THE EFFECT OF CONTACT WITH CONSPECIFICS AND HUMANS ON CALVES' BEHAVIOUR AND STRESS RESPONSES

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Abstract

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In this study, we analysed the effects of social and human contact on calves' behaviour and stress responses. We also measured the effect of this contact on calves' reactions to novel conspecifics and novel humans. Sixty-four calves were housed either alone or in pairs and received either minimal human contact or 'additional' human contact (stroking and talking). At six, 10 and 14 weeks of age, the behaviour of the calves was recorded in their home pens. Calves were then tested in an unfamiliar arena either alone, with an unfamiliar calf, or with an unfamiliar man, and in a Y-maze with one arm leading to a calf and the other to a man. An adrenocorticotrophic hormone (ACTH) challenge was performed in order to assess chronic stress responses. Compared with individually housed calves, pair-housed calves were more active and made fewer contacts with their neighbours when in their home pens; they were also less active in the arena, spent more time near the calf in the Y-maze, and had lower cortisol responses to ACTH. Calves that had received additional human contact interacted more with the man in the arena and had lower mean heart rates than those that had received minimal contact. This study confirmed that calves feel a need for social contacts and that pair-housing can lower the stress felt by calves separated from their conspecifics. Additional contact from stockpersons increases calves' likelihood of approaching humans but cannot compensate for their lack of social partners. Hence, when calves are separated, the duration of the separation should be limited, and visual and physical contact with other calves should be provided.

Keywords: *ACTH challenge, animal welfare, behaviour, cattle, housing, human–animal interactions*

Introduction

Cattle are highly gregarious animals (Bouissou *et al* 2001); therefore, housing them in groups rather than individually can improve their welfare. From 1 January 2004, group housing will be compulsory in the European Union for calves over eight weeks of age (Directive

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97/2/EEC). Some individual housing of calves will remain, however; this may be because calves are under eight weeks of age, because of lack of farm-animal welfare regulations (as in North America), or because the calves are being used for experimental purposes (eg studies on nutrition or metabolism often require animals to be individually housed in crates). Housing calves alone can be stressful to them. Calves reared in individual pens have higher cortisol responses to adrenocorticotrophic hormone (ACTH) than do calves reared in groups, and this is considered to be the result of chronic stress (Dantzer *et al* 1983; Friend *et al* 1985). According to Dellmeier *et al* (1985), this stress occurs because of the high motivation of calves to interact with other calves. When a calf that has been denied social contact is put in the presence of another calf, it interacts with it more frequently than does a calf that has had prior social contact (the 'damming up' phenomenon, Dellmeier *et al* 1985). Corticosteroids, which are involved in stress responses, affect metabolism by increasing gluconeogenesis at the cost of protein synthesis (Mormède 1995). This is supported by the finding in several studies that calves reared alone grow more slowly than calves housed in groups (Warnick *et al* 1977; Veissier *et al* 1994).

Individual housing of calves can affect their behaviour. Calves housed in individual crates spend more time licking or nibbling at parts of their crate than do calves reared in groups (Veissier *et al* 1998; Blokhuis *et al* 2000). This increase in activity is even more marked when calves are in total isolation: not only do they spend more time nibbling, but also they spend less time lying down (Waterhouse 1978; Creel & Albright 1988; Veissier *et al* 1997). Individually housed calves are more highly disturbed by external events than calves with social contacts. This has been observed both in farm conditions (Webster *et al* 1985) and in experimental conditions (open-field test [Warnick *et al* 1977; Arave *et al* 1985]; water-throw test [Veissier *et al* 1997]), and is also demonstrated in the production of higher levels of cortisol during handling in calves that lack contact with neighbours (Creel & Albright 1988). Such increases in reactivity to external events are likely to be energy consuming, which may lead to altered metabolic function.

The first objective of this study was to investigate whether pair housing, compared to individual housing, reduces chronic stress in calves and affects their general activity and their reactivity to external events. It has been proposed that, under some circumstances, a stockperson can act as a substitute for social partners to calves (Arave *et al* 1985). This is supported by the observation that lambs that have been reared alone and have received positive contacts from humans (through hand feeding or stroking) respond to the arrival of the stockperson in the same way as group-housed lambs respond to re-mixing with their peers after separation (Boivin *et al* 2000). In some species, contact with animals of other species at an early age can lead to socialisation to this species; that is, elements of social behaviour are displayed between animals of the two species. This has been observed in dogs and other species (for a review, see Scott 1992). Price and Wallach (1990) observed that bulls that have been hand-reared in isolated single pens show agonistic behaviour, threat or attack to humans, as though they consider humans as a species companion. Thus, cattle can express social behaviour to humans. Hence, the second objective of the present study was to investigate whether contact with humans could partly compensate for the lack of contact with conspecifics.

In order to meet these two objectives, a 2×2 factorial design was set up to analyse the effects of pair housing and human contact and their interactions on calves' behavioural and stress parameters. To further analyse the socialisation of the animals, their reactions to unfamiliar calves and unfamiliar humans were observed.

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Material and methods

The study was performed at the Lintupaju farm (61°N, 23°E) at MTT Jokioinen, Finland. The experimental protocol was scrutinised and approved by the MTT committee for experiments on animals. In addition, according to national regulations in Finland and France, M Pyykkönen, A Boissy and I Veissier were licensed for carrying out experiments on animals.

Animals and general management

The animals used were the same as those in Lensink *et al* (2001a). Sixty-four Finnish Ayrshire male calves (*Bos taurus*) were reared in four batches of 16 calves from autumn 1997 until winter 1999. At birth, the calves were kept with their dams for three days. They were then housed in individual pens where they learned to drink from a teat bucket with human assistance. The stockperson was instructed not to stroke the calves at that time. When they were 15.9 ± 1.3 days old, all of the calves were moved in batches to the experimental building. In this heated building, lights were on from 0600h to 1800h. The calves were fed milk replacer from teat buckets twice daily, at 0700h and 1500h, and they had free access to concentrates and hay and to water from a nipple. The calves were housed in pens with wooden slatted floors (slats 10 cm, slots 2 cm), which were littered with wood shavings once per day without the stockperson entering the pens. For ethical reasons, no calf was in total isolation in this study: partitions between pens were of open wood, 120 cm high, with slots of 10 cm through which the calves could see and sniff their neighbours. For each batch of calves, a male and a female stockperson took care of the calves on alternate days. Until the first behavioural test was carried out (see below), no other people entered the calves' building. The health of the calves was monitored at feeding times and appropriate medical treatments were given when necessary. No human contact was provided except for feeding and littering.

Experimental treatments

Upon their arrival in the experimental building, the calves were allocated to four treatment groups according to a 2 × 2 factorial design, with two housing conditions and two contact conditions. The age and the weight of the calves were balanced over treatments.

Housing conditions: Half of the calves were individually housed in 1.2 × 1.8 m pens. The other half were pair-housed in 2.4 × 1.8 m pens.

Contact conditions: Half of the calves in each housing condition received minimal contact from the stockperson — that is, they saw the stockperson as he/she carried out feeding and littering, but had no physical contact. The remaining calves received additional contact after meals on five days per week: when the teat bucket was removed 15 min after a milk meal, the stockperson stroked each calf's neck, head and shoulders, all the while speaking in a gentle tone and allowing the calf to suck his/her other hand. This was done for 60 s after the morning meal and 30 s after the evening meal. These contacts (stroking, talking, allowing sucking) have been previously described as positive, as they increase calves' motivation to interact with humans and reduce their withdrawal from them (Lensink *et al* 2000, 2001b).

Diurnal behaviour measurement

The calves were video-recorded in real time from 0600h to 1800h for one day when they were 6, 10, and 14 weeks old. After the experiment, the videotapes were analysed and the

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calves' posture and activity were scan sampled every 5 min. Two postures were distinguished: standing and lying. The following activity patterns were distinguished: moving (walking, jumping or running); sniffing or licking an inanimate object (floor or pen); eating or drinking; self-grooming; contact with neighbour calf (touching, sniffing or licking a calf in an adjacent pen through slots); contact with penmate (for pair-housed calves only, touching, sniffing or licking the penmate); and inactivity (none of the previous activities). These patterns were mutually exclusive. The proportion of scans on which a posture or activity was observed and the number of changes in posture and activity from one scan to the other were further calculated for each observation day.

Tests in the unfamiliar arena

Calves' reactions to being alone in an unfamiliar arena were observed when they were 15 weeks old. The arena was a room measuring 4 × 4 m, with walls made of 2.5 m high plywood boards. The floor was divided into nine squares marked by white lines and covered with a thin layer of wood shavings, which was refreshed between the tests.

In order to ensure in the pair-housed calves that the observed behavioural reactions were reactions to novelty rather than to separation from their pen mate, the pair-housed calves had been habituated to separation by placing a plywood plate in the middle of their pen and keeping one calf on each side for 4 h on the five days preceding the tests. Three 5 min tests were conducted in the arena on consecutive days. For each test, an electrode belt and receiver (Polar Vantage NV™ Tester; Polar Electro Oy, Finland) were placed on the chest of the calf in order to record its heart rate. This procedure, which took less than 2 min, was carried out 30 min before the calf was brought to the arena in a wheeled cart measuring 1.0 × 1.0 × 0.7 m. The heart-rate recording was begun when the calf entered the cart. The cart was then placed at the entrance of the arena and its door was opened. If the calf did not enter the arena within 30 s, it was gently pushed in. In Test 1, the calf was left alone in the arena. In Test 2, an unfamiliar male calf was present in the arena. This unfamiliar calf was of the same size, age and breed as the test calf, and it was attached by a rope to the midpoint of one of the arena walls. The unfamiliar calf had been habituated to this procedure for 3 h on the two days preceding Test 2. In Test 3, an unfamiliar man (wearing overalls that were a different colour from those of the stockpersons) stood motionless in the arena in the same position as the unfamiliar calf in Test 2.

An observer stood behind a one-way screen and recorded the behaviour of the calf on a hand-held computer (Psion Workabout, Psion PLC, UK) using the software package Observer (Noldus, The Netherlands). Two measures were recorded: the position of the calf (ie the square on which it stood); and its activity (running, exploration [ie sniffing or licking the floor or walls of the arena], contact with the unfamiliar calf in Test 2 and contact with the man in Test 3 [ie sniffing, licking or touching], or no activity). These states were mutually exclusive. In addition, buck-kicks were recorded as events, defined as when the calf lifts its hindquarters and hind legs and extends at least one hind leg behind its body (Dellmeier *et al* 1985). The time spent on each square, the frequency of moves from one square to another (frequency of line crossing), the time spent running and exploring, and the frequency of buck-kicks were further calculated using the Observer software. In Tests 2 and 3, the latency and the frequency of contacts were also calculated. The mean heart rate was calculated over each test.

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of variances could not be assumed on the basis of the raw data. Student's t-tests for paired data were carried out in order to compare the behaviour with the unfamiliar calf to that with he unfamiliar person in the Y-maze. All results on quantitative data will be expressed as neans (± standard errors). Chi-squares were calculated to compare proportions of calves, which were not averaged across pens (Siegel & Castellan 1988).

Although some significant effects on diurnal behaviour were observed for batch and age, hey are not reported in the present paper. Our focus here is on the effect of the environment on behaviour.

Results

Diurnal behaviour

Posture

On average over the whole experiment, the calves were observed standing for 47 (± 2.2)% of he daytime. Pair-housed calves stood more often than their individually housed counterparts Table 1). An interaction between housing and contact conditions was also found, with additional contact decreasing standing frequency of individually housed calves and ncreasing standing frequency of pair-housed calves. Calves changed their posture (from standing to lying, or from lying to standing) about 30 (± 1.5) times during the daytime, with no variation between treatments ($F_{1,44}$ [housing] = 0.4; $F_{1,44}$ [contact] = 0.0; $P > 0.05$).

Table 1 Effects of housing (individual versus paired) and human contact (minimal versus additional) on the diurnal behaviour of calves. Calves' posture and activity in their home pens were scan sampled every 5 min during one day (0600h–1800h) at 6, 10, and 14 weeks of age.

	Housing		Contact		SE	Main effects				Interaction	
	Individual	Pair	Minimal	Additional		Housing		Contact		Housing × Contact	
						F	P	F	P	F	P
Frequency (% scans)											
standing	44.0	49.7	47.4	46.3	2.16	14.9	0.00	0.41	0.53	4.26	0.05
moving	0.57	0.92	0.74	0.74	0.21	7.7	0.01	0.00	0.96	0.02	0.88
contact with neighbours	2.66	1.02	1.35	2.33	0.75	12.8	0.00	0.94	0.34	0.94	0.34
No. activity changes between scans	45.2	58.7	51.6	52.3	1.9	57.6	0.00	0.13	0.72	1.37	0.25

Activity

On average over the whole experiment, inactivity was recorded for 55.2 (± 6.5)% of the daytime, moving for 0.7 (± 0.2)%, sniffing or licking an inanimate object for 10.1 (± 1.4)%, eating and drinking for 22.2 (± 2.0)%, self-grooming for 2.5 (± 0.4)%, contact with neighbours for 2.1 (± 0.7)%, and contact with penmates (for pair-housed only) for 4.3 (± 3.8)% of the daytime. Compared to individually housed calves, pair-housed calves were more often observed moving and less often observed in contact with their neighbours, and they changed activity more often (Table 1). No effects of the contact conditions and no interaction between housing and contact conditions were found.

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On average over the whole experiment, the calves were observed standing for 47 (± 2.2)% of the daytime. Pair-housed calves stood more often than their individually housed counterparts (Table 1). An interaction between housing and contact conditions was also found, with additional contact decreasing standing frequency of individually housed calves and increasing standing frequency of pair-housed calves. Calves changed their posture (from standing to lying, or from lying to standing) about 30 (± 1.5) times during the daytime, with no variation between treatments ($F_{1,44}$ [housing] = 0.4; $F_{1,44}$ [contact] = 0.0; $P > 0.05$).

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	Housing		Contact		SE	Main effects				Interaction	
	Individual	Pair	Minimal	Additional		Housing		Contact		Housing × Contact	
						F	*P*	*F*	*P*	*F*	*P*
Frequency (% scans)											
standing	44.0	49.7	47.4	46.3	2.16	14.9	0.00	0.41	0.53	4.26	0.05
moving	0.57	0.92	0.74	0.74	0.21	7.7	0.01	0.00	0.96	0.02	0.88
contact with neighbours	2.66	1.02	1.35	2.33	0.75	12.8	0.00	0.94	0.34	0.94	0.34
No. activity changes between scans	45.2	58.7	51.6	52.3	1.9	57.6	0.00	0.13	0.72	1.37	0.25

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Tests in the unfamiliar arena

Because of technical problems, the heart rate could not be recorded in 10, 8, and 6 calves in Tests 1, 2, and 3, respectively, in the arena. In Test 1, when the calves were tested alone in the arena, pair-housed calves tended to spend less time running and to move from one square to another less frequently than individually housed calves (Table 2). No effects of the contact conditions and no interaction between contact and housing were found. No differences in time spent exploring or in heart rates were found between treatments (Figure 1).

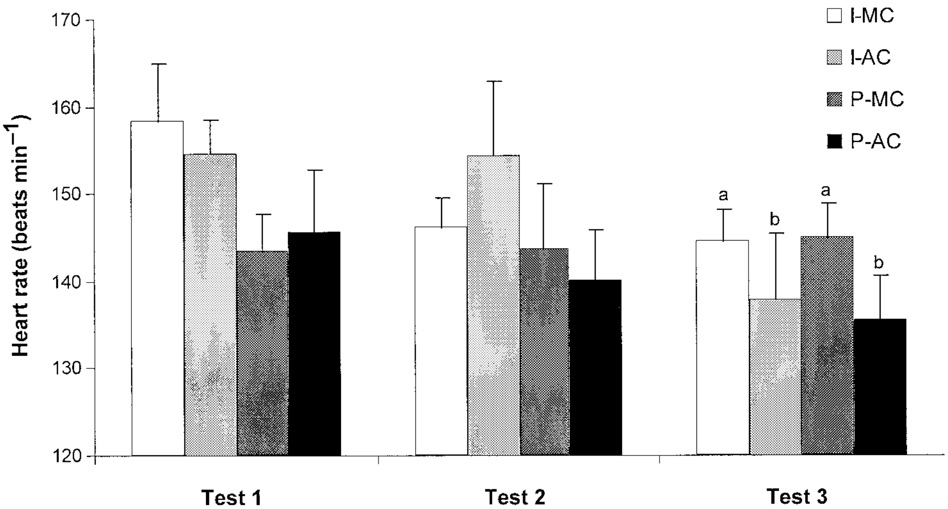

Figure 1 **Heart rate in the arena tests, in calves reared in individual pens (I) or pair-housed (P) and receiving minimal human contact (MC) or additional human contact (eg stroking and talking; AC). Treatments with no common letter differ significantly ($P < 0.05$).**

In Test 2, when the calves were in the presence of the unfamiliar calf, those which were pair-housed moved from one square to another and buck-kicked less often than their individually housed counterparts (Table 2). No effects of the contact conditions and no interaction between housing and contact conditions were found. No differences in time spent exploring or in heart rates were found between treatments (Figure 1).

In Test 3, when the calves were exposed to the unfamiliar man, the calves that had received additional human contact made more frequent contact with the unfamiliar man than those that had received minimal contact, and they also tended to spend more time on square six where the man stood (Table 2). No housing effects and no interaction between housing and contact conditions were found. No differences in time spent exploring were found. Lower heart rates were found in calves that had received additional contact than in those that had received only minimal contact ($F_{1,44}$ [contact] = 5.6; $P < 0.05$; Figure 1).

Y-maze test

The Y-maze test was interrupted for two calves that had received minimal contact, one in each housing condition, because they jumped out of the construction. Data from these calves could not be used in the analyses. When released into the Y-maze, most pair-housed calves went to the arm leading to the calf before that leading to the man and made their first

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Table 2 **Effects of housing (individual versus paired) and previous human contact (minimal versus additional) on behaviour of calves in an unfamiliar arena and in a Y-maze. Calves' behaviour in a 4 × 4 m arena was recorded for 5 min either alone (test 1), with an unfamiliar calf (test 2), or with an unfamiliar person (test 3). The behaviour of calves was observed in a Y-maze for 2 min, one arm of the maze leading to an unfamiliar calf and the other to an unfamiliar man.**

	Housing		Contact		SE	Main effects				Interaction	
	Individual	Pair	Minimal	Additional		Housing		Contact		Housing × Contact	
Unfamiliar arena						*F*	*P*	*F*	*P*	*F*	*P*
Test 1: Alone											
Freq. line crossing	63	42	50	55	6.8	3.7	0.06	0.2	0.68	0.1	0.75
Time spent running (s)	22	3	9	15	5.2	3.8	0.06	1.3	0.27	0.4	0.54
Freq. buck-kicks	4	3	4	3	0.8	0.5	0.47	0.1	0.72	0.1	0.79
Test 2: Unfamiliar calf											
Freq. line crossing	47	28	37	37	5.1	4.6	0.04	0.0	0.92	0.8	0.38
Time spent running (s)	9	1	4	6	3.6	1.3	0.26	0.0	0.97	1.0	0.32
Freq. buck-kicks	7	3	6	4	1.2	4.1	0.05	0.5	0.49	2.1	0.15
Latency to contact calf (s)	66	53	50	69	11.0	0.1	0.75	0.4	0.52	0.0	0.87
Freq. contact with calf	12	14	12	14	0.91	0.9	0.36	2.6	0.12	0.1	0.78
Time spent in square 6 (s)	94	100	92	101	9.6	0.2	0.68	0.3	0.57	0.7	0.41
Test 3: Unfamiliar man											
Freq. line crossing	33	30	32	31	4.5	0.2	0.63	0.1	0.82	0.3	0.62
Time spent running (s)	4	1	1	4	1.6	0.0	0.91	0.6	0.44	0.0	0.83
Freq. buck-kicks	4	3	5	3	1.1	0.3	0.59	1.7	0.19	0.4	0.55
Latency to contact man (s)	70	75	88	57	14.2	0.1	0.81	1.9	0.18	0.0	0.94
Freq. contact with man	9	9	7	12	1.08	0.0	0.86	7.4	0.01	0.6	0.43
Time spent in square 6 (s)	101	83	75	109	11.6	0.9	0.36	3.2	0.08	0.2	0.65
Y-maze											
Time spent in arm with calf (s)	58.1	71.6	63.5	66.2	6.73	1.42	0.24	0.04	0.84	0.06	0.81
Time spent in arm with man (s)	44.4	15.3	29.1	30.6	6.8	6.78	0.01	0.04	0.84	0.05	0.82
Time spent in middle zone (s)	17.5	31.7	27.4	21.8	3.5	8.88	0.00	0.67	0.42	0.00	0.98
Freq. contact with calf	2.7	4.4	3.8	3.4	0.47	4.98	0.03	0.26	0.61	0.00	0.95
Freq. contact with man	2.7	0.94	1.5	2.1	0.46	5.37	0.03	0.79	0.38	0.05	0.83
						X^2	*P*	X^2	*P*		
No. animals initially going to arm with calf	15	22	17	20							
No. animals initially going to arm with man	16	6	12	10		8.9	0.01	0.7	0.71		
No. animals staying in middle zone	0	3	1	2							
No. animals initially contacting calf	15	23	17	21							
No. animals initially contacting man	15	5	11	9		7.7	0.02	0.6	0.76		
No. animals making no contact	1	3	2	2							

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physical contact with the calf, whereas the calves housed individually went to both arms with equal frequency and were equally likely to make initial contact with the calf as with the man (Table 2). Over the whole test, pair-housed calves spent more time near the calf than near the man (paired $t = 4.5$, $P < 0.001$) and made contact with the calf more frequently than with the man (paired $t = 4.2$, $P < 0.001$). Calves housed individually spent the same amount of time near the calf as near the man, and made the same number of contacts with the calf as with the man (paired $t = 0.86$ and 0.03, $P > 0.10$). Compared to their individually housed counterparts, pair-housed calves spent less time near the man and more time in the middle zone, and they made less contact with the man and more contact with the calf (Table 2). No effects of the contact conditions and no interaction between housing and contact conditions were found.

ACTH challenge

Changes in blood cortisol levels over time after the administration of ACTH varied according to housing conditions ($F_{2,80}$ [time × housing] = 4.3, $P < 0.05$), with a lower increase 30 min after ACTH administration in pair-housed calves ($F_{1,40} = 4.5$, $P < 0.05$; Figure 2). No effects of contact conditions and no interaction between contact and housing conditions were found.

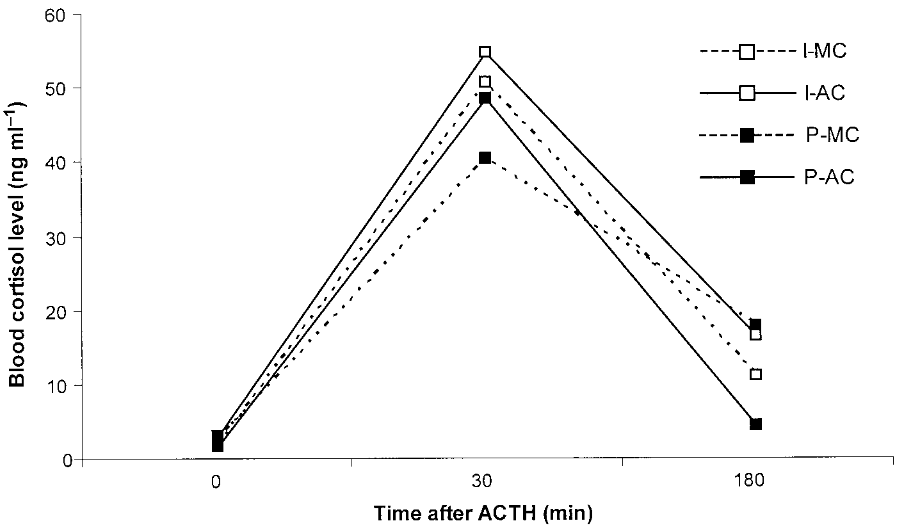

Figure 2 **Cortisol response to exogenous ACTH in calves reared in individual pens (I) or pair-housed (P) and receiving minimal human contact (MC) or additional human contact (eg stroking and talking; AC). Between- and within-subjects standard errors were 2.07 and 1.10, respectively.**

Discussion

In the present study, calves housed in pairs differed from calves housed alone in their stress responses, their diurnal behaviour, and their responses to conspecifics and humans. Gentle contacts from stockpersons made calves more ready to approach and interact with humans, and made the interactions with humans less stressful for the calves.

The first point to note is that calves housed individually had higher cortisol responses to ACTH. The ACTH challenge has been used in humans to detect depressive states and in animals to detect chronic stress. In humans, increased sensitivity of the adrenals is observed in depression (O'Toole *et al* 1998). In animals, although there is still some controversy as to

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the interpretation of this test, most authors report an increase in corticosteroid release when animals are subjected to chronic stress (cattle, Veissier *et al* 2001; pigs, Janssens *et al* 1995). The present result confirms earlier findings by Dantzer *et al* (1983) and Friend *et al* (1985), who reported that calves whose movements are limited by tethering or confinement have higher cortisol responses to ACTH. In these earlier studies, calves had very limited contacts with other animals: they could see each other and could probably interact physically with neighbouring calves only through the front of their crate and at feeding times. In these calves, the increase in cortisol responses to ACTH may have been partly attributable to the reduction of social contact and the low space allowances. In our work, the calves that were in individual pens could see, sniff, touch and lick the other calves in adjacent pens through open wooden partitions (10 cm slots). Hence, even when they are able to have some contact with their neighbours, calves housed individually in small pens seem to be more stressed than calves housed in pairs in larger pens.

Calves housed in pairs were found to be more active in their home environment: they were more often seen standing and moving around. Their higher activity levels could result from the size of their pens, which were twice as large as the individual pens (4.32 versus 2.16 m^2). According to Dellmeier *et al* (1985) and Jensen (1999), the longer the duration of confinement of an animal, the greater its activity when released into a larger area. Compared to pair-housed calves, the individually housed animals spent more time running and moved over a longer distance (as assessed by line-crossing frequency) when released into the unfamiliar arena, which was far larger (16 m^2) than the home pens. Hence, despite the fact that the individual pens were larger than the minimum required standards in Europe (Directive 97/2/EEC), the individually housed calves were probably experiencing a lack of movement.

In the present study, calves housed individually made more contact (touching, sniffing, licking) through the wooden partitions with their neighbours than did the pair-housed calves. Nevertheless, social contacts of individually housed calves (restricted to their neighbours) remained less frequent than social contacts of pair-housed calves (with their penmates or neighbours). We could estimate that calves of a pair had contacts with each other for 14.3% of the daytime (ie 1 h 43 min), whereas the increase in contact with neighbouring calves observed in individually housed calves accounted for only 2% of the daytime (14.5 min). Dellmeier *et al* (1985) reported that lack of social contact leads calves to interact more with conspecifics when given the possibility to do so. No such 'damming-up' effect was observed in our individually housed calves when they were with another calf in the arena. Their behaviour towards this animal did not differ from that of calves housed in pairs. Also, during this test, their heart rate was similar to that of pair-housed calves, suggesting that they were not more stressed by the presence of a calf despite the fact that they were not used to such contacts. In the Y-maze, individually housed calves approached the calf at the end of one arm less often than did the pair-housed calves. Therefore, visual and physical contact with neighbours through slatted partitions was probably sufficient for the individually housed calves not to experience lack of penmates.

The effect of additional contact from the stockperson (stroking, talking, letting suck fingers at each feeding time) was observed in the arena when a man was present. Positive contacts from the stockpersons mitigated the increase in heart rate seen in naive calves when they were in presence of an unfamiliar human, compared to calves with minimal contacts. This lower heart rate in the calves exposed to additional contact cannot be accounted for by differences in activity, as previous contact experience was found to have no effect on the time spent moving in the arena. During this test, the calves that had received additional

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contact spent more time near the man and made more contacts with him (sniffing, licking or touching) than did the calves that had received only minimal contacts. Such effects of positive human contact on the behaviour of animals towards humans have been described in detail in calves (Boissy & Bouissou 1988; Boivin *et al* 1998; Jago *et al* 1999; Lensink *et al* 2000) as well as in sheep (Boivin *et al* 2000) and pigs (for a review, see Hemsworth & Coleman 1998). Calves that had received positive human contact retreated in their home pen less often when approached by a man than did calves that had received minimal contact, and they were also easier to handle (Lensink *et al* 2000, 2001a). It is therefore likely that calves that had received positive human contact were less fearful in the presence of a human, even an unfamiliar one, than calves that had not received this contact.

In the Y-maze test, where both an unfamiliar calf and an unfamiliar man were present at the same time with the calf to be tested, no effects of previous contact were found; however, strong effects of previous housing conditions were found. Calves reared in pairs oriented their behaviour towards the calf, whereas calves housed individually spent the same amount of time near the calf and the man and interacted equally frequently with both. Therefore, it seems that no preference between conspecifics and humans exists in calves reared individually, whilst calves reared in pairs have a clear preference for conspecifics. In our experiment, all calves had been trained to drink from the teat-buckets with human assistance between three and ten days of age. Feeding by humans during the first days of life has a large and long-lasting effect on calves, reducing their fear reactions and increasing their likelihood of approaching humans (Györkös *et al* 1999; Jago *et al* 1999; Krohn *et al* 2001). Hence, all of our calves may have developed positive behaviour toward humans before the start of the experiment. In calves reared in pairs, social encounters were certainly exchanged between the two penmates (for a review on social behaviour of cattle, see Bouissou *et al* 2001). This probably led to better socialisation of these animals than of individually housed ones, making pair-housed calves more likely to orientate their behaviour toward the calf in the Y-maze test.

On the whole, housing and contact conditions affected different parameters. No interaction between contact and housing conditions was observed except on the standing frequency of calves in their home pen. Thus, contact with humans and contact with conspecifics seem to act independently on calves. In addition, considering the interaction with standing frequency, additional contacts with humans decreased the standing frequency in calves housed individually while it increased it in pair-housed calves, thus enlarging the difference between the two housing conditions. Hence, additional contacts with humans cannot be considered as a way to counteract the stressful effects of single housing.

In conclusion, pair-housed calves seem less stressed than individually housed calves. This is likely to be due to the increased available space, even though the space allowance calculated per calf is the same. Calves seek social contact, and visual and physical contact with neighbours seems to be enough for calves not to feel the lack of a penmate, even if it is not enough to allow proper socialisation. Regular and positive contacts with humans cannot compensate for individual housing but should be maintained to reduce calves' fear of humans.

Animal welfare implications

When calves have to be housed in individual pens and their movement restricted, the duration of these restrictions must be as short as possible and contacts with neighbouring calves should be maintained. In addition, habituating the animals to humans' presence by regular positive contact is essential, particularly when handling is necessary.

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References

Arave C W, Mickelsen C H and Walters J L 1985 Effects of early rearing experience on subsequent behaviour and production of Holstein heifers. *Journal of Dairy Science 68*: 923-929

Blokhuis H J 2000 Final report of EU-project 'Chain Management of Veal Calf Welfare'. ID-Lelystad: Wageningen, The Netherlands

Boissy A and Bouissou M-F 1988 Effects of early handling on heifers' subsequent reactivity to humans and to unfamiliar situations. *Applied Animal Behaviour Science 20*: 259-273

Boivin X, Garel J P, Durier C and Le Neindre P 1998 Is gentling by people rewarding for beef calves? *Applied Animal Behaviour Science 61*: 1-12

Boivin X, Tournadre H and Le Neindre P 2000 Hand-feeding and gentling influence early-weaned lambs' attachment responses to their stockperson. *Journal of Animal Science 78*: 879-884

Bouissou M-F, Boissy A, Le Neindre P and Veissier I 2001 The social behaviour of cattle. In: Keeling L J and Gonyou H W (eds) *Social Behaviour in Farm Animals* pp 113-145. CAB International: Wallingford, Oxon, UK

Creel S R and Albright J L 1988 The effects of neonatal social isolation on the behaviour and endocrine function of Holstein calves. *Applied Animal Behaviour Science 21*: 293-306

Dantzer R, Mormède P, Bluthé R M and Soissons J 1983 The effect of different housing conditions on behavioural and adrenocortical reactions in veal calves. *Reproduction Nutrition et Développement 23*: 501-508

Dellmeier G R, Friend T H and Gbur E E 1985 Comparison of four methods of calf confinement. II: Behavior. *Journal of Animal Science 60*: 1102-1109

Friend T H, Dellmeier G R and Gbur E E 1985 Comparison of four methods of calf confinement. I: Physiology. *Journal of Animal Science 60*: 1095-1101

Györkös I, Mézes M, Szücs E, Kovács K, Borka G, Gábor G and Völgyi-Csík J 1999 Behavioural development of Holstein-Friesian cows and calves. *Acta Agronomica Hungarica 47*: 39-52

Hemsworth P H and Coleman G J 1998 *Human–Livestock Interactions: The Stockperson and the Productivity and Welfare of Intensively Farmed Animals.* CAB International: Wallingford, Oxon, UK

Jago J G, Krohn C C and Matthews L R 1999 The influence of feeding and handling on the development of the human–animal interactions in young cattle. *Applied Animal Behaviour Science 62*: 137-151

Janssens C J J G, Helmond F A and Wiegant V M 1995 Chronic stress and pituitary–adrenocortical responses to corticotropin-releasing hormone and vasopressin in female pigs. *European Journal of Endocrinology 132*: 479-486

Jensen M B 1999 Effects of confinement on rebounds of locomotor behaviour of calves and heifers, and the spatial preferences of calves. *Applied Animal Behaviour Science 62*: 43-56

Krohn C C, Jago J G and Boivin X 2001 The effect of early handling on the socialisation of young calves to humans. *Applied Animal Behaviour Science 74*: 121-133

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