n.s.	−0.57	−0.049	n.s.	−1.67	−0.144	n.s.	−1.55	−0.133	n.s.
Group 2	1.54	0.140	n.s.	2.39	0.217	n.s.	−1.26	−0.115	n.s.	0.90	0.082	n.s.

Based on the above definition, 32 out of the 33 pigs (97%) showed referential associations in one or both pens. This amounted to 50 dyads. Nearly all of the pigs, therefore, appeared to form preferential associations. However, 20 of these pigs (61%) were involved in preferential associations in one pen only. Since it is impossible to have a lying partnership without a spatial location, this means we were not able to determine whether these were short-term preferential associations, in evidence in one pen only, or were simply shared preferences for the same lying locations within one of the pens. We cannot, therefore, be certain whether these pigs were in fact showing preferential associations or simply shared preferences of the same lying locations. Pigs were introduced into two separate observation pens to test for this. By moving pigs into a different observation pen, it was hoped this would force them to change their preferred lying location. If two pigs were found to associate highly in both pens it would suggest this was due to a preferential association rather than to a shared preferred lying location. However, it cannot be ruled out that a pair may still lie together in the second pen due to a continued shared preference for some aspect of that lying location, e.g. beside the entrance gate. However, it is unlikely that a pair would choose exactly the same preferred lying location in the second pen. Although most pigs showed preferential associations in one pen only, six dyads (12 pigs or 36%) showed preferential associations in both pens, providing more conclusive evidence for long-term preferential associations amongst these pigs.

These findings show that pigs do appear capable of forming preferential associations based on their choice of lying partners, although it is unclear how widespread or important these relationships are among pigs. This is because, of the 33 pigs observed, 12 pigs (36%) showed clear evidence of forming long-term preferential associations. Another 20 pigs (or 61%) may have formed short-term preferential associations, but it cannot be ruled out that these pigs were instead demonstrating a preference for the same lying locations. Although studies suggest that pigs are capable of forming associations with certain groups of pigs over others, for example their mother and littermates over other group members (e.g. Peterson et al., 1989; Jensen and Strangel, 1992) or other pigs introduced into an established group at the same time as them (e.g. Durrell, 2003), the findings of previous studies on preferential associations between individual pigs have also been ambiguous. For example, Stookey and Gonyou (1998) reported lying partner preferences amongst 80% of piglets in their study, but only observed pigs for an extremely limited single period of 6 h. Newberry and Wood-Gush (1986) found strong relationships between pairs of pigs based on several measures of association, but found that these were short-term relationships only since they were not consistent over time. They also only classed pigs as having a relationship if they had the highest score on a measure but carried out no statistical analysis to determine whether these pairs associated more than would be expected by chance. Neither study, therefore, satisfactorily addresses how widespread preferential associations are amongst pigs.

4.2. Nature of preferential associations

Pigs that formed a preferential association with the same pig in both pens, only formed such an association with one other pig. However, most pigs formed associations in one or both pens with several pigs. Two pigs had associations with one pig, nine pigs had associations with two pigs, 11 pigs had associations with three pigs, five pigs had associations with four pigs, four pigs had associations with five pigs and just one pig had associations with seven other pigs. Differences in popularity between individuals have also been reported in previous studies with pigs (Newberry and Wood-Gush, 1986), cows (Reinhardt and Reinhardt, 1981) and sheep (Arnold et al., 1981). For example, Newberry and Wood-Gush (1986) used arrows to link pigs with the strongest relationship on different measures of association and found that some piglets had more arrows pointing towards them than others. Reinhardt and Reinhardt (1981) found vast differences between the popularity of individual cows, for example, with one cow preferred by a quarter of the other cows as a grazing or licking partner.

On average, dyads with preferential associations spent 0.11% of time lying together out of the total time spent lying. This ranged from 0 to 0.36% of time. If the lying patterns of pigs were random, each individual would be expected to lie with each pig for just 6% of their total time spent lying. Previous studies provide no information on the amount of time spent in association by pairs with preferential associations. However, Durrell et al. (2003) found that even 5 weeks after their introduction into a resident group of 29 sows, sows spent approximately 45% of their total lying time lying in contact with at least one of the three pigs introduced with them. If the choice of lying partner amongst these sows had been random, sows would have been expected to spend approximately 10% of their resting time with these sows. Lying partners in the current study, therefore, spent less time lying together than these sows. However, they were housed in a much smaller and more crowded environment than the sows and this would have made access to lying partners more difficult. Pigs may also have ended up resting with non-lying partners due to the movement of other pigs (Newberry and Wood-Gush, 1986). Unfortunately, other tried and tested methods of measuring association in pigs, such as nearest neighbours or inter-individual distances (e.g. Newberry and Wood-Gush, 1986; Peterson et al., 1989; Jensen and Strangel, 1992), would have been entirely inappropriate in this investigation where space allowance was limited and pigs were forced into close proximity.

4.3. Factors influencing preferential associations

There were no relationships between the relative sex, weight, familiarity or relatedness of dyad members and whether they formed a preferential association. Previous studies show that associations between sheep tend to be between individuals of the same sex (Arnold et al., 1981; LePendu et al., 1996), whilst associations between cattle tend to be between adult females and between calves, but in the case of the latter these relationships are independent of sex (Reinhardt and Reinhardt, 1981). No previous studies have examined the effects of sex or weight on preferential associations between pigs. However, studies have examined the effects of relatedness on association between pigs. Several studies with pigs reared in semi-natural environments have found that piglets tend to associate more with their littermates than with non-littermates of the same age (Jensen and Strangel, 1992; Newberry and Wood-Gush, 1986; Peterson et al., 1989). However, Stookey and Gonyou (1998) suggest that familiarity rather than relatedness may exert a greater influence on the extent to which pigs associate, since they found that degree of relatedness had no effect on lying partner preferences amongst unfamiliar pigs. It has been suggested that since the social group of wild pigs is made up of related animals, pigs may have evolved to learn relatedness through familiarity (Puppe, 1998; Stookey and Gonyou, 1998). However, in this study, neither familiarity nor relatedness significantly or substantially increased the likelihood of pigs forming associations. There are a few possible reasons for this. Firstly, only a small proportion of the total number of pigs within the groups were familiar (3.5%). Secondly, the majority of the familiar pigs were related, save from a few foster pigs. Finally, although familiar pigs were reared together from birth, unfamiliar pigs had also been housed together for some time, namely 7 weeks, by the start of the experiment, so they too were fairly familiar.

5. Conclusions

In conclusion, it appears that unrelated pigs are capable of forming preferential associations. What is not clear is how widespread or important these associations are among pigs. This is because only 12 of the 33 pigs observed appeared to form a long-term preferential association. All but one of the remaining pigs appeared to form short-term preferential associations, as these were only apparent in one of the two pens each group was introduced into. However, it is unclear whether these were in fact short-term preferential associations or whether the pigs were simply demonstrating a shared preference for the same lying locations. The findings, therefore, suggest one of two conclusions: (1) that just over one-third of pigs formed long-term preferential associations and that the remaining pigs, instead of demonstrating preferential associations, had shared preferences for the same lying locations with individuals in their group; and (2) that just over one-third of pigs formed long-term preferential associations, with the remaining pigs forming only short-term preferential associations, lasting about 3 weeks but which were no longer in evidence 4 weeks later.

Since piglets are capable of forming strong social bonds with their mother (e.g. Peterson et al., 1989; Jensen and Strangel, 1992), one would expect they would also be capable of forming preferential associations with other specific individuals, especially related or familiar individuals. However, this study found no significant effect of relatedness or familiarity, or for that matter sex or weight difference, on whether pigs formed preferential associations.

It is possible that the environment the pigs were housed in inhibited associative behaviour. The large number of individuals and the limited space allowance may have prevented individuals from lying with the partner of their choice. The movement of other pigs may also have influenced which pigs were lying together (Newberry and Wood-Gush, 1986). On cold days, the need for thermal comfort via contact lying may have outweighed the pigs' need to lie beside their preferred associate (Stookey and Gonyou, 1998). No data on ambient temperature was collected during the experiment, however, to suggest that pigs experienced low temperatures during this period. However, the experiment was carried out during the winter months when low temperatures were experienced within the pig unit. There may also be fewer benefits to be gained from forming preferential associations within intensive environments, since many needs, such as, food, shelter, warmth, protection from predation, are met by the human caretaker. Alternatively, it may be that as a species pigs are not highly motivated to form preferential associations. Newberry and Wood-Gush (1986) suggest that this may be because greater unity between groups rather than between specific individuals may have been more adaptive in evolutionary terms, for example, with respect to protection from predators and warmth from group resting.

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