

Influence of breed on reactivity of sheep to humans

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Summary – Ewe lambs from 2 breeds (Mérinos d'Arles and Romanov) and their crossbreds, from Mérinos ewes sired by Romanov rams, were observed during 5 individual tests. During the first 3 tests there were no other sheep in sight and animals were alone, with concentrate or with a human. During the last 2 tests, some penmates were in sight and the experimental animal was alone or with a human. Romanov animals were much more reactive than the Mérinos. They eliminated more, ate less and avoided the human more. For most of the criteria, crossbreds were closer to the Romanov than to the Mérinos purebreds. This seemed to be due to genetic differences and not to direct maternal influence.

sheep / breed / reactivity to man / Mérinos / Romanov

Résumé – Influence de la race sur le comportement d'ovins vis-à-vis de la présence humaine. Des agnelles de deux races (Mérinos d'Arles et Romanov) et des croisées issues de mères Mérinos saillies par des mâles Romanov ont été observées dans cinq épreuves individuelles. Pendant les trois premières épreuves il n'y avait pas de congénères en vue et les animaux étaient seuls, avec de l'aliment concentré ou avec un homme. Pendant les deux dernières épreuves, des congénères étaient visibles, dans un parc contigu, et les animaux étaient seuls ou avec un homme. Les agnelles de race Romanov ont été beaucoup plus réactives que celles de race Mérinos d'Arles. Elles déféquaient et urinaient plus fréquemment, mangeaient moins et évitaient plus l'homme. Pour la plupart des critères les croisées avaient des performances plus proches de celles des Romanov que de celles des Mérinos. Ces différences semblent être d'origine génétique plutôt que dues à la mère.

ovin / réaction à la présence de l'homme / race / Mérinos / Romanov

INTRODUCTION

For domestic animals human beings are a common feature of the environment, and their adaptation to human presence may be important for animal production and welfare. The adaptation of animals to production systems with differing degrees of human intervention depends partly on their reactivity towards man. In this respect, some breeds may be better adapted than others because they are basically less disturbed by the presence of man. There are indeed indications that the reactivity of animals to humans varies between breeds and can be influenced by genotype. This has been shown in poultry (Faure and Folmer, 1975; Murphy and Duncan, 1977), and also in domestic ungulates such as cattle (Dickson *et al*, 1970; Murphey *et al*, 1980, 1981; Boivin, 1991), pigs (Hemsworth *et al*, 1990) and goats (Lyons *et al*, 1988).

In sheep, several studies have been carried out concerning the behavioural reactivity of animals to a novel environment (*ie* open field), but data concerning reactivity to man and possible breed differences in this respect are lacking. For example, Zito *et al* (1977) and Moberg and Wood (1982) compared the behaviour of lambs reared in isolation, in groups or with their mothers. Similarly, Lachaux *et al* (1983) and Winfield *et al* (1981) analysed the reaction of sheep depending on their familiarity with each other. These studies showed differences in behaviour between the various types of animals in various social or non-social situations. Putu *et al* (1988) found differences in open-field behaviour of ewe lambs that were correlated with later maternal behaviour at first lambing. They also reported intraracial differences in the reactivity of animals to humans. On the other hand, breed differences are known to exist in several behaviours, such as selection of lambing sites (Alexander *et al*, 1990), mother-young relationships (Alexander *et al*, 1983; Shillito Walser *et al*, 1983; Poindron *et al*, 1984), or open-field behaviour and reaction to the presence of a dog (Torres-Hernandez and Hohenboken, 1979). There are also indications that fear reactions, including fear of humans, vary with the breed (Romeyer and Bouissou, personal communication). It is possible that the breed differences found in open field reflect genotypic variations in reactivity of animals to various stressful situations, including the presence of man. This would appear to be the case from the results of Romeyer and Bouissou concerning fear reactions. However, other data on cattle fail to confirm this hypothesis; Boivin (1991) found no correlation between open-field behaviour and reaction of animals to their handling by man. Similarly, Boissy and Bouissou (1988) did not find a clear-cut relation between open-field behaviour and reactions to man in heifers. Obviously, more investigations are needed to fully assess the possibility of genotypic influence in the reaction of sheep to man.

To further investigate the possibility that breeds of sheep may differ in their reactivity towards humans, we compared the behaviour of 2 breeds of sheep (Mérinos d'Arles and Romanov) that are subjectively reported as differing widely in their reactivity. We also studied one of their crosses in preliminary attempt to distinguish between direct and maternal effects. To this end, we studied the behaviour of females in the presence of man, in a standard situation. This necessitated taking the animals to a closed area that was previously unknown to them, as well as social isolation. Thus we compared tests performed in the presence of congeners

and also studied reactivity to a novel environment. This allowed clarification of the extent to which the behavioural reactions observed were specific for reactivity to man, and their possible relations with other aspects of general reactivity that are usually taken into consideration when studying temperament (Price and Thos, 1980; Boissy and Bouissou, 1988; see also Archer, 1973 and Jones, 1993, for general reviews).

MATERIALS AND METHODS

Animals

The study was carried out in 1988 at the ENSA-INRA experimental station of Le Merle in south-east France. This station is run according to the traditional system in this part of France, involving daily contact with man for most of the year. Animals are kept indoors all winter, and let out to pasture daily for the rest of the year, except during summer when they are driven to pasture in the Alps under the constant supervision of a shepherd.

Fifty-five female lambs 1 yr of age were used in the experiment. They had been reared by their mothers in the same group from birth, weaned at 3 months of age and kept thereafter in one single all-female group. They were of 2 breeds: Mérinos d'Arles ($N = 19$, a French population from south-east France) and Romanov ($N = 20$, a Russian breed used for its high prolificacy) and their cross ($N = 16$, Mérinos ewes sired by Romanov rams) that will be referred to as "crossbred".

Testing procedure

Five individual tests of 4 min each were conducted over a 5-d period. Two persons drove each animal from the barn to the testing room, which consisted of a 4×6 m enclosure with plain walls. Six squares were marked on the floor with plaster powder (fig 1).

The test were as follows:

- Test 1: subject alone. This corresponded to the classical open-field test described in the literature (Archer, 1973);
- Test 2: subject alone. Concentrate (100 g) was placed in the middle of the enclosure (square 2). The latency before eating and the duration of feeding provided objective measurements of the degree of distress caused by social isolation and novelty;
- Test 3: a human stood stationary in square 5;
- Test 4: five non-experimental animals from the same flock were set behind a wire-mesh door in front of square 5. The subject was alone in the enclosure;
- Test 5: as in test 4, but with a human standing in square 5.

Each animal was tested only once daily. On the first 3 d, approximately one-third of the subjects from each breed were allocated to one of the first 3 tests (table I). On the last 2 d, half of the animals from each breed were allocated to 1 of the last 2 tests. On the first d of study, animals were selected at random, except for the breed. The first female was a Mérinos, the second a Romanov and the third

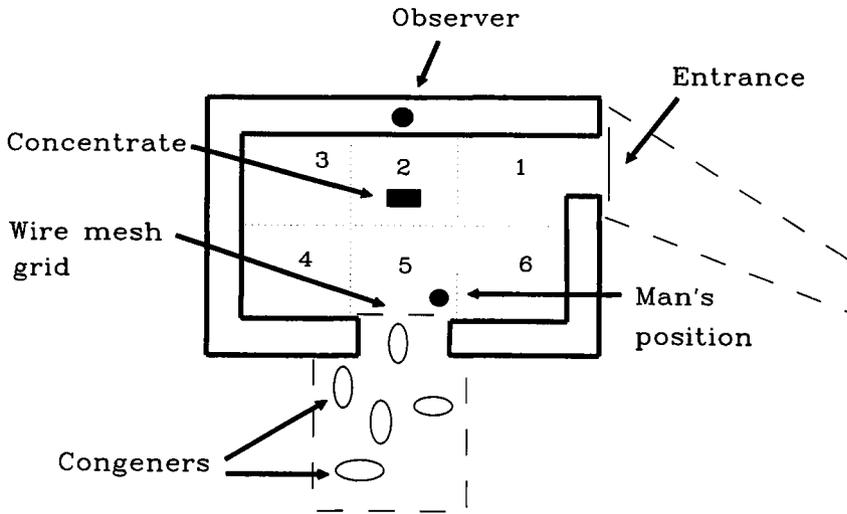


Fig 1. Diagram of the enclosure.

a crossbred; the order changed for each group of 3 animals. The 3 females were tested alone. Then, the next 3 (again one of each genotype) were tested with food, and the next 3 with man. This sequence was repeated until all animals had been tested, and each animal was marked on the head, the back or the rump, according to the type of test carried out. The following day, the same testing procedure was used. A similar procedure was used for tests 4 and 5. In this way, type of test and breed were kept balanced throughout the study.

The personnel remained the same during the whole study, and all operators wore similar blue clothing (overalls and a jacket). During the tests, animals could see the observer who sat on a platform 2 m above the ground. A data recorder with an internal clock (DATAMYTE 1006) was used to record the activities. All the personnel, including the man standing in the testing pen, were unknown to the animals before the start of the study.

Behaviour recorded

The following behaviour was recorded:

- while the ewe was being driven to the testing room, the number of times it turned back and tried to force a passage through the personnel and back to the barn;
- during all 5 tests: the number of squares crossed, the number of times the animals sniffed the ground, door and walls, the number of low and high-pitched bleats, defaecations and urinations, looks in the direction of the observer, rearings against the wall;
- during test 2, the feeding time and time spent in square 2;

Table I. Distribution of animals tested each day by breed and type of test.

Day of test	Breed	Type of test				
		No penmates in sight			Penmates in sight	
		Alone (1)	With food (2)	With a human observer (3)	Alone (4)	With a human observer (5)
1	Mérinos	6	6	7		
	Crossbred	5	5	6		
	Romanov	6	7	7		
2	Mérinos	6	7	6		
	Crossbred	5	6	5		
	Romanov	7	7	6		
3	Mérinos	7	6	6		
	Crossbred	6	5	5		
	Romanov	7	6	7		
4	Mérinos				10	9
	Crossbred				8	8
	Romanov				10	10
5	Mérinos				9	10
	Crossbred				8	8
	Romanov				10	10

- during tests 3 and 5, the latency before sniffing and number of sniffs at the observer;

- during tests 4 and 5, the time spent in square 5.

Statistical analyses

The overall results for the breeds over the 5 d were compared using Mann-Whitney tests. Parameters that were measured in the 5 tests were summed. The numbers of times animals came back when driven to the testing pen when there was no other sheep in sight (first 3 tests) were summed.

More detailed analyses were then made of 4 variates (numbers of squares crossed, of high and low pitched bleats and of eliminations). Square roots of these variates were used to obtain homogeneity of the variances. Influences of type of test, order of day and breed were tested with variance analyses according to the following basic model:

$$Y_{ijkl} = C + J_i + G_j + T_k + GT_{jk} + e_{ijkl}$$

where:

Y_{ijkl} is the performance of the l th individual with the j th genotype in the k th type of test on the i th day;

C is a constant;

J_i is the effect of the i th day;

G_j is the effect of the j th genotype;

T_k is the effect of the k th type of test;

GT_{jk} is the effect of the interaction between the j th genotype and the k th type of test;

e_{ijkl} is a random effect.

These analyses were made separately for test without congeners (first 3 d) and for tests with congeners (last 2 d).

The intragenotype correlations of the sums of the results from tests 1 and 3 (respectively alone or with a human, first period) with those from tests 4 and 5 (with peers in sight when alone or with a human, second period) were calculated. Correlations between variables within the same periods were also calculated.

Effect of the presence of congeners was tested, on these 4 variates and on the number of times the animals came back when driven to the testing pen by studying the differences between the results obtained in periods 1 and 2. As period and treatment are confounded, their effects cannot be isolated in this analysis.

RESULTS

Influence of breed (overall comparisons of table II)

When the results of the 5 tests were considered together, Mérinos animals differed significantly from Romanov animals in most behaviours studied. Mérinos sniffed the ground and door more frequently, and emitted more high-pitched but fewer low-pitched bleats than Romanov ewes. They eliminated (defaecated-urinated) and looked in the direction of the observer less often. They spent more time in square 2 eating concentrate. In the presence of the human observer, they sniffed him sooner and more often. The 2 breeds spent a similar amount of time in square 5 near the congeners in the absence of an operator (test 4). By contrast, in the latter's presence the time spent near the congeners was significantly lower in the Romanov (test 5) while in the Mérinos there was little difference whether or not a human was present during the test. When driven to the enclosure the Mérinos turned back less often than the Romanov. However, despite all these differences the number of squares crossed, the usual variate for indicating general activity, did not differ significantly between the 2 breeds.

Crossbred animals had performances midway between those of their parental genotypes for 4 parameters and in 3 cases (sniffing the door, feeding time, time in square 5 with a human) the results did not differ from those of the other 2 groups. The differences regarding both Mérinos and Romanov were significant only for the number of times the animals turned back when driven to the testing pen. For 5 of the remaining parameters performances of crossbreds were similar to those of the Romanov. Only in 2 cases did crossing result in performances similar to those of the Mérinos genotype (number of low-pitched bleats and time in square 2). Only one mobility parameter (numbers of squares crossed) was lower for the crossbred than for the other 2 genotypes.

Table II. Influences of breed on behaviour of ewe lambs (4-min tests, mean \pm SD)

<i>Genotype</i>	<i>No of Mérimos 19</i>	<i>No of Crossbred 16</i>	<i>No of Romanov 20</i>
Sun of the 5 tests—mean number recorded			
Squares crossed	127.0 \pm 37.0 ^a	95.0 \pm 65.0 ^b	135.0 \pm 61.0 ^a
Sniffs door, walls and ground	57.2 \pm 25.3 ^a	39.2 \pm 18.6 ^{ab}	34.8 \pm 15.5 ^b
Bleats			
Low-pitched	7.1 \pm 8.8 ^a	6.9 \pm 5.1 ^a	15.2 \pm 10.5 ^b
High-pitched	76.9 \pm 44.7 ^a	31.8 \pm 34.3 ^b	32.5 \pm 46.2 ^b
Total	84.8 \pm 41.2 ^a	38.7 \pm 33.4 ^b	47.7 \pm 44.8 ^b
Eliminations (defaecations—urinations)	3.05 \pm 2.90 ^a	5.12 \pm 2.53 ^b	5.55 \pm 3.32 ^b
Looks in direction of observer	10.4 \pm 7.1 ^a	22.8 \pm 6.5 ^b	24.2 \pm 10.3 ^b
Rearing against walls	17.8 \pm 18.5 ^a	8.1 \pm 16.7 ^b	10.9 \pm 14.1 ^b
Feeding (Test 2)			
Time in square 2 (min)	1.60 \pm 1.20 ^a	1.18 \pm 0.96 ^a	0.52 \pm 0.58 ^b
Feeding time (min)	1.09 \pm 1.07 ^a	0.62 \pm 0.87 ^{ab}	0.39 \pm 0.72 ^b
Test with a human observer (Test 5)			
Latency before sniffing human observer (min)	1.98 \pm 1.33 ^a	3.76 \pm 0.72 ^b	3.77 \pm 0.73 ^b
Number of sniffs at the human observer	2.95 \pm 2.32 ^a	0.44 \pm 1.50 ^b	0.45 \pm 1.23 ^b
Time in square 5 (min)			
Test 4 (without a human observer)	2.31 \pm 0.63 ^a	2.43 \pm 0.81 ^a	2.28 \pm 0.81 ^a
Test 5 (with a human observer)	2.13 \pm 0.91 ^a	1.60 \pm 1.31 ^{ab}	1.38 \pm 1.07 ^b
Number of times animals turned back when driven to the testing pen (sum of the first 3 tests)			
	2.42 \pm 2.14 ^a	5.06 \pm 2.49 ^b	6.90 \pm 2.49 ^c

Groups with the same superscripts are not significantly different; ($p < 0.05$ Mann-Whitney test).

Analyses of variance

The influences of day and the interaction between test and breed were never significant in the variance analyses for the 4 variates analysed. On the other hand, the 2 other factors (the type of test and breed) had significant influences.

Type of test (table III)

The presence of food was associated with a decrease in the numbers of squares crossed and of high-pitched bleats. A similar tendency was observed for the influence of human presence on the number of crossed squares. In contrast, eliminative behaviour and low-pitched bleats did not change.

The presence of congeners

Effects of day within the 2 periods were not significant. It is then possible to consider that the effect of periods is also not significant and that differences can be attributed mainly to the absence or presence of congeners. The presence of congeners was associated with a clear-cut reduction in locomotor activity and a reduction in eliminative behaviour (-2.06 ± 1.82 , $p < 0.01$; -0.87 ± 0.97 , $p < 0.01$). The difference in high-pitched bleats was not significant (0.57 ± 2.11 , NS). Low-pitched bleats increased significantly only for the Romanov ($+1.51 \pm 1.65$, $p < 0.01$). The number of times the animals came back when driven to the testing pen decreased sharply when there were congeners penned next to the testing enclosure (-1.92 ± 1.86 , $p < 0.01$) which could be seen by the subject while it was being driven to be tested.

Relationships between variates

Correlations of measures according to the presence or not of congeners

The correlations between results of the same variate from the sums of tests 1 and 3 with those of tests 4 and 5 were highly significant for all the variables except for the number of low-pitched bleats (squares crossed, $r = 0.402$, $p < 0.01$; high-pitched bleats, $r = 0.64$, $p < 0.01$; low-pitched, bleats, $r = 0.16$, NS; eliminations, $r = 0.38$, $p < 0.01$).

Intraperiod relationships between variates

Within a period (with or without the presence of a human) the numbers of crossed squares and the number of high-pitched bleats were significantly related (first period, $r = 0.31$, $p < 0.05$; second period, $r = 0.28$, $p < 0.05$). The number of low-pitched bleats and number of crossed squares was related only during the first period ($r = 0.52$, $p < 0.05$). The number of eliminations and number of crossed squares was related only during the second period ($r = 0.30$, $p < 0.05$). Numbers of eliminations and numbers of bleats were not significantly related.

Table III. Influences of type of test, breed and day on animal activity (4-min test, square roots of the variates).

	Influence of test			Influence of breed			Influence of day			SD within group
	Alone	With concentrate	With a human observer	Merinos	Crossbred	Romanov	Day 1	Day 2	Day 3	
	(1)	(2)	(3)							
Without penmates in sight (mean number of occurrences/test)										
Squares crossed	5.64 ^a	4.66 ^b	4.76 ^b	5.24 ^a	4.44 ^b	5.40 ^a	4.97 ^a	4.76 ^a	5.35 ^a	1.77
High-pitched bleats	2.58 ^a	1.58 ^b	1.94 ^{ab}	3.04 ^a	1.72 ^b	1.33 ^b	1.80 ^a	2.03 ^a	2.27 ^a	1.93
Low-pitched bleats	0.86 ^a	0.59 ^a	0.68 ^a	0.65 ^a	0.72 ^a	0.77 ^a	0.72 ^a	0.79 ^a	0.62 ^a	0.96
Eliminations	0.91 ^a	0.77 ^a	0.90 ^a	0.60 ^a	1.02 ^b	0.92 ^b	0.80 ^a	0.89 ^a	0.62 ^a	0.69
With penmates in sight (mean number of occurrences/test)										
Squares crossed	4.24 ^a	3.38 ^b	(5)	4.14 ^a	3.23 ^b	4.06 ^a	3.92 ^a	3.69 ^a		1.29
High-pitched bleats	3.10 ^a	2.14 ^b		4.13 ^a	1.74 ^b	1.99 ^b	2.63 ^a	2.61 ^a		1.69
Low-pitched bleats	1.34 ^a	1.01 ^a		0.70 ^a	0.85 ^a	1.97 ^b	1.33 ^a	1.01 ^a		1.05
Elimination	0.37 ^a	0.42 ^a		0.28 ^a	0.34 ^{ab}	0.56 ^b	0.35 ^a	0.44 ^a		0.56

For each variation factor, data with the same superscripts are not significantly different ($p < 0.05$) NS (n): group defined in table I.

DISCUSSION

A number of points emerge from the study. The differences observed between the 3 types of animals indicate that they differ very clearly in their behavioural reactions to man, as well as in their reactions to a novel situation. The good correlation of measurements in the presence or in the absence of congeners, the lack of effects of the day of testing and the order used for the various tests further demonstrate the validity of these behavioural tests and their ability to discriminate between sheep on the basis of temperament. Frequency of eliminations, usually considered an indicator of fear or behavioural discomfort, was higher in Romanov than in Mérinos. Similarly, feeding time and time spent in the square containing food were lower in Romanov, again indicating a higher degree of reactivity in this breed. This was also evident in the reactions towards man, where human presence was perceived as unpleasant, because he was avoided even when mates were present. In this context, Romanov females emerged as being more reactive and disturbed by man in an open field than Mérinos. The Romanov also took longer to approach the human and were driven to the testing pen with more difficulty. Because they also looked more often at the observer, it cannot be excluded that differences between breeds in the absence of a human were partly due to the presence of the observer, and not only to isolation and a new environment. Consequently, even though our results appear to agree with the hypothesis that there is a relation between behavioural reactivity in an open field and reactivity to man, as suggested by the results of Romeyer and Bouissou (personal communication) on fear, this may still need to be confirmed.

The 2 breeds can also be distinguished by a number of other factors. For example, overall olfactory investigations and vocal activity were lower in Romanov than in Mérinos. This might be related to the higher reactivity of the Romanov, whose behaviour might be more affected by the anxiogenic characteristics of the tests. In support of this suggestion it can be noted that the disturbing presence of humans was also associated with a reduction in vocalizations, mainly due to a reduction in high-pitched bleats. This is in agreement with the results of Price and Thos (1980) and Zito *et al* (1977), who found that the presence of a human reduced mobility and bleating. However, in contrast with the conclusion of Price and Thos (1980), our results indicate that the role of a person as a substitute for penmates is not appropriate in our situation, since females avoided the human even in the presence of mates.

It is possible that the breed differences found here do not reflect only differences in behavioural reactivity. They might also express some basic differences in the relative importance of the sensory cues characteristic of each breed, independent of behaviour, as already shown for example in mutual mother-young relationships (Shillito *et al*, 1982). It cannot be excluded for example that Mérinos are simply more vocal than Romanov, without this marking a higher reactivity. On the other hand, breed differences in vocalizations have also been found by others (Torres-Hernandes and Hohenboken, 1979), with variations probably associated with differing levels of behavioural distress due to age and habituation. This suggests that vocalizations are probably a good indicator of reactivity.

The study on crossbred animals sheds some light on the differences found in the pure breeds. Because crossbred females were born to Mérinos mothers, the differences cannot be explained solely by the influence of the mother. Otherwise the crossbreds would not have differed from the pure Mérinos, whereas in fact they were in many variates closer to their Romanov father than to their Mérinos mother. Thus it appears that the differences reflect, at least in part, some genetic variability of general reactivity, including behavioural reactivity to the presence of man. Our results therefore suggest that it might be possible to select animals on the basis of their reaction to man in an attempt to facilitate the management of sheep. A better knowledge of the weight of the various parameters influencing the measured behaviours, reaction to novelty, social tendency, and fear of man, however, would certainly facilitate the design of such a selection programme. Similarly, the genetic components of the various behaviours reflecting reactivity to man (direct and maternal effects, heterosis) have still to be clarified.

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REFERENCES

- Alexander G, Stevens D, Bradley LR (1990) Distribution of field birth-sites of lambing ewes. *Aust J Exp Agric* 30, 759-767
- Alexander G, Stevens D, Kilgour R, de Langen H, Mottershead BE, Lynch JJ (1983) Separation of ewes from twin lambs: incidence in several sheep breeds. *Appl Anim Ethol* 10, 301-317
- Archer J (1973) Tests for emotionality in rats and mice: a review. *Anim Behav* 21, 205-235
- Boissy A, Bouissou MF (1988) Effects of early handling on heifer's subsequent reactivity to humans and to unfamiliar situations. *Appl Anim Behav Sci* 20, 259-273
- Boivin X (1991) Etude des facteurs expérimentiels et génétiques de la relation des bovins domestiques (*Bos taurus* L) avec l'homme. PhD thesis, University of Rennes
- Dickson DP, Barr GR, Johnson LP, Wieckert DA (1970) Social dominance and temperament of Holstein cows. *J Dairy Sci* 53, 904
- Faure JM, Folmer JC (1975) Etude génétique de l'activité précoce en open-field du jeune poussin. *Ann Génét Sél Anim* 7, 123-132
- Hemsworth PH, Barnett JL, Treacy D, Madgwick P (1990) The heritability of the trait fear of humans and the association between this trait and subsequent reproductive performance of the gilts. *Appl Anim Behav Sci* 25, 85-95
- Jones RB (1989) Avian open-field research and related effects on environmental novelty. *Psychol Rec* 39, 397-420
- Lachaux M, Bouissou MF, Berges JC, Orgeur P (1983) Etude du comportement en open-field de béliers Ile de France soumis à différentes conditions d'élevage. *Biol Behav* 3, 257-269

- Lyons DM, Price ED, Moberg GP (1988) Individual differences in temperament of domestic dairy goats: constancy and change. *Anim Behav* 26, 1323-1333
- Moberg GP, Wood VA (1982) Effect of differential rearing on the behavioral and adrenocortical response of lambs to a novel environment. *Appl Anim Ethol* 8, 269-279
- Murphey RM, Moura Duarte FA, Torres Penedo MC (1980) Approachability of bovine cattle in pasture: breed comparisons and a breedXtreatment analysis. *Behav Genet* 10, 171-181
- Murphey RM, Moura Duarte FA, Torres Penedo MC (1981) Responses of cattle to humans in open spaces: breed comparisons and approach-avoidance relationships. *Behav Genet* 11, 37-47
- Murphy LB, Duncan IJH (1977) Attempts to modify the response of domestic fowl towards humans beings. I: the association of human contact with a food reward. *Appl Anim Behav Sci* 3, 321-334
- Poindron P, Raksanyi I, Orgeur P, Le Neindre P (1984) Comparaison du comportement maternel en bergerie à la parturition chez des brebis primipares ou multipares de race Romanov, Préalpes du Sud et Ile de France. *Génét Sél Evol* 16, 503-522
- Price EG, Thos J (1980) Behavioral responses to short-term social isolation in sheep and goat. *Appl Anim Ethol* 6, 331-339
- Putu IG, Poindron P, Lindsay DR (1988) Early disturbance of Merino ewes from the birth site increases lamb separations and mortality. *Proc Aust Soc Anim Prod* 17, 298-301
- Shillito Walser E, Hague P, Yeomans M (1983) Variations in the strength of maternal behaviour and its conflict with flocking behaviour in Dalesbred, Jacob and Soay ewes. *Appl Anim Ethol* 10, 245-250
- Shillito Walser E, Willadsen S, Hague P (1982) Maternal vocal recognition in lambs born to Jacob and Dalesbred ewes after embryo transplantation between breeds. *Appl Anim Ethol* 8, 479-486
- Torres-Hernandez G, Hohenboken W (1979) An attempt to assess traits of emotionality in crossbred ewes. *Appl Anim Ethol* 8, 109-117
- Winfield CG, Syme GJ, Pearson AJ (1981) Effect of familiarity with each other and breed on the spatial behaviour of sheep in an open-field. *Appl Anim Ethol* 7, 67-75
- Zito CA, Wilson LL, Graves HB (1977) Some effects of social deprivation on behavioral development of lambs. *Appl Anim Ethol* 3, 367-377