Anim. Behav., 1978, **26**, 1255–1263

EFFECTS OF GROUP-REARING OR PARTIAL ISOLATION ON LATER SOCIAL BEHAVIOUR OF CALVES

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Abstract. Calves were either isolated, spatially but not visually, or group-reared for eight months and then kept together. Rank orders based upon competitive interactions were similar at eight and 20 months. Almost all group-reared animals were higher in rank than all isolation-reared animals. The most frequent nearest neighbour associations were between group-reared animals especially those from the same rearing group. Also frequent at eight months were associations between calves which had been isolated in adjacent pens. Isolation-reared animals associated infrequently with group-reared animals and spent more time alone. Body weight was not correlated with rearing conditions or with behavioural measures. Increase, or decrease, in rank between eight and 20 months was associated with faster, or slower, than average weight gain.

Prolonged early social deprivation has effects upon later social and non-social behaviour in many species of animals. When animals which are spatially separated from companions are observed in those conditions they may rest a lot, or carry out stereotyped movements, or spend much time exploring any detectable aspects of their surroundings including their own bodies (Hediger 1955; Berkson et al. 1963; Baenninger 1967; Broom 1968). Isolated animals have no opportunity to practise activities requiring social contact whilst social facilitation and copying other individuals are reduced or absent. Even if isolated animals pay more attention to physical aspects of their surroundings, the overall complexity of their experience is likely to be less than that of group-reared animals. As a consequence, the rate at which behaviour changes with age may initially be slower (Ratner 1965; Broom 1968) and the ability to respond optimally in any situation is generally impaired (Melzack & Scott 1957; Kruijt 1971).

When moved from one empty cage to another, the extent to which behaviour is disturbed may be more (Liddell 1956; Mason & Green 1962) or less (Harper 1968; Coulon 1971; Brown & Kiely 1974) amongst isolation-reared animals than amongst group-reared animals. If, however, that strange cage contains conspecifics isolation-reared animals are more disturbed (Hogan & Abel 1971) and show much less marked preferences for proximity to members of their own species (Pattie 1936; Baron & Kish 1960; Mason 1961). If encounters do occur social responses are drastically altered by rearing in isolation (Ratner 1965; Harlow 1969). In both *Peromyscus* (Rosen & Hart 1963) and cattle (Donaldson et al. 1966; Donaldson 1970) one result of this is that group-reared animals tend to dominate those reared in isolation if there are competitive encounters.

Dairy calves are normally separated from the mother on the first or second day of life and are frequently reared in spatial isolation for some weeks or months. It is not known whether this maternal deprivation has any adverse effects (Kiley-Worthington 1977). In this paper the effects of spatial isolation on various aspects of later group behaviour of heifer calves are studied with reference to weight changes and any factors which might be of significance to production. Since individually-reared calves in calf houses are normally able to see, hear and smell other calves, we have used one calf house for both group-reared and isolation-reared calves. The age at which heifer calves are grouped depends upon the time of year at which they are born and pressures on housing facilities. We chose to keep the calves in their two rearing conditions for eight months from early September to early May, the longest period in such conditions which is likely to occur in practice.

Methods

In each of two years 12 Friesian heifer calves, born within one week in September, were taken from the mother after 24 h and allocated to one of two rearing conditions. Six were put into individual pens 1·15 × 3·25 m with 1·22 m high solid walls and six were put into two groups of

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three in two pens with three times the floor area (3·45 × 3·25 m). The mean weight of the calves was the same for each condition. The pens were arranged as in Fig. 1 and conditions were kept the same during the two replicates of the experiment.

The calves were fed milk replacer from a bucket for 28 days. Early weaning concentrate and water were on offer from day 1 to 8 weeks and barley/ground-nut cube after 8 weeks, both up to a maximum of 2 kg per calf per day. The calves were weighed monthly and dehorned at two months.

During replicate 2, three of the calves became seriously ill with pneumonia. One group-reared calf lived for just over a year but was always small and sickly. A second group-reared calf died after two months and was replaced with another group-reared calf which was three weeks younger than the other two in the group. An isolation-reared calf died after four months. Data relating to the replacement calf and to the animal which died before the end of the experiment were included in the analysis of nearest neighbour associations but not in any of the other calculations of experimental results because these might have been affected by the abnormal rearing conditions and consequent small size of the calves.

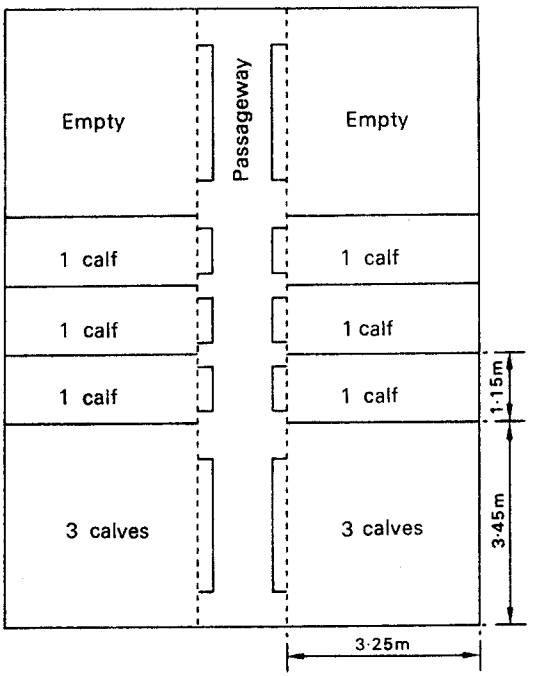


Fig. 1. Plan of calf rearing pens.

In May, at 8 months of age, all the calves were fitted with coloured plastic collars and released into a 0·2 ha paddock in which there was sufficient grass for grazing and supplies of concentrates (2 kg per calf per day) and water. Concentrates were provided once a day at 09.00 hours for a further 9 days. The calves were then moved on from field to field according to grass availability. They were housed again from November to April and grazed thereafter until they calved the following October. They were kept together as a herd and weighed once every two months throughout this period.

After the animals had been grouped, all behaviour observations were made by observers who did not know which animals had been isolated and which had been group-reared. The animals were watched for a 2-h period after feeding on their first and second mornings in the field and on subsequent mornings and afternoons during the first two weeks. One month later and one year later they were watched again. Those in replicate 1 were watched for 12 h in May, for 16 h in June and early July and for 12 h in May of the following year. Those in replicate 2 were watched for 10 h in May, for 16 h in June and for 10 h in the following May.

The behaviour of the calves was watched by one or two observers standing outside the field at a distance of at least 10 m from the nearest animal and not more than 40 m from the furthest. The observers remained as still as possible and commenced recording, by writing on a previously prepared recording sheet, at least 5 min after arrival. After this time few animals looked at the observers, especially after the first week and none showed any evidence of being disturbed by the observers' presence.

All detectable interactions between animals were recorded, together with the time at which they occurred (to the nearest minute). The participants were denoted by the initial letter of their collar colours and the following types of interaction were recorded:

lick, tongue applied to other animal; sniff, nose put within 20 cm of other animal for at least 2 s; nuzzle, gently touch other animal or rub gently against other animal; butt, ridges at top of head forcibly applied to other animal; push, side of head or shoulder forcibly applied to other animal; nudge, nose forcibly applied to other animal; displace, take up place at feeder forcibly so that another

individual moves back from the feeder; turn away, response to approach or look by another individual which involves turning the head away or turning and walking away or diverting the path while walking so as to avoid the path of the other animal.
Occasionally, other interactions were written on the record sheet.

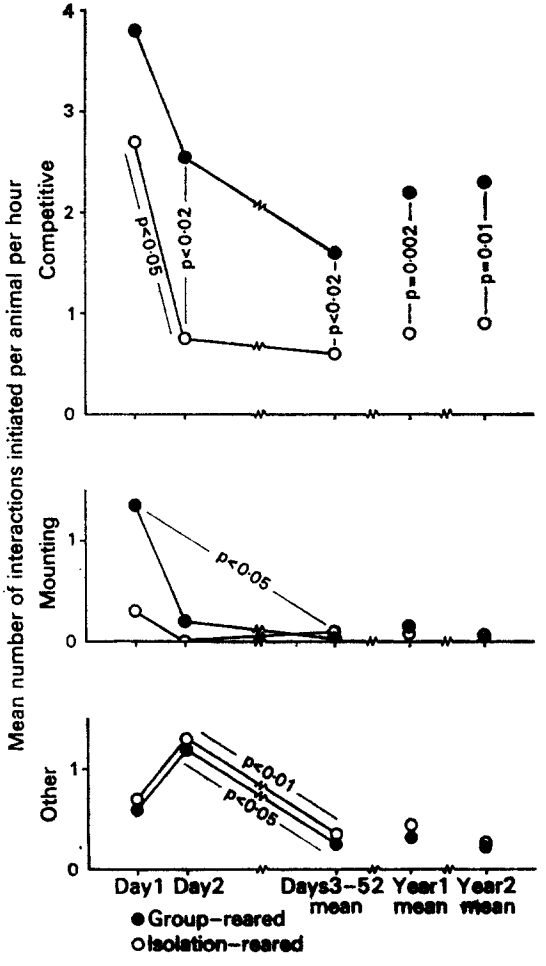
At intervals of 20 min the general activity of each of the animals was recorded using one or more of the following categories: grazing, eating concentrates, drinking, standing but not feeding, mooing, looking at observer, looking away from observer, and other looking. Eight other measures such as posture of head, and position of ears were recorded during some observation sessions. At the times that the general activity was recorded, the nearest neighbour to the animal was noted, provided that there was another individual within 3 m. At 5-min intervals the collar colours of all animals which were at least 3 m from any other individual, or which were in pairs, and the size and composition of each group of animals whose members were less than 3 m apart, were noted.

Results

It was clear from the various methods of recording behaviour that, although the animals from the two rearing conditions soon moved around together as a herd, the group-reared animals continued to associate with one another and encounters with isolation-reared animals often ended when the latter were butted or just moved away.

Frequency of activities. When the eight month old calves were introduced into the field they spent some minutes running and jumping. They then started sniffing at grass, food-troughs, posts, and one another. This behaviour led to the occurrence of interactions between calves and, among both group-reared and isolation-reared animals, more interactions per hour were observed on day 1 than on subsequent days (Figs. 2–4).

Those interactions which are rapidly terminated by one individual moving away from another (butt, push, nudge, displace, or turn away) are referred to as competitive. Other interactions which are not terminated in this way (lick, sniff, or nuzzle) often last for 15 s or more. Isolation-reared calves initiated many competitive encounters on day 1 but few thereafter (Fig. 2). There was also a small decline from day 1 to day 3 in the initiation of such encounters by group-reared calves but the frequency after day 1 was considerably greater than that by isolation-reared calves. Mounting (Fig. 3) was initiated by group-reared calves more frequently than by isolation-reared calves on days 1 and 2 ($P = 0{\cdot}07$, 2-tailed Mann–Whitney U-test). After this time it was rarely seen. The animals had not reached puberty



Figs. 2–4. Changes with time in the frequency of competitive interactions (Fig. 2), mounting (Fig. 3), and other interactions (lick, sniff or nuzzle) (Fig. 4). Means for group-reared and isolation-reared animals are shown on the day that the animals were put together at eight months of age (day 1), on the following day (day 2), and on the subsequent observation days in that year. Means for year 1 and for year 2 are also shown. The P values shown are from comparisons using a 2-tailed Mann–Whitney U-test.

during year 1 and were pregnant when watched in year 2. Animals reared in the two conditions were observed with almost equal frequency licking, sniffing or nuzzling, the peak frequency being on day 2 (Fig. 4).

The 16 measures of general activity revealed considerable individual differences amongst the animals but the only clear differences between animals from the two rearing conditions were in eating concentrates, drinking and looking, During replicate 1 group-reared calves were observed eating concentrates 41% more often than were isolation-reared calves ($P = 0{\cdot}05$, 2-tailed Mann–Whitney U-test) and drinking 44% less often ($P = 0{\cdot}026$). Group-reared calves spent 50% longer looking at the observer ($P = 0{\cdot}033$) and there was an indication that isolation-reared animals spent more time looking at other calves.

Nearest neighbour associations. In order to determine with which other individuals each calf associated most, the nearest neighbour to each animal was recorded at 20-min intervals. The frequency of association between each possible pair of animals from the two rearing conditions is shown in Fig. 5. The mean frequencies and results of 2-tailed Mann–Whitney U-tests against G-I are shown in Table I. In order to ensure that the independence of the data is adequate, animals which were lying are excluded from these analyses. Group-reared animals were much more likely to associate with other group-reared (G-G) than with isolation-reared (G-I) and there was an indication, clear in

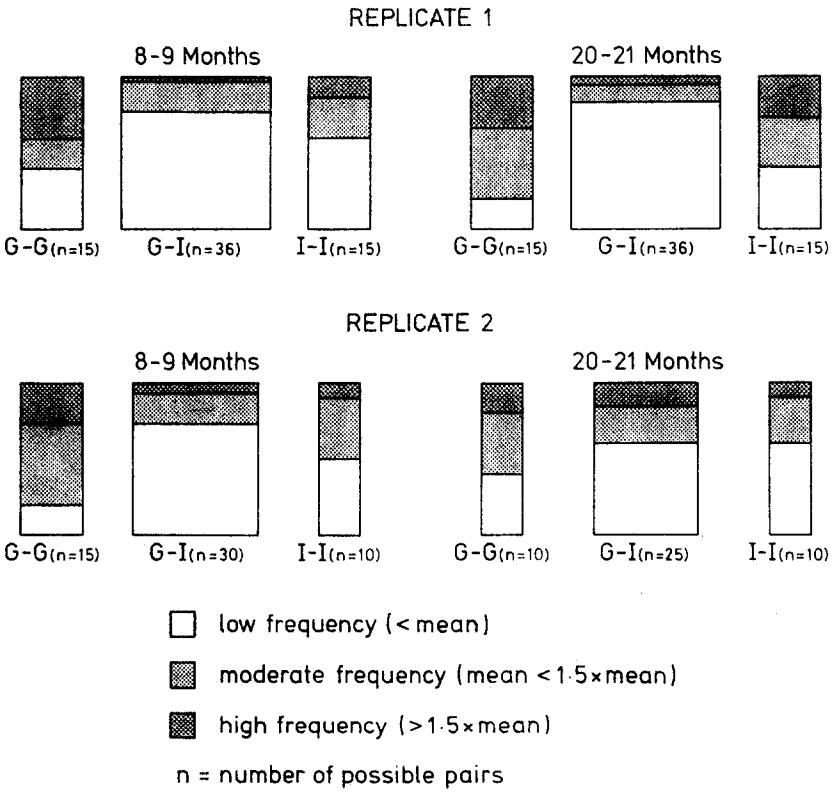


Fig. 5. Frequencies of nearest neighbour associations. The area of each histogram is proportional to the number of possible pairs of two group-reared animals (G-G), two isolation-reared animals (I-I), or group-reared with an isolation-reared animal (G-I). If the frequency with which any two animals were observed as nearest neighbours was lower than the mean frequency of association for that replicate and age, the area on the histogram is white. More frequent associations are shown as light stippled or dark stippled areas. For statistical comparisons see Table I.

Table I. Nearest Neighbour Associations. The Mean Number of Times that each Possible Pair of Two Group-reared Animals (G-G), a Group-reared and an Isolation-reared Animal (G-I), etc., Were Observed Standing Together as Nearest Neighbour

Type of pair (see text)	All G-G	G-own G	G-other G	G-I	All I-I	I-adj I	I-non adj I
Replicate 1							
8 to 9 months	5·8	8·2	3·9	2·5	3·6	7·0	2·4
Mann–Whitney *U*-test v G-I *P* =	0·005	0·007	0·087	—	> 0·1	0·052	> 0·1
Replicate 2							
8 to 9 months	23·0	25·0	21·7	15·4	17·6	23·5	16·1
Mann–Whitney *U*-test v G-I *P* =	0·002	0·026	0·011	—	> 0·1	0·079	> 0·1
Replicate 1							
20 to 21 months	15·7	17·7	14·3	10·1	14·5	12·3	15·3
Mann–Whitney *U*-test v G-I *P* =	0·001	0·009	0·013	—	0·002	> 0·1	0·001
Replicate 2							
20 to 21 months	6·4	7·8	5·7	5·6	4·6	4·0	4·8
Mann–Whitney *U*-test v G-I *P* =	> 0·1	> 0·1	> 0·1	—	> 0·1	> 0·1	> 0·1

replicate 1 heifers, that isolation-reared animals associated more often with one another (I-I) than with group-reared (G-I), see Table I. Associations between members of the same group of three during rearing (G-own G) were recorded more frequently than those between members of different groups (G-other G) and only G-own G was ever clearly different from I-I (8 to 9 months, replicate 1, $P = 0{\cdot}026$, 2-tailed Mann–Whitney *U*-test). Isolation-reared animals associated most frequently with those which had been isolated in adjacent pens (I-adj I). Sample sizes were small but whilst I-adj I were clearly different from G-I at 8 to 9 months (Table I), I-non adj I were different from G-G (8 to 9 months, replicate 1, $P = 0{\cdot}018$; replicate 2, $P = 0{\cdot}056$, 2-tailed Mann–Whitney *U*-test). These effects within rearing conditions were shown at 8 to 9 months but not at 20 to 21 months. The lack of clear results in replicate 2 heifers is due in part to the low frequency of associations whilst grazing during continuous sunny weather. The data for heifers in replicate 1 do, however, show that many associations did persist until the second year.

A rank order, calculated on the basis of the mean proportion of wins in competitive interactions (see later), was plotted against the frequency of association. Animals close together in the rank order were more likely to associate with one another. When correlation coefficients were calculated and an F test carried out on the mean square in an analysis of variance, the probabilities for both were $P < 0{\cdot}05$ for heifers and $P < 0{\cdot}1$ for calves in the first replicate. The calculated regression lines did not fit the data as well in replicate 2.

Group size. During the first month in the field, individuals in replicate 1 spent a mean of 28% of their time in one large group of 12 whose members were all within 3 m of another individual. Time spent in groups of 2 to 11 individuals ranged from 4% to 11% of total time. During the following year these animals behaved more as a herd and spent a mean of 55% of time in one group of 12 and 2 to 8% of time in the smaller groups. The mean group size was smaller in sunny weather and thus in replicate 2 less time was spent in large groups.

There were no significant differences between group-reared and isolation-reared animals in the time spent in large groups but in the first month in the field group-reared calves were observed as single individuals a mean of 4% of the time whereas isolation-reared calves were single 9% of the time ($P < 0{\cdot}002$, 2-tailed Mann–Whitney *U*-test).

Social interactions. As mentioned above (Fig. 2), group-reared animals initiated more competitive interactions (butt, push, nudge,

Table II. Mean Weights (kg) of Animals

	Group-reared	Isolation-reared
Replicate 1		
Calves (birth)	37	39
Calves (8 months)	176	180
Heifers (20 months)	389	385
Replicate 2		
Calves (birth)	39	36
Calves (8 months)	207	192
Heifers (20 months)	408	396

displace, or turn away) than did isolation-reared animals in both replicates and at both ages. The individuals to which such actions were addressed eventually moved away from the initiator in most encounters. Sometimes a period of butting and pushing intervened before the initiator could be said to have won the encounter. A table, which included all possible pairs of animals, was constructed and the results of all encounters, about ten per pair, were entered in it. It was apparent that group-reared animals won a majority of their encounters with isolation-reared animals. When each animal was allocated a score between 0 and 1 indicating its proportion of wins against each other animal, the mean proportion of wins could be calculated and the animals placed in order. Figures 6 and 7 show the orders for animals in each replicate both as calves in the first year and as heifers in the second year. At the time that these observations were made, the observers did not know which animals had been group-reared and which isolation-reared but it was obvious that some individuals responded to any sort of approach by turning away and withdrawing rapidly whilst others did not. The withdrawal response was often followed by a butt or push from the approaching animal. Most of these withdrawal responses were later found to have been shown by isolation-reared animals. The great superiority of the group-reared animals in such encounters clearly persisted for at least a year but there were some changes in the rank order from one year to the next (see later).

As shown in Fig. 4, licking, sniffing, or nuzzling were initiated equally frequently by group-reared and isolation-reared animals. For such interactions, the ratio initiated/total was between 0·49 and 0·52 for each age and rearing condition. When these ratios for each individual were plotted against the proportion of competitive interactions won, no clear relation was apparent for either replicate at either age. There was a slight indication that group-reared animals licked, sniffed or nuzzled members of their own group more often than members of the other group, but this was not significant. Neither was there any difference in the frequency with which butts, pushes, etc., were initiated towards members of their own or other groups.

Weight changes in relation to behaviour. Table II shows the weights of animals at birth and at the times that observations were started. There were no significant differences between group-reared and isolation-reared animals, and no significant correlations between weight and any behavioural measure. When weight gains were calculated for each individual they were found to be related to the changes in rank apparent in

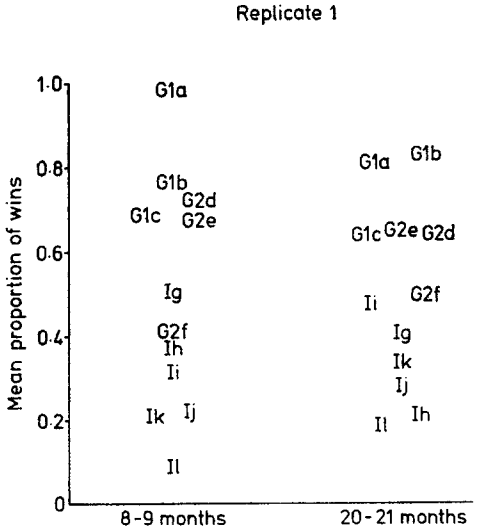


Fig. 6. For each animal (a, b, c, etc.) the mean of the proportion of competitive interactions won against each other animal is plotted. The calves watched in a group at 8 to 9 months were watched again at 20 to 21 months. G1-Group 1 during rearing (0 to 8 months), G2—Group 2, I—isolation-reared.

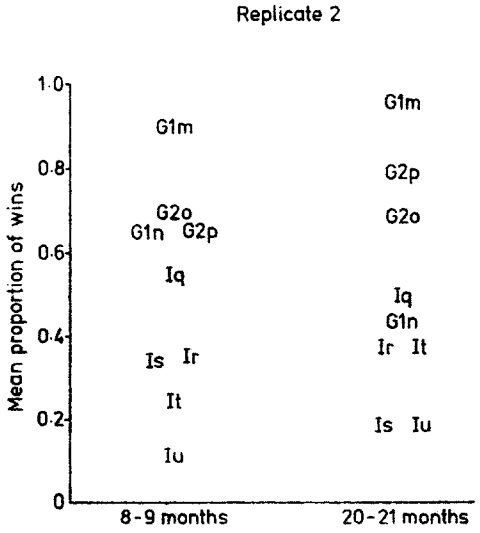


Fig. 7. Legend as Fig. 6.

Figs. 6 and 7. Most animals which increased in social rank also showed a greater than average increase in weight and most which decreased in rank showed a smaller than average increase in weight. The correlation coefficient between weight gain as a proportion of the mean weight gain and rank change (Fig. 8) was 0·44 (20 *df*, $P < 0{\cdot}05$). Amongst the apparently anomalous points in Fig. 8, animals Il and Iu were at the bottom of the rank order at both ages in replicates 1 and 2 and therefore could not drop in rank. The proportion of wins shown by animal G2d at 20 months was only slightly lower than that of the animal above it while that of animal G2e was only slightly higher than those of the two animals below it. Thus it appears that there was a clear correlation between weight change and rank change. Three animals which suffered long periods of illness, G2o, Gln and Iu, all declined in weight and, where possible, in rank.

Discussion

The difference in rank, deduced from competitive interactions, between animals reared in the two conditions is the most obvious result of this experiment and is perhaps the most significant in terms of possible effects on production. Group-reared animals dominated isolation-reared animals at both 8 and 20 months. This confirms the results of Donaldson et al. (1966), and Donaldson (1970) whose calves had been grouped or isolated for 4½ months. Studies of rodents (Rosen & Hart 1963) and primates (Harlow 1969) have given similar results. McBride et al. (1970), who worked with domestic chicks, suggested that rank orders amongst young animals reflect only the tendency of some individuals to initiate encounters and of others to avoid them. It did appear that the 8-month-old calves which initiated most encounters on day 1 were those which were finally highest in the rank order but the likelihood that isolation-reared calves would avoid encounters was certainly increased by the experience of being butted or chased. As Barton et al. (1974) explain, the likelihood of initiating a competitive interaction need not be positively correlated with that of winning the encounter and neither of these need be negatively correlated with the likelihood of submission if attacked. In our experience, however, after day 2 almost all of those attacked, submitted. Further analysis of what happens during an encounter and how relationships between individuals develop are in progress but as Maynard Smith & Price (1973) have pointed out such a combination of strategies may be evolutionarily stable in some circumstances.

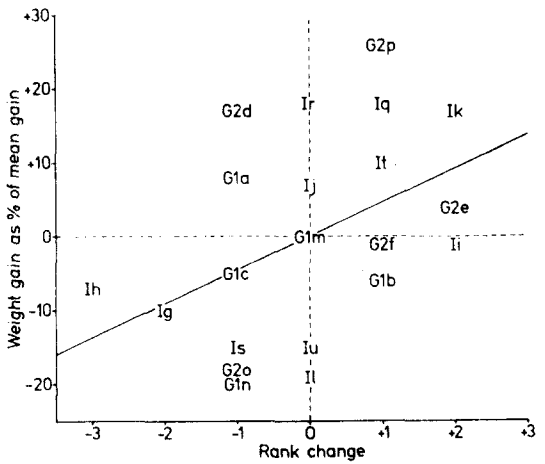


Fig. 8. The weight gain between 8 and 20 months of each heifer in both replicates is expressed as the percentage more or less than the mean weight gain in its replicate. This percentage is plotted against the heifers' change in rank as calculated from competitive interactions. $R = 0{\cdot}44$, $P = < 0{\cdot}05$. Key as in Fig. 6.

As previously found for various other species, e.g. jungle fowl (Kruijt 1971), calves which had been spatially isolated for 8 months showed the same range of basic motor patterns as did those which had been reared in groups. They did not show the behavioural disturbance and partial or complete avoidance of conspecifics which totally isolated animals show, e.g. domestic chicks (Pattie 1936; Baron & Kish 1960; Hogan & Abel 1971), or rhesus monkeys (Mason 1960). On the first day of grouping, isolation-reared calves initiated many interactions with all other calves. If they pushed or butted group-reared calves they were often repulsed with a vigorous counter-attack or were attacked and chased by that individual shortly afterwards. If isolation-reared calves were attacked they retreated rapidly so it appeared that they lacked skill in dealing with encounters. Their response to being butted and briefly chased was to keep away from group-reared animals, at least for some of the time. In addition to initiating fewer competitive interactions after day 1 they were observed as single individuals more often than group-reared, especially in the first month, and they associated with other isolation-reared animals rather than with group-reared.

Animals from both rearing conditions showed a decline in competitive interactions between day 1 and day 2. Mounting, which occurred after similar approach behaviour, was rare after day 2. The results of most competitive encounters were predictable after the first few days. All animals tolerated licking, sniffing and nuzzling and the proportion of social interactions which were of this type increased after the first day. The weak preference for grooming members of the same rearing group was much less pronounced than that observed between monozygotic twins by Wood (1977). The members of the herd spent more time as a single group at 20 to 21 months but both the group-reared and isolation-reared heifers continued to associate more frequently with individuals reared in the same way than with those reared in the other way. Calves reared in the same pen associated often during year 1 and year 2, as also found by Ewbank (1967), but associations between isolation-reared calves from adjacent pens were frequent at 8 months but not at 20 months.

The positive correlation between closeness in rank order and likelihood of association may be partly explained by the increased association and the similarity in rank of animals reared in similar conditions. As Bouissou & Hövels (1976) have found, animals which have been kept in a group for some time are likely to have similar ranks when their group is combined with others. Their animals, which had been grouped indoors for 18 months, initiated fewer competitive interactions with members of their own group but ours showed no clear differences in frequency of such initiations towards their own or the other group.

The weights of the group-reared and isolation-reared animals were similar at eight and twenty months so there was no sign that isolation reduced growth (Coffey unpublished, quoted by Kiley-Worthington 1977). Weight was not correlated with any behavioural measure. Studies of herds of cows have often shown that weight is partially correlated with rank order based on some transformation of the proportion of wins in competitive encounters (Beilharz et al. 1966; Dickson et al. 1967; Bouissou 1972) but such herds usually include considerable variety in age and weight of members. The relationships between weight gain and behaviour are clearly of interest in animal production studies so our finding that rate of weight gain was correlated with change in rank order poses some interesting questions. Sometimes, as in replicate 2 of our experiment, slow weight gain and drop in rank are due to a period of illness. The question of whether weight change always precedes rank change, or whether some animals gain or lose weight faster or slower than the mean as a result of changes in their rank, needs further investigation.

Since the animals fed by grazing, supplemented initially by concentrates, competition for food did not preclude adequate intake so it is not surprising that group-reared and isolation-reared animals showed no differences in weight gain despite their differences in rank. In replicate 1, however, group-reared animals were observed eating concentrates more often than were isolation-reared animals. This finding can be attributed to the observations that isolation-reared animals tended to keep away from group-reared animals and were often displaced by them when they were at the feeder. The group-reared animals had had 8 months of practice in situations where they had to compete for food so they had developed the habit of eating fast and threatening individuals who impeded them. This result is similar to that of Stephens (1974), who found that calves low in rank order drank less milk in a competitive situation.

Acknowledgments

We thank Mrs R. Cleevely and Miss S. J. Evans for help with behaviour observations and various colleagues for helpful discussion.

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(*Received* 18 *August* 1977; *revised* 21 *November* 1977; *MS. number:* 1668)