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VETERINARY ETHOLOGY
25TH ANNIVERSARY
1966-1991

APPLIED ANIMAL BEHAVIOUR: PAST, PRESENT AND FUTURE

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Applied Ethology: Past, Present and Future

Society for Veterinary Ethology 1966-1991 25th Anniversary Review

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ORIGINS

The following extract is taken from the Minutes of the First Meeting:

"Following the proposal approved at a preliminary informal meeting of interested persons held in Edinburgh on the 16th February, 1966 to form a Society, within the veterinary profession, for the study of animal behaviour, a meeting was held at Hume Tower, Edinburgh University, on Saturday, 4th June, 1966 under the chairmanship of Mr A.F. Fraser and was attended by 26 veterinarians from Scotland and England.

The Meeting agreed on the above title for the Society, approved a Constitution and elected a governing council for 1966/67.

The aims of the Society are:-

(a) the stimulation within the veterinary profession of enquiry and research into the behaviour of animals;

(b) the encouragement of discussion on the veterinary aspects of animal behaviour and the publication of original work in this field;

(c) the furtherance of ethological knowledge relative to the care and utilization of animals, domesticated, captive and free-living;

(d) the provision of a medium to promote exchange of information between veterinarians and between them and others concerned with behaviour and well-being of animals."

At a meeting in 1970 it was decided that the Society would extend its qualification for membership by amendment of the Constitution to include non-veterinarians. This resulted in some slight changes to the aims, which reflect the broader range of professions involved in the Society:

(a) now reads:

"the stimulation of enquiry and research into the behaviour of animals among agricultural scientists, veterinarians and zoologists;"

and (d) now reads:

"the provision of a medium to promote exchange of information between those concerned with behaviour and wellbeing of animals."

David Wood-Gush (Edinburgh) became an “Associate” member of the SVE in 1970, before it was open to non-veterinarians and David Fraser (currently in Ottawa, Canada) was the first non-veterinarian to join the Society in 1972.

TABLE 1
Founder members

J.R.Baillie	Kirriemuir	B.R.Howard*	Edinburgh
P.J.Barden	Edinburgh	P.Imlah*	Edinburgh
W.G.Beaton	Edinburgh	R.A.Jones	Edinburgh
W.P.Blount	London	D.R.Lane*	Leamington Spa
B.Boswood	Brentwood	A.Littlejohn	Edinburgh
A.Brownlee*	Newbury	C.T.McCrea*	Thirsk
L.Collery	Dublin	A.D.McEwan	Glasgow
M.A.Couttie	York	H.S.McTaggart	Edinburgh
M.D.Eaglesome	Lanark	J.Milne	Duns
R.Ewbank*	Liverpool	D.Moodie	Ayr
L.C.Faulkner	Colorado	G.S.Peyton	Canterbury
G.S.Ferguson	Edinburgh	H.C.B.Reed	Selby
W.Ferguson	Edinburgh	P.G.M.Rowntree	Liverpool
M.W.Fox*	Illinois	W.N.Scott	London
A.F.Fraser*	Edinburgh	I.E.Selman	Glasgow
J.A.Fraser*	Edinburgh	J.M.Swanney	Perth
T.GrahamMarr	Edinburgh	J.C.Wilson	Edinburgh
H.Hastie*	Edinburgh	D.K.M.Young	Pitlochry
T.W.Heard*	Chippenham		

*still members in 1991

OFFICE BEARERS

Administration of the Society is the responsibility of a Council. At first there were 11 Council members, but this has increased gradually to the present total of 16. The Presidents and Honorary Secretaries to date are shown in Table 2.

The post of Honorary Assistant Secretary was established in 1969. Between 1975 and 1980 the position was held by A.F.Baldry, thereafter it has been held by B.Flatlandsmo. There have been just two Honorary Membership Secretaries; the post was held by J.R.Baillie from the time the post was established in 1974 until 1989 when, on Jim Baillie's death, it was taken over by J.C.Petherick. The position of Treasurer was initially held by B.R.Howard, then R.Ewbank from 1973 to 1977. B.O.Hughes held the post from 1977 to 1983 and since then it has been held by K.Carson. A.Brownlee held the post of Honorary Librarian from its establishment in 1967 until 1983. The post of Honorary Assistant Librarian and Editor was created in

1981 and was held by I.J.H.Duncan for two years, when he then took over as Honorary Librarian, and R.I.Horrell became Honorary Assistant Librarian and Editor, a post which he has retained to date. M.C.Appleby took over from I.J.H.Duncan as Hon. Librarian in 1987. In 1989 W.T.Jackson offered his services as Legal Advisor to the Council. In addition to the office bearers there have always been six other Council members.

TABLE 2
Presidents and secretaries

	President	Secretary
1966	A.F.Fraser	W.G.Beaton
1967	R.Ewbank	”
1968	J.M.Swanney	”
1969	”	”
1970	J.R.Baillie	R.A.Jones
1971	L.E.Hughes	A.F.Fraser
1972	C.T.McCrea	”
1973	J.Milne	”
1974	G.B.Taylor	I.J.H.Duncan
1975	”	”
1976	D.G.M.Wood-Gush	”
1977	I.Ekesbo	W.T.Jackson
1978	L.Collery	”
1979	G.van Putten	”
1980	H.Simonsen	”
1981	R.Ewbank	”
1982	M-F.Bouissou	”
1983	H.H.Sambraus	”
1984	B.A.Baldwin	”
1985	P.Wiepkema	”
1986	I.J.H.Duncan	A.B.Lawrence
1987	D.M.Broom	”
1988	”	”
1989	B.Algers	”
1990	”	”

MEMBERSHIP

Membership has increased from the original 37 to 342 at the present time. These members come from all over the world as is shown in Table 3 and Figure 1.

With the increasingly international nature of the Society it was decided in 1988 that National Secretaries should be established. The rôle of these people is to liaise with local applied ethologists and other related societies, to plan and coordinate local SVE meetings and to publicise the Society to animal productionists and veterinary scientists.

TABLE 3
Current membership

EUROPE	Austria	1	N.AMERICA	Canada	15
	Belgium	6		USA	12
	Bulgaria	2			
	Czechoslovakia	5	S.AMERICA	Argentina	1
	Denmark	18		Brazil	1
	Eire	7			
	Finland	5	AUSTRALASIA	Australia	7
	France	4		New Zealand	2
	Germany	9			
	Hungary	5	MIDDLE EAST	Israel	1
	Italy	31			
	Netherlands	15	ASIA	Japan	1
	Norway	11		Taiwan	1
	Poland	1			
	Portugal	1			
	Spain	5			
	Sweden	22			
	Switzerland	5			
	United Kingdom	148			

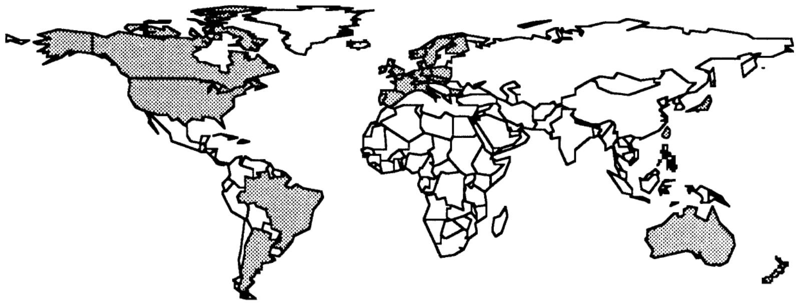

Figure 1. World distribution of members

MEETINGS

The Society holds Scientific meetings twice a year, in the winter and in the summer. The pattern in recent years has been for the winter meeting (Nov/Dec) to be held at the Royal Veterinary College, London, and to last for one day. In 1988 it was decided that it would be appropriate for other Regional meetings to be held in the winter, in addition to those held in London. Since 1974 the summer meeting has been held in various European countries and normally lasts for three days. The summer meeting is now given the title "International Congress", and next year (1992) will be held in N.America for the first time.

The venues of past summer meetings and winter ones that have been held outside London are listed in Table 4.

TABLE 4
Venues of meetings

Year	Venue	Year	Venue
1966	Edinburgh	1977	Brighton
1967	Edinburgh	1978	Skara
1968	Glasgow	1979	Dublin
1968	Bristol	1980	Zeist
1969	Edinburgh	1981	Edinburgh
1969	Cambridge	1982	Reading
1970	Edinburgh	1983	Tours
1971	Cambridge	1984	Kiel†
1971	Bristol	1985	Cambridge
1972	Liverpool	1986	Wageningen
1972	Dublin	1987	Tänikon
1973	London*	1988	Skara†
1974	Ghent	1989	Bristol
1975	Bristol	1990	Montecatini
1976	Cambridge	1991	Edinburgh

* in conjunction with the RSPCA † in conjunction with EAAP and DVG

PROCEEDINGS/ABSTRACTS

The proceedings of the first three meetings were published by the Universities Federation for Animal Welfare (UFAW). From 1968 to 1973 the abstracts appeared in the British Veterinary Journal (vols. 125 to 130). The abstracts from the "First European Symposium of the SVE" (held in Ghent in 1974) were published in vol. 1 of Applied Animal Ethology (currently Applied Animal Behaviour Science) and this has continued to the present time, with the exception of the two meetings held in 1975, the abstracts of which appeared in the British Veterinary Journal (vol. 133).

COUNCIL OF EUROPE

Following correspondence in 1976, the Society was offered a place on the Standing Committee of the European Convention for the Protection of Animals kept for Farming Purposes (Council of Europe) in 1979. H.Simonsen was the representative from 1979-82, when laying hens were discussed. The discussion moved to pigs in 1982 and G.van Putten became the representative until 1986, when H.Simonsen again took over briefly when the topic returned to poultry. In 1987 D.Broom was selected as the representative and he has continued in this capacity until the present time. In this period there have been discussions on cattle, fur-bearing animals, genetic engineering and recently consultation has started on sheep and goats. Current policy is that the representative seeks advice from other Society members concerning the subject under discussion. Since 1979 the Council of Europe has produced recommendations for laying hens, pigs and cattle (not calves), and those for fur-bearing animals are nearing agreement. Changes have been made to original agreements to account for developments in genetic engineering. Many of the recommendations made are used in national legislation.

THE FUTURE

The study of applied animal behaviour has developed to an extent not anticipated 25 years ago. It has contributed greatly to the advancement of biological sciences in general and to animal welfare science in particular. The Society for Veterinary Ethology has played a cardinal rôle in this development and, it is hoped, will continue to foster such development in the next 25 years.

The development of Applied Ethology in relation to certain agricultural animals over a century

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In writing on the development of Applied Animal Ethology a number of questions immediately present themselves. What does one mean by Applied Animal Behaviour? Should it embrace all work that even in some indirect way addresses a practical problem or should it only include work that sets out unambiguously to solve a practical problem? Then there is the question of how far back one should go. Modern experimental methodology makes some of the earlier work seem anecdotal, although to the investigators of the time and their contemporaries their efforts were experimental.

Examples of these ambiguous areas are numerous. Aristotle castrated an adult bull and finding that the animal still showed sexual behaviour, concluded that the testes have no rôle in sexual behaviour: an experiment with an animal of economic importance involving a vital behavioural system. In the late 18th Century a Scots farmer, James Anderson, observed his cattle grazing and from these observations initiated rotational grazing, a system that became widely used in Britain and Germany in the 19th Century. Here we have a practical problem being solved by observation of animal behaviour, but no modern editor would accept Anderson's work which lacks quantification, controls and statistics. The development of Animal Welfare research grew from questions of morality, but who sparked off the flame that was to nurture the social conscience of modern societies to finance the development of research in this area? The following passage would seem as seminal as any: "It is right for a good man to feed horses which have been worn out in his service, and not merely to train dogs when they are young, but to take care of them when they are old..... we ought not to treat living things as we do our clothes and our shoes, and throw them away after we have worn them out: but we ought to accustom ourselves to show kindness in these cases, if only in order to teach ourselves our duty towards each other." This was written by Plutarch in the first century AD.

These examples show how difficult it is to determine the beginning of our subject. I have therefore decided to limit the study to animal behaviour studies which are related to practical problems and which transcend the anecdotal or quasi-anecdotal level, even if they do not meet the standards required by the editor of a modern scientific journal. I have chosen to start in the year 1864 not because, as my school history reminds me, it was the year that Bismarck acquired Schleswig and Holstein and the Federal troops were marching through Georgia taking Atlanta and Savannah, but because it was the year in which the 'Zoological Record' first appeared. This remarkable journal listed the scientific papers from America, Britain, France, Germany, Russia and Scandinavia. However, with regard to our area I am certain that it did not cover the bulletins published by the American Land grant colleges, many of which were to appear in the last third of the 19th Century. Thus some early observations on the behaviour of farm animals may be missing from this paper.

In the 'Zoological Record' of 1884 the first mention of comparative psychology occurs, while ethology first appears in 1901 in a paper by Wasmann with the intriguing title 'Biologie oder Ethologie'. In the following year a section on ethology is included and in each successive year this section grows significantly with work of practical importance. Literally hundreds of papers are cited. These mainly concern work on what we today would call the behavioural ecology of invertebrates of economic importance, generally pests and parasites. The importance of their behaviour seems to have been clearly recognised although the ecological aspect was dominant in these studies.

In light of these problems and with the time at my disposal I have limited my investigations to work on farm animals, and to work which is recognisably experimental in the modern sense. In presenting the data I shall deal first with the fowl and then with pigs, sheep, cattle and horses. Due to lack of time I have omitted fur bearing animals, and my report on the rabbit is sketchy. In cases in which an author reviews both his early and later work, I have cited the review rather than just the first paper.

In 1985 I wrote a paper on the history and development of applied poultry ethology, generally covering the period 1873 to 1973. In that paper[(1)] I took four areas of research, viz learning, social behaviour, mating behaviour and animal welfare studies, and attempted to see how research in those areas had arisen. In the cases of learning and social behaviour initial work had been done because of fundamental interest. For example, experiments on learning as far as I could make out had been initiated by Spalding who published in 1873[(2)]. His experiments, although innocent of any proper controls or statistical treatment, were brilliant in their direct, incisive approach and simplicity. The question they addressed was the great Nature - Nurture one which remained alive and kicking in ethology until the 1950s. The chicken was a latecomer to the area of imprinting, largely due I think to the influence of Konrad Lorenz who viewed domestic animals as 'degenerate'. By this I suppose he meant that the process of domestication had probably so altered their behaviour as to make them unsuitable models for the elucidation of any widely applicable principles of animal behaviour. However, in the 1950s and 1960s much interesting work in this area was done with chicks. Early in this century many experiments were performed in Germany on discrimination learning in the fowl. Classical conditioning appears to have first been performed by Watson in 1916[(3)] and the first case of operant conditioning appears to have been in 1951[(4)]. All these cases and others that I cited[(1)] appear to have been unconcerned with production problems, but today it is obvious that learning affects all facets of the chicken's life and hence production. For example, imprinting and early learning are seen to affect the bird's social and sexual behaviour to appreciable extents. In the life of every caged chicken the use of a nipple drinker involves learning.

In general, studies on learning in the mammalian species under review developed from fundamental interest rather than from practical problems, as in the case of the chicken. Many experiments were concerned with ascertaining the perceptual abilities of the animal. In the case of the horse, however, following the Clever Hans episode, many were concerned with testing its intelligence[5,6,7,8]. The earliest record of a paper on imprinting in these animals concerned the sheep[9] and the application of classical conditioning to a practical problem in sheep was described in a Russian paper published in 1940[10], although classical conditioning had been carried out on the sheep, pig, goat and rabbit in 1931 by Liddell and Anderson at Cornell University[11]. An experiment by Yerkes and Coburn using the pig in a multiple choice paradigm involving learning was reported in 1915[12]. However, the first report on operant conditioning in the pig seems to be that of Marcuse and Moore[13]. Maze learning experiments were reported on by Liddell in 1925[14]. Experimentation on learning in cattle does not seem to have occurred as early as in the other animals. For example, the earliest paper I could find on classical conditioning in cattle is a Russian report in 1962, but it seems likely that the author was summarizing work that had been carried out over a number of years[15]. Thus, as in the fowl, most of the pioneering work on learning in the mammalian farm animals seems to have been motivated by fundamental rather than applied interest.

Early work on social behaviour was performed for its fundamental interest. Schjeiderup-Ebbe's pioneering work on the social hierarchy[16] was a fundamental study unconcerned with production records, and as far as I could judge he was interested in it as a comparative psychologist rather than as a zoologist. His work was later developed by Allee and his students who have had a very large effect on applied ethology in the USA. Allee's interest in social behaviour arose from his work on an aquatic isopod *Asellus communis*, for he viewed animal aggregations as constituting a primitive stage in the evolution of society. In order to avoid anthropomorphism he used the term protocooperation for cases such as aquatic invertebrates, in which aggregations led to chemical changes in the water that enhanced survival of the group. His first published paper on the social behaviour of the fowl was entitled 'The social order in flocks of the common chicken and the pigeon' published in 'The Auk' in 1934[17]. Between that date and the early 1950s he and his post-graduate students published numerous papers dealing with different aspects of the social hierarchy in fowls. The application of social behaviour studies to poultry production was really pioneered by Guhl and Allee[18]. Although the work was generally on a small scale it resulted in larger scale work, sometimes involving genetic selection, under conditions comparable to industry. This was by Craig and his co-workers and has affected the poultry industry. An early experiment by McBride[19] showed that hens kept individually in cages performed better in terms of egg production than their full sisters kept in groups in which they had low social status. This paper I consider gave a great fillip to the application of ethology in relation to poultry production.

As in the case of the chicken, early studies on the social behaviour of cattle, sheep and goats stemmed from the work of Allee. Woodbury[20], for example, in the introduction to his paper on the 'hook' order of dairy cattle states that his interest in the subject was directly due to Allee's description of how, as a boy on the family farm, he had watched cows settle their 'seniority'. In the following year Scott[21] published a paper, 'The social organization of sheep' and in 1946 described dominance relationships in a small flock of goats[22]. The dominance order of boars appears to have been first studied by Jakway and Sumption in 1959[23] and that of sows by Slebodnick and Klopfer in 1953[24], but the main contribution in this area was by Ewbank and his students from 1969 onwards[25]. Schein and Fohrman[26] appear to be the first to have tried to relate dominance and milk production in a dairy herd. The phenomenon which today we call the 'teat order' in piglets seems to have first been described by Carlisle in 1903[27], while Donald[28] was the first to show its importance commercially.

The social behaviour of young animals of course includes play, a subject which seems first to have been introduced into the animal behaviour literature by Groos[29], who published a treatise on the subject in 1896 which ran to several editions. However, whether it included observations on farm animals I am unable to say. The first certain study of play in cattle was that by Brownlee in 1954[30] which is still widely cited in the literature on play in animals.

In these examples from the study of social behaviour we can clearly see the development of applied work stemming from fundamental work.

The earliest record that I have been able to find on the experimental study of the reproductive behaviour of the fowl is that of Heuser which was published in 1916[31]. In this work Heuser found a correlation between the hens mating frequency and her egg production over a 4 week period. The earliest report on preferential mating in the fowl was that by Upp in 1928[32]. This was followed by a small number of experiments over the next decade that dealt with mating behaviour and social dominance in relation to production factors. Another early paper published in 1918 by Turpin[33] dealt with nest preferences. Thus, one can easily see that early impetus for study of reproductive behaviour in the fowl came from practical considerations. When I joined the AFRC Poultry Research Centre in the early 50s I started working on preferential mating in the fowl. I was interested in it as a possible brake on random mating within lines on which most genetic selection programmes depended. While doing this work I discovered genetic differences in the mating behaviour of males[34] and almost simultaneously Paul Siegel embarked on the same line of research[35]. In 1960 I switched to studying nesting behaviour. At that time there was discussion in ethology about the relative importance of central and peripheral stimuli in motivating behaviour. I felt that nesting behaviour might be an ideal behaviour pattern to study in relation to this controversy, being sure that peripheral stimuli from the distal end of the oviduct triggered off the behaviour. I therefore set up a small number of hens in pens and watched their nesting behaviour. One day one hen laid a soft shelled egg that had been due to be laid at about 16:00 hr that day. To my surprise at about 14:30 hr she started her nesting behaviour and entered a nest as though to lay the egg and at 16:00 hr wanted to leave the nest. My work for the next 20 years was set.

In other farm animals the sheep appears next on the stage with regard to studies in reproductive behaviour. Early interest in the 30s and 40s was evident in Australia and South Africa, countries where the sheep has great economic importance[36,37]. This early interest involved the underlying physiological mechanisms and Schinkel, another Australian worker, reported in 1954 on how the ram's presence affects ovarian activity in the ewe[38]. The maternal behaviour of the ewe in relation to lamb survival was first reported by Wallace in New Zealand in 1949[39] and within a decade[40] Alexander and his co-workers in Australia started their long and fruitful studies in this area. Later, with the advent of techniques allowing ovariectomized ewes to exhibit oestrus, Lindsay and his colleagues approached the problems of maternal behaviour in the ewe in another way[41].

Artificial insemination led to studies on the mating behaviour of the bull by Almquist and Hale[42]. However, Walton, who perfected the techniques of semen collection and storage, had started his studies on the rabbit, publishing in 1938 as junior author to Macirone[43]. Interestingly some of the parameters he used in this work were identical to those used later by Beach in his classical studies on the sexual behaviour of the male rat[44]. A number of studies on the sexual behaviour of the cow were carried out in the 1950s, some observational and others physiological[45].

The earliest reference I have been able to find on the mating behaviour of the boar, rather than on reproductive physiology, is that by Hodgson[46] who reported preferential mating. Investigation into the stimuli leading the boar to mount were reported by Rothe[47] while Signoret and his colleagues made a classical investigation into the main external stimuli causing the sow to stand for the boar[48]. A similar approach to analysis of the stimuli involved in mating behaviour of the stallion was taken by Wierzbowski[49] in the 1950s.

Feeding behaviour experiments with the fowl started with an interest in taste perception[50]; and the preferences of the birds[51], none of the early workers in the area were apparently motivated by practical issues. However by 1932 there was work in progress on self selection of feedstuffs by chickens which was motivated by practical industrial interests[52,53]. In 1931 Hellwald tested hens mildly deprived of calcium to see if they would consume more calcium than those that were not deficient. Again this experiment was not orientated towards a practical problem. The involvement of the hypothalamus in feeding behaviour was first tested in the fowl by Lepkovsky and his co-workers[54]. The neurophysiological basis of taste perception was studied by Kare and his colleagues[55], who also investigated taste perception in other species of farm livestock[56].

In the 1920s interest in mineral deficient grazing areas was apparent in the scientific agricultural press. Australia and South Africa are countries with large areas of mineral deficiencies and papers appeared describing the pikas of grazing animals[57]. However, general interest in grazing behaviour was also shown; e.g. Stapledon and Jones in the UK recorded the length of grazing and rumination bouts in sheep[58], and between 1931 and 1939 Johnstone-Wallace at Cornell carried out a series of grazing studies in cattle[59]. The effect of drought on the grazing social behaviour of Merino sheep in Australia was described by Nichols[60], the flocks breaking up into very small groups. During the 40s and 50s a number of grazing behaviour studies appeared but these generally were very practical with little psychological or ethological input. In contrast an interesting review paper by Tribe[61] raised a number of interesting theoretical questions, but it was Arnold who mainly attempted to look at the perceptual factors involved in the grazing animals[62,63] and Hunter who investigated some of the social factors involved in pasture utilization in sheep[64].

In the late 50s and early 60s profound changes took place in the structure of the poultry industry in the USA: small family farms were vertically integrated (as the phrase went) by large firms supplying poultry foodstuffs and this led to radical changes in the poultry farms. The age of 'Big is Beautiful' had arrived and the poultry farmer now became a mere operator following the husbandry methods laid down by the firm that more or less owned him. Sociologically it was not pretty and from the animal welfare point of view it was disastrous. Battery cages holding birds at very high densities became the norm. The wave of Americanization that hit Europe in the 1950s and 60s included much of this process. Up to this time all the birds in the British poultry industry had been truly on open range or kept in small groups in pens at low densities often with outside runs. Within a very few years the battery cage was ubiquitous. It was not long before reaction set in. Mrs Ruth Harrison's book "Animal Machines", published in 1966, was serialized in a Sunday newspaper and the public reacted quickly and vociferously. The Government appointed a committee under Professor Rogers Brambell and its report paved the way for animal welfare research as we now know it as well as the 'Codes of Recommendation for the Welfare of Livestock' (1968). Many experiments dealing with immediate problems were carried out, examining the effects of density, colony size, cage size, flooring and so on. However some research most pertinent to Animal Welfare had been carried out for fundamental interest. The work that Duncan and I had done on frustration in the fowl, for example, had been done as an inquiry into frustration[65]. In 1973 I had published an article showing the importance of understanding motivation for better animal welfare[66] and as stated earlier my work on nesting behaviour had started because of its intrinsic interest[67]. Much of today's research effort in Animal Welfare involves the study of stereotypies and the earliest reference on this class of behaviour is a paper by Levy entitled 'Tics, stereotyped movement and hyperactivity' published in 1944[68]. Again it seems to have been written for the intrinsic interest in the behaviour. Nevertheless the scene was now set for animal welfare research as we see it today in which problems are being tackled at several levels.

Having written this paper one is tempted to look for patterns in the progress of science. In March of this year a PhD thesis appeared on my desk for examination. One of its objectives was to ascertain whether the behaviour of an animal could be used as an index of pain suffered by that animal. In 1901 W.Norman published a paper entitled "Do the reactions of the lower animals against injury indicate pain sensations?"[69]. One is tempted to ask: Are we merely dancing round the mulberry bush?

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The future of Applied Ethology

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Trying to predict what is going to happen in the future is something that should perhaps be left to a fortune-teller. Nevertheless, the future of applied ethology is of such great interest to all of us, that we have today set a lot of time aside to discuss what may happen in the future. And I believe that we all feel that we can do something about it, not just relying upon faith.

To say something about the future, one must first look back. But rather than simply drawing straight lines from the past to the future, we must identify the scientific challenges that are present at this very moment.

TOPICS OF SPECIAL INTEREST

The themes of sessions of our previous summer meetings give us some ideas about what have been considered important topics of our discipline. Motivation, Animal handling and transport, Behaviour and stress, Human animal relationships, Behaviour and genetics, Ontogeny of behaviour, How to measure well-being, Behaviour in relation to welfare, Behaviour in relation to social and physical environments, Mother-offspring interactions, Zoo animals and Wildlife management are examples of themes which have occurred at several of our meetings. I believe that it is important to discuss all of these areas to be able to find out if there are scientific problems or tasks, that are of a general kind within the area, or even that are in common to more than one of these areas. I will give one example to show what I mean.

Recent work, for example that by the group with Benus, Bohus, Koolhaas and others (Benus et al., 1989; Koolhaas et al., 1986), shows us that there are no average individuals in a social group. Individual differences and how they relate to genetic as well as ontogenetic processes are interesting, and the knowledge about such differences is also of crucial value to any researcher working in any of the above stated fields. The animal to be studied might have been subjected to a handling procedure early on that has influenced its behaviour and physiology (Levine et al., 1967).

Not very long ago, a researcher could regard a group of fifty layers, a litter of piglets or a herd of cattle as a sufficiently homogenous group from which simply to make averages. Those days are gone now, and we need to know a lot about each individual, its genetic as well as ontogenetic background, before we expose it in our test situation. I believe that the future of applied animal ethology will be one, where the characteristics and reactions of the individual are focused upon, irrespective of which type of problem the researcher is studying.

To work with applied ethology in the most effective way we need a firm and up to date contact with basic ethology. This by no means implies one-way communication from basic ethologists to applied. Especially within the areas of disturbed behaviour, e.g. the work on stereotypies, applied ethology has made important contributions to basic research. Behavioural disorders and relations between behaviour and disease are areas where applied animal ethology faces an important and challenging future.

INTERDISCIPLINARY APPROACH

It is not only for us to discuss which problems or tasks need further effort within our established areas of research. We must also consider new areas where research is being carried out successfully and to which applied animal ethology can contribute as well as benefit. For example neuroendocrinology and neurobiology within human medicine are areas where today problems such as social support, disturbing life-changes and personality types are dealt with (Theorell et al., 1976). This is just one example of an interdisciplinary approach where I believe that we will see in the future much firmer cooperation between scientists within applied animal ethology and those from another discipline, in this case human medicine.

The change of the composition of members within the Society for Veterinary Ethology from mostly veterinarians to veterinarians, agronomists, zoologists, psychologists and others gives evidence to the need of knowledge from all these areas to be incorporated in applied animal ethology. For the future we might expect neurologists, endocrinologists, surgeons and others in our membership list.

EDUCATION AND INFORMATION

The future of applied animal ethology does not consist of research activities alone, even if it must be based upon them. Within the fields of education and information, there is much that needs to be done. Applied animal ethology is not being taught in all universities, and where it is taught the courses are often short. Over the last decade, we have managed to bring about an acceptance of our discipline in society, but we are still far from bringing about the understanding of applied animal ethology. For example the psychological component in stress reactions, first demonstrated by Mason et al. (1968), which can explain the physiological reaction in the individual, is not well enough recognized among many agronomists or veterinarians. Yet these specialists are designing the environments for our farm animals and trying to seek causes for disease.

Our efforts to inform students, colleagues and society as a whole can be no less in the future than they are today. The rôle that the SVE has at the European Committee on Animal Welfare is a key rôle, and it is well accepted. However, today we must ask ourselves if the time has not come for the SVE to be more active in other areas of education and information. For example an SVE network for universities that are teaching applied animal ethology could serve as a base for information to students as well as society as a whole.

It is my sincere belief that all of us have ideas about what we would like to see happen in the future. There is no doubt that applied animal ethology has a large potential when used to explain causes and events of illness and disease, when used to understand how the animal interacts with the environment given to it and when used to understand the well-being of the animal. Let us now formulate our ambitions for the future!

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Human-Animal Interactions

The interaction of humans with food animals: making husbandry a science

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The interaction of humans with current food producing species probably began some time before domestication started. In the process of domestication, humans have assumed more and more control over all aspects of the animals' lives. Both genetic and developmental changes in the animals have resulted from this process (Price, 1984). Today, animal agriculture within developed countries varies from very extensive systems such as cattle ranching to intensive confinement production of pigs and poultry. Confinement was developed as a means of obtaining more complete control over the nutrition and environment of the animal. The pig in the sty and the dairy cow in the byre are examples of confinement management of food animals that have existed for centuries.

Many problems have been resolved through the application of scientific knowledge to animal management in the past century and a half; growth potential has been improved by genetic selection and nutritional science has changed the feeding programs of our animals from seasonally available, and often limiting, feedstuffs to complete balanced rations. It was appropriate that a scientific approach was used in the development of confinement housing in the early part of this century.

As we learned more about the physiology of our domestic animals in relation to the environment we realized that the cost of better controlled buildings could be recovered in terms of increased production. But as we imposed greater control over the animals' thermal environment, we began encountering problems associated with humidity, dust and undesirable gases. In order to reduce the cost per animal of the more expensive facilities, we reduced space allowances and problems associated with waste management and social behaviour developed. Uniformity of conditions within pens was accepted, but resulted in animals having little control over their environment. Changes in animal management, including development of new housing systems, were made with good intentions and usually resolved the original problem. Other knowledge, much of which lies within applied ethology, needs to be incorporated into design to alleviate other problems. In the area of housing and equipment design, we can continue to improve the intensive systems we have developed, or return to less intensive control of the animals. In either case, the management of the animals will be improved as we apply our ever-increasing knowledge of the animals.

Direct interactions of humans with animals have always been a part of animal production. Modern economies have reduced the interaction of humans with animals because of high labour costs and it has been suggested that robot milkers and shearers may virtually eliminate the need for human/animal contact. Yet, good stockpersons will continue to be needed to observe and monitor animals for problems which cannot be anticipated or corrected by mechanical means. The necessity of a stockperson raises the questions of how well animals tolerate human contact, and if necessary interactions can be made more acceptable to the animals. Although conventional knowledge has always suggested that there are good and bad stockpersons, Seabrook (1980) was among the first to attempt to define the qualities of good stockpersons.

As applied ethologists we are interested in measuring the animals' response to key environmental stimuli such as human presence. Our efforts have been important in applying scientific principles to stockmanship. The first evaluations of cattle were based on subjective assessments by stockpersons or milkers (Agyemang et al., 1982). Such scoring systems were improved by using independent observers and better defined scoring systems. Further attempts to avoid subjectivity have included electronic measurement of weight shifts (Veissier et al., 1987), the use of specific behaviour events such as flinch, step or kick (Hemsworth et al., 1989a), and timed behaviour tests. Hens have been tested for tonic immobility as a means of assessing fear of humans (Jones and Faure, 1981), and pigs have been subjected to approach tests (Gonyou et al., 1986). These tests are relatively easy to conduct and yield useful results.

Improving the quality of the response of animals to humans has involved the strategies of frequent exposure, improving the quality of the exposure, and exposure during critical periods. Repeated exposure to humans has resulted in improved responses to humans in pigs (Gonyou et al., 1986) and chickens (Jones and Faure, 1981). The nature of the exposure also affects the responses of pigs (Gonyou et al., 1986) and chickens (Gross and Siegel, 1982). Studies indicate that negative interactions, such as slapping, are the most detrimental to pigs and should be avoided (Hemsworth et al., 1989b). Early exposure of pigs (Hemsworth et al., 1986) and chicks (Gross and Siegel, 1982) to humans has been used to exploit any critical period which may exist, but one of the most interesting attempts was the exposure of heifers to humans during the calving process (Hemsworth et al., 1989b). The reaction of animals to humans also has a genetic component with moderate heritabilities reported for pigs (Hemsworth et al., 1990) and beef (Heisler, 1979) and dairy cattle (Dickson et al., 1969).

The effects of good human/animal interactions include improved growth and immune response in chickens (Gross and Siegel, 1979), and fewer problems in the milking parlour in dairy cattle (Hemsworth et al., 1989b). Negative handling of pigs has resulted in increased adrenal activity, poorer growth and reduced reproductive performance (Hemsworth et al., 1986). These studies illustrate that scientific principles can be applied to topics such as stockmanship as well as to traditional areas such as nutrition and genetics.

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Relationship between animal behaviour and housing in zoos

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INTRODUCTION

Originally zoological gardens were places to exhibit wild animals. At the beginning of this century a change began; having started as places for recreation and education zoos became sites for the preservation and protection of endangered species, and increasingly they are becoming centres for scientific research. One of the main areas of this research is animal behaviour or zoo ethology.

HOUSING AND BEHAVIOUR

Zoo animals are more or less accustomed to humans. Comparisons between several species show differences in the ability of the animals to adapt to the artificial environment of the zoo. There is a large difference in the ability of the two African eland antelopes, *Taurotragus oryx Pallas* and *Taurotragus derbianus gigas Heuglin*. The first (*T. oryx Pallas*), which originates from the steppes, shows few problems in adapting; it is even possible to handle it like domestic species. However, the forest subspecies (*T. derbianus gigas Heuglin*) (Altmann and Scheel, 1980) is so shy, even when born in captivity, that it is unsuitable for zoos. In contrast, another forest animal, the wild boar (*Sus scrofa L.*) is characterized by great adaptability and plasticity of its' behaviour when living in small enclosures in captivity.

Keeping deer in zoos sometimes causes problems during the rutting season. It is normal for males to fight with each other and so, the enclosure has to be designed for this behaviour, for example by the provision of so-called "love-passages".

Enrichment of an enclosure means more than the quantity of space provided. Monotonous, barren environments, the so-called "hard architecture" (Sommer, 1974 cited in Maple and Finlay, 1989), are inadequate to fulfil animals' "needs". In order to keep animals, optimal "softened architecture" is necessary; it allows for well-being, comfort, territorial and social behaviours, as it is natural, flexible and manipulable (Maple and Finlay, 1989).

An important factor in keeping is feeding, which is often performed in a way very different to the situation found in nature. In the wild the migrating species spend a lot of time feeding, but in captivity time and space are reduced and this has led to the occurrence of behaviour patterns which are not seen in the wild, such as whilst grazing on the steppes.

Another interesting problem for the display of animals in zoos is the activity rhythm; an attempt is made to fit the period of animal activity to the time of human activity, as an active animal is more attractive to the zoo visitor than a resting one. This has led to the construction of night-animal houses. However, most species are polyphasic (Hediger, 1974). We found that for pygmy armadillos (*Euphractus pichiy Desm.*) it was possible to influence the natural nocturnal habit by special time-entrainers, such as a social partner or feeding (Altmann and Scheel, 1976).

Zoos play a very important rôle in man-animal interactions. Evidently differences do exist between different species. We found that wolves (*Canis lupus L.*) recognized different keepers and wild boars were capable of distinguishing three kinds of humans: keepers, visitors and ethologists (Altmann, 1989).

CONCLUSIONS

Behavioural scientists should play an active rôle in determining the environmental conditions of animals in zoos and should provide the scientific basis for the maintenance of optimal and appropriate housing of wild animals. The free-living animal is not completely free, it is bound to territorial, social and ecological limits. In captivity, the animal requires a certain amount of space, but also needs the opportunity to perform species-specific behaviours in certain places within the space. A well kept animal in the zoo does not behave like a prisoner, but like a "land owner" and defends its territory.

Some species need companions, others are solitary. The first sign of inappropriate housing/keeping conditions is a change in the normal behaviour of the animal and this occurs before the onset of illness. Zoos have the task of exhibiting animals, but the welfare of the animals has to come first. For the protection of endangered species and the welfare of animals living under human care, the zoo staff have to adapt the housing conditions to the requirements of the animals. The scientific field of zoo ethology should help to bring together both the requirements for the animals' natural behaviours and the needs of the keepers and visitors.

SUMMARY

The methods by which the well-being of animals living in captivity can be maintained determines the areas for study in zoological gardens. One of the goals of zoo ethology is to establish the norms for "behaviour-adapted-holding-systems". Animal behaviour is plastic and adaptive, but not without limits! If the contrast between housing conditions and the natural habitat is too great a breakdown occurs. This is shown by high aggression, disturbances in social and maternal behaviour, infanticide, stereotyped behaviour, refusal of food, sickness and death. Therefore, zoo ethologists should provide the scientific basis for the housing conditions of wild animals. Zoos have the task of exhibiting animals, but this has to be related to the welfare of the animals, which must take priority.

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Applied ethology in the laboratory: a neglected field

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The discipline of ethology was founded by naturalists and field workers. The great pioneers, Lorenz and Tinbergen, regarded ethology as a branch of evolutionary biology and they were concerned with the adaptation and survival value of behaviour under natural conditions. Subsequently, ethology moved into the laboratory and investigations, among others, of imprinting, motivation and behavioural physiology developed. However, because of their traditional evolutionary and field orientations, ethologists have largely neglected to study the behaviour of domesticated animals.

The Society for Veterinary Ethology was founded partly in response to public concern for the welfare of animals in intensive husbandry systems, and the majority of applied research is still concerned with farm animals. Thus, pure ethology moved into the laboratory and applied ethology to the farm, while the ethological aspects of laboratory animal science have largely been neglected.

A 25th Anniversary provides an opportunity to consider past achievements and also to plan for the future. Briefly, I shall consider some examples of the findings of laboratory animal ethology and try to look forward by identifying the future needs for research, with the aim of encouraging applied ethologists to take more interest in this area.

The two main areas of concern to laboratory animal ethology are in providing information on the behaviour of animals in different housing and husbandry systems and in assessing suffering and distress in experimental situations. United States and European legislation respectively specify that the 'psychological well-being' or 'ethological needs' of non-human primates should be assured. In fact there is a real dearth of ethological data to identify what these needs might be, and some biomedical research workers have doubted that they even exist.

Rodents are the most commonly kept laboratory vertebrates but their ethology is much neglected. For example, it is common practice for stock laboratory mice to be kept in same-sex housing; male mice, however, are highly aggressive and severe injuries and deaths can occur under these conditions. Poole and Morgan (1973) found that the severity of attacks depended on the number of mice in the group and whether or not they were littermates; for CFW mice in the size of cage tested ($0.18m^2$), five appeared to be the optimum for the welfare of the mice. Clearly this work needs extending to other strains and housing conditions.

It is difficult to assess suffering in rodents, but most animals which are stressed or in pain show changes in their expected normal behaviour patterns. Barclay et al. (1988) devised a 'Disturbance Index' to assess the extent to which routine veterinary and laboratory procedures disturb the exploratory behaviour of rodents when introduced into a clean cage. This index allowed for the comparison of the severity of different procedures. It showed, for example, that the injection of 50ml/kg normal saline into a mouse is highly disturbing, whereas a similar volume of Hartmann's solution created no significant disturbance.

In many laboratories it has been traditional to house monkeys singly in spite of their social habits. Reinhart et al. (1988) not only showed that social housing is beneficial in the laboratory but also that it is possible to introduce most long term single housed individuals to the same cage to provide companionship, something which is commonly regarded as very risky, and avoided. Erwin (1986) doubled the space available for a harem group of pig-tailed macaques by giving them access to a second room of the same size. He expected that the extra space would be beneficial, but found that there was double the amount of aggression, because access to the second room allowed dominant females to bully subordinates, when out of sight of the male.

Environmental enrichment for captive primates can be both practical and inexpensive. In captivity, food is normally provided for monkeys in excess and in a readily accessible form, so that finding food occupies very little time. In contrast, wild primates may spend up to 70% of their time foraging during daylight hours. Chamove et al. (1982) found that simply providing a woodchip substrate with food concealed in it, even when readily available food was also present, increased foraging in most species of non-human primate and at the same time significantly reduced aggression.

It is clear that there is much to be learned from applied animal ethology in the laboratory. There are many fields worthy of exploration, among the most important of which are to identify the behavioural "needs" of different species and to discover ways of eliminating or minimising abnormal behaviours.

There should be more emphasis on techniques for handling and training laboratory animals to reduce stress in both husbandry and experimental conditions. More effort could also be made to provide objective assessments of the likely distress caused to different species by different experimental procedures.

Welfare guidelines for the housing and care of laboratory animals would also be far more realistic if they were based on sound ethological principles. For example, the temperature and humidity ranges specified for rodents and primates in current European and UK legislation are completely unrealistic. Those for mice and rats (19-23°C, 50-60%RH) are based on the ability of a mother to rear pups exposed on a substrate without any nest material. Female rodents can survive in a very wide range of temperatures because they normally have the facilities to make a nest, which provides them with some control over microclimatic temperature and humidity. Simply applying sound ethological principles and providing nest materials not only benefits the mouse and her young, but can also save the laboratory the very large sums of money required to install precisely-controlled air conditioning!

A similar anomaly exists for primates where official guidelines specify that most species should not be kept at temperatures which they would normally experience on a day to day basis in the wild.

To conclude, applied ethologists should become much more active in the laboratory because their expertise is badly needed. The application of their research could not only lead to the improvement of laboratory animal welfare, but would also help to improve the quality of the science based on these animals.

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Interactions between owner and companion animal behaviour

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The most popular pets, the cat and the dog, are normally allowed to share the owner's living space. In addition, the owners usually form some kind of emotional relationship with them; in fact this relationship is often the purpose of acquiring the pet. These pets and their owners are, therefore, well placed to influence each others' behaviour in a variety of ways.

In recent years, there has been much interest in the beneficial effect of pets on the mental and physical well-being of owners (Friedmann et al., 1980; Mugford and M'Comisky, 1975). It also seems self-evident that dogs or cats with behaviour problems can adversely effect the quality of life of their owners, although there have been no studies which investigate how profound or long-lasting this effect is.

It is also clear that owners can influence their pets' behaviour in many ways. In the case of the dog, selective breeding has altered the comparative probability of various behavioural traits (e.g. protective aggression) in different breeds. The early environment which breeders and owners arrange for their puppies can also have a marked effect on later behaviour (e.g. Scott and Fuller, 1965). Because social interaction is such a powerful reinforcer for dogs, their behaviour even as adults is profoundly affected by their interaction with their owners: they can be trained reliably to perform complex tasks, but they also learn undesirable behaviours. In addition, depending on the owner's behaviour, the dog will instinctively display dominant or subdominant behaviour towards him/her (O'Farrell, 1989). Owners may also indirectly affect their dogs' behaviour by altering the balance of circulating hormones, for example by castration (Hopkins et al., 1976) or spaying (O'Farrell and Peachey, 1990).

It is commonly believed that an owner's personality can affect his/her dog in subtle and involuntary ways (e.g. "fear transmitted down the lead") but this subject has received little scientific attention. In a study of 50 owners, it was found that the dogs of owners who wanted a loving, dependent relationship with them were more likely to show dominance aggression towards them (O'Farrell, 1987). This is probably because these owners were more likely to engage in subdominant behaviour towards their dogs. Owners of dogs engaging in displacement activities tended to score higher on the Neuroticism scale of the Eysenck Personal Inventory. This is probably because neurotic owners tend to behave more inconsistently towards their dogs, thus putting them into a state of conflict and raising their level of stress. The results also showed no association between owner neurosis and phobias in the dog. There was a positive correlation, however, between owner neurosis and the extent to which the owner considered the dog's behaviour to be a problem.

The results of this kind of study suggest that certain types of attitude and personality in the owner are correlated with certain kinds of behaviour in the dog. This does not do justice to the subtlety and complexity of the interactions between individual dogs and individual owners. These can often be better understood by the use of the psychoanalytical concept of "projection": the mental mechanism of putting part of oneself into another person. In mutually beneficial owner/dog relationships, a benign form of projection takes place in which the owner correctly perceives the dog as sharing some of his/her own needs and pleasures (e.g. play, walks) and vicariously enjoys satisfying those needs. A potentially harmful form of projection takes place when an owner, as a means of dealing with problematic feelings in himself/herself (e.g. aggression, separation anxiety), denies them in himself/herself, but sees them in the dog. Although this process is best illustrated by clinical examples, it was also demonstrated in a study in which 20 owners rated themselves, their ideal selves and their dogs on 24 adjectives describing personality (O'Farrell, 1986). Over all subjects, rating of self and dog were correlated. The correlation was lower for subjects who showed most personality disturbance as measured by the discrepancy between "self" and "ideal self" ratings (Ryle and Breen, 1972). These disturbed owners also perceived their dogs as having more behaviour problems.

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Applied ethology and animal damage control

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INTRODUCTION

The notion of pests makes sense only in terms of their relationship with people. "Pests" are a human construct; animals that decrease the value of our resources, in terms of quantity, quality, public health or aesthetic values. For example, introduced rabbits, foxes and feral animals, notably pigs, dogs, goats, horses, buffalo and donkeys, are pests in Australia because they cause hundreds of millions of dollars of damage annually. Resource protection is therefore the goal of animal damage management.

Control programs frequently waver from this objective to the surrogate goal of reducing animal numbers. Killing animals usually reduces damage, because there is an association between density and impact, but may not be the most effective, economical or humane approach. By focusing instead on alternatives which manipulate the animal behaviour that affects human resources, ethologists can deliver major advances in pest management. Indeed, there have been successes in the application of ethology to pest management. However, it is an area neglected by ethologists, one which will benefit from applying ethology to produce damage control techniques which modify problem behaviour.

This paper provides selected examples of current and potential applications of ethology to pest animal management. Its purpose is to identify significant challenges in animal damage control and to encourage increased attention to pest management by applied ethologists.

CURRENT APPLICATIONS AND ISSUES

Identifying the problem

Pests can be real or perceived. Ethologists have a pivotal rôle to play in distinguishing between the two by careful experimental and observational study. This is an important first step, because the solutions differ fundamentally. A perceived pest problem is solved by education and extension; a real pest problem by implementing cost-effective damage control.

Pest control and animal welfare

Pest control usually involves large-scale recurrent killing, posing ethical and welfare issues and challenges for applied ethologists; to assess and improve existing techniques, and to identify more humane alternatives. Pest animals are treated very differently from their domestic and wild counterparts. They are trapped, poisoned, fumigated and controlled with diseases, all practices that would be unacceptable and illegal for use on domestic animals.

"Judas" goats as a tool in pest eradication

Feral goats damage vegetation, compete with wildlife and domestic stock and have a potential rôle in the transmission of exotic animal disease. They are a conservation problem on islands, where they were introduced historically as food for passing or shipwrecked mariners.

Eradication of feral goats is frequently a management goal, but is exceptionally difficult to achieve with conventional hunting, because of the negative exponential relationship between catch-per-unit-effort and density. Finding the last few animals is increasingly time consuming and prohibitively expensive, forcing managers into recurrent culling, rather than the perpetual freedom from the pest and its damage promised by eradication.

The challenge is to identify a technique to locate feral goats as they become rare, so that eradication becomes economically feasible. Feral goat social behaviour and radio-telemetry combine to provide the solution in the 'Judas goat' technique (Taylor and Katahira, 1988).

The technique involves releasing a radio-transmitter equipped feral goat into the eradication area. After a few days, the radio-collared Judas goat is tracked using telemetry and the feral goats with which it has associated can be shot. The Judas goat is allowed to escape and the process repeated until all goats are removed. This technique has effectively eradicated feral goats from areas where it was considered impossible.

Controlling predators

Wild animal predation on domestic livestock is a widespread problem. A variety of solutions have been attempted: Australia maintains a 5,500 km fence, intended to keep dingoes on one side and sheep on the other; and in Australia and elsewhere predators are trapped, poisoned, and shot. Some of these procedures are perceived as inhumane.

Gustavson et al. (1982) sought to limit predation by coyotes on sheep using lithium chloride treated sheep-meat baits to induce learnt aversion. Although the experimental design was flawed by use of "before" as a control for "after", consistent declines in predation suggest that these aversive baits were effective. This approach warrants rigorous assessment. Making sheep distasteful to predators has the potential to reduce coyote density humanely, and allow them to co-exist with agriculture.

POTENTIAL APPLICATIONS

Identifying opportunities

Ethological studies can identify opportunities for damage control. Recurrent killing of a pest is expensive and unnecessary if other means of reducing pest density or access to the resource are available.

Much damage control has been directed at killing the animals causing the damage. Reducing the population necessarily has a short-term effect and is recurrent, because it does not reduce the environmental carrying capacity for the pest or reduce pest access to the resource under contention. On the contrary, the fortunes of remaining animals are enhanced through compensatory changes in fecundity and survival. Resources other than those in human-animal contention, for example water, nest and rest sites, can be made limiting, effectively lowering carrying capacity and reducing pest density.

Improving the effectiveness of toxic baits

Toxic baits are used widely to control pest animals, particularly rodents. Killing a sufficiently large proportion of the population to produce persistent, cost-effective damage reduction requires overcoming genetic resistance to toxins, selection for neophobia, and maximising the attractiveness of the toxic bait. Semio-chemicals are a recent and innovative approach to the latter problem. Work on social transmission of rodent feeding preferences is an example of basic research with the potential to enhance pest control dramatically. Galef and colleagues have demonstrated that Norway rats prefer feeding sites that conspecifics are using, choose novel foods that are eaten by conspecifics, and that this behaviour is mediated by volatile cues. They have recently shown that the addition of carbon disulfide, present in the breath of rats, produces dramatic increases in bait consumption (Mason et al., 1988). Application of this research has the potential to increase both the effectiveness and target specificity of rodent control.

Reducing non-target hazard

The target specificity of pest animal control is frequently scrutinised and criticised. Many lethal pest control techniques, such as trapping, poisoning and fumigation, have the potential to harm species other than the target.

Usually, the lethal element of the practice, a toxin, trap or fumigant, is not species-specific. Species-specificity results from manipulating non-target access, and requires an understanding of the comparative behaviour and ecology of target and non-target species (O'Brien, 1986). Exploiting differences between target and non-target species in activity patterns, space use and feeding behaviour provide opportunities to design pest control systems which are increasingly target specific. For example, adding green or black dye to toxic baits reduces consumption by wild birds without affecting intake by feral pigs (Hone et al., 1985).

Identifying effective sonic devices

Biologically meaningful sounds, such as taped alarm vocalisations, appear to have a rôle in reducing animal damage, but have not been fully assessed. For example, Naef-Daenzer (1983) tested the effect of distress calls on crow damage to corn fields. Fields where taped distress calls were played received significantly less damage than other treatments.

Manufacture and sale of sound producing devices to control animal damage is big business; 51 manufacturers had sales exceeding $US17m in 1982. Sonic devices are promoted as scientifically sound, humane, inexpensive and simple to operate. Unfortunately, sounds other than communicative signals have no persistent effect on animals' use of space or food intake (Bomford and O'Brien, 1990). They do not work!

There is a need for adequately controlled and replicated experiments assessing the rôle of sound in damage control, particularly the communicatory signals of birds. Proper assessment provides a basis for humanely preventing damage and preventing consumers from investing in ineffective devices.

Novel approaches

A number of novel approaches to pest animal behaviour show potential in damage control. Sullivan et al.'s evaluation (1985) of predator odours as repellents in order to reduce feeding damage by herbivores is one example.

There is also considerable scope for transferring basic findings into applied solutions to pest problems. For example, Muller-Schwarze et al.'s (1984) identification of an alarm pheromone in the metatarsal gland of blacktailed deer which alerts conspecifics and produces avoidance behaviour may also have potential in reducing deer damage.

Recent work in Australia on the use of decoy and screening crops to reduce native bird damage to cereal crops offers potential for humane, effective and economical damage control. Monofilament lines are also proving a highly effective way of excluding gulls from parks and nesting sites (Blokpoel and Tessier, 1983).

CONCLUSIONS

Pest animals are pests because some aspect of their behaviour decreases the value of a human resource. It is ultimately an animal's behaviour we want to manipulate to reduce damage, whether it is the sheep-preying behaviour of dingoes; the fence-damaging behaviour of wombats; or the electric insulation-gnawing behaviour of rats.

Ironically, our historic focus on lowering animal density has largely ignored prospects for influencing behavioural frequency. It is time ethologists shifted that focus to the behavioural aspects of these persistent, significant problems.

This paper identified areas where innovative ethological approaches to animal damage control have produced results, and where ongoing problems challenge applied ethologists; in problem definition, non-target and welfare aspects of pest control, increasing species-specificity and in novel approaches which modify pest animal behaviour.

If ethologists direct their attention to these issues, we may see some very productive outcomes for problem animals, people with problems, and applied ethologists.

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Assessment of donkey temperament and the influence of home environment

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The temperament of individual donkeys being sent to foster homes from the Sanctuary was evaluated using eight pairs of contrary adjectives, e.g. calm/nervous. Assessors marked the position on a line joining the adjective pairs that best reflected the donkey's expression of that trait. This was then converted into a numerical score. A pilot study showed the method to be reliable and valid. The donkeys' attitude to other animals and people was also recorded. A factor analysis of the scores for the traits produced two factors; one labelled 'cooperation' and the other 'timidity' (Table 1).

TABLE 1
Factor analysis

Adjective pair	Factor 1	Factor 2	Name
Staid-Playful	0.25884	0.72095	'timidity'
Shy-Outgoing	-0.14354	0.88003	'timidity'
Calm-Nervous	0.43888	-0.62930	'timidity'
Gentle-Rough	0.79437	0.28339	'cooperation'
Obliging-Wilful	0.85187	0.10727	'cooperation'
Friendly-Spiteful	0.76944	-0.24460	'cooperation'
Content-Agitated	0.74061	-0.32282	'cooperation'
Easy handling-Difficult	0.82224	-0.10497	'cooperation'

Kaiser-Meyer-Olkin Measure Sampling Adequacy = 0.786
Bartlett's Test of Sphericity = 1304.2, $P<0.001$

An assessment was made of the effect on the factors of the fostering process and the donkeys' histories and attitudes towards other animals. 'Cooperation' was affected by changes of home; donkeys being less cooperative at their new home than at the Sanctuary (Table 2a). This change to a more 'boisterous' temperament may be because they experience less social intimidation living in a pair in a home than living in larger groups at the Sanctuary, or it may reflect the inexperience of the foster home. 'Cooperation' in the foster home was negatively correlated with the number of previous homes (Table 2b); i.e. donkeys that had been in many homes were more cooperative than other donkeys. At the Sanctuary those donkeys that liked dogs were less cooperative than others (Table 3). This reflected their upbringing within a household and their subsequent familiarity with humans. The other factor 'timidity' was unaffected by changes of home but donkeys that liked children were less timid than others (Table 3).

TABLE 2

Effect on 'cooperation' of changes in home

a On release to latest foster home					
Home Score > Sanctuary Score. N=38 Z=-2.94 P=0.003					
Wilcoxon Matched-pairs Signed-ranks Test using mean scores					
b Effect of previous homes on handlability in latest home					
b.1 Correlation coefficient					
	Years at:	Sanc.	Owners home	Unknown	Foster
	'Cooperation' (in home)	-0.1771	-0.3229	-0.4268	0.0929
	P (1-Tailed N=42)	0.131	0.018	0.002	0.279
b.2 Multiple regression: 'cooperation' vs years spent in					
	a: known homes	F= 5.59	(DF 1,51)	P=0.022	
	b: unknown homes	F= 11.05	(DF 1,41)	P=0.002	

TABLE 3

Significant relationships between temperament and attitudes

Factor	place	animal	N	W	Z	P	
'cooperation'	group	dogs	53	438	-2.42	0.015	like>dislike
'timidity'	both	child	50	120	-2.22	0.026	like>dislike

Wilcoxon Rank Sum W Test

Factors influencing Fallow deer fawn mortality in Phoenix Park

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Between 17% and 30% of fallow deer fawns in Phoenix Park die within their first year. The most critical period is during the fawns' first six weeks (Moore and Hayden, 1988). Sixteen fawns were found dead during the 1990 fawning period. The aim of this study was to try and determine the factors influencing fawn mortality in Phoenix Park by monitoring fawn and doe behaviour during and after the critical period. The fieldwork was conducted in Phoenix Park, Dublin, between 30 June 1990 and 19 August 1990. Observations were restricted to the "Fifteen Acres", where the majority of does and fawns were located between 08:00 hr and 18:00 hr each day. The study area was classified into three habitat categories: woodland, edge habitats and meadow. The activity of randomly selected does and fawns was monitored using focal animal sampling (Martin and Bateson, 1986). A total of 98 records of doe behaviour and 82 records of fawn behaviour were made. The presence of people within 50 m had a marked effect on fawn behaviour, reducing the time spent suckling by approximately 70%, increasing vigilance and the time spent moving and decreasing the time spent resting. The magnitude of the behavioural changes varied with the type of habitat the fawn was in at the time. Although does formed larger groups in the open meadow habitat, doe behaviour did not significantly differ in the presence of people.

Self-sucking in orang-utans after loss of offspring

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In the zoo of Ouwehand (Rhenen, Netherlands) two pairs of orang-utans are kept. One pair consists of an adult male and a female, the other one consists of the adult daughter of the male accompanied by an adolescent male. In the spring of 1990 both females were pregnant. However, both lost their baby offspring. In the subsequent period both females developed the habit of sucking on their own teats and maintained this behaviour very consistently. The sucking kept them lactating and may have prevented them from getting pregnant again. Administration of lactation-inhibiting hormones could possibly have diminished the sucking, but administration of such hormones was regarded as undesirable. To clarify possible causes for the unwanted sucking behaviour we investigated behavioural and environmental correlates of the teat-sucking, including presence of the public. Female and males were observed over a period of three months. The female of the first pair sucked 3.20 times/hr with a mean duration of 72 sec; the sucking occurred in periods when she was more or less solitary. In the other pair, the female sucked 2.64 times/hr with a mean duration of 19 sec. There was no correlation with other behavioural categories. Furthermore, the adolescent sucked at a mean of 3.22 times/hr (duration 29 sec), especially in periods in which both animals were socially engaged, for example in play. Although we have no clue to solve the unwanted sucking and suckling by behavioural rather than hormonal intervention, it may be that experiences of others with such a phenomenon can help in attacking the problem. No previous descriptions of this phenomenon have been found in the literature, and we do not, at present, have the ability to prevent the unwanted sucking and suckling by behavioural rather than hormonal intervention. Suggestions from others with experience of similar phenomena would be welcome to help in solving the problem.

Regurgitating as a weaning strategy in the domestic dog

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Regurgitation is a way of feeding young animals by throwing up partially digested food, and among animals is exclusively used by Canids. It has been suggested to be an important step in the weaning process, in that it gives the pups a chance to choose easily accepted regurgitated food instead of milk. This could lead to an easier weaning with a lower level of aggression as a consequence. Recently, it has been shown that not all domestic dogs regurgitate. In a questionnaire study, the frequency of regurgitation was found to be 65% and was associated with begging behaviour of the pups. This is interesting as begging is not necessary for regurgitation to occur. In fact both regurgitation and begging may be becoming less and less common in the domestic dog population. The interplay between the two behaviours may also influence the late development of "active submission", a kind of submissive greeting. The physiological status of the pups during the weaning period may be influenced by consuming regurgitated food. In the mother, the digestive and lactogenic systems are activated simultaneously at both suckling and feeding, and a decrease in both systems could prevent a dog from either digesting or producing milk following ingestion. This would open up the possibility for the food to be regurgitated. Results from these studies of regurgitation in relation to weaning are presented.

Effects of environmental enrichment and gentle handling on fearfulness in transported broilers

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In experiment 1, 80 chicks were randomly allocated to enriched/handled or non-enriched/non-handled groups and reared to 45 days. Enrichment comprised the provision of intermittent background music and novel objects, which were regularly altered. Handling involved gently picking birds up. After transportation, the duration of tonic immobility (TI) was unexpectedly longer in the enriched/handled birds. In experiment 2, 80 chicks were reared as above and monitored regularly during rearing and for 12 hr after transportation. Enriched/handled birds were more active during rearing and performed more preening, standing and agonistic interactions after transportation. In experiment 3, the rearing groups were subdivided to separate the handling and enrichment treatments. TI durations after transportation were greatest in enriched/handled birds and least in enriched/non-handled birds. This suggests an adverse effect of handling confined to the enriched birds which is possibly due to greater environmental sensitivity in enriched birds.

Farm Animal Behaviour

Ethology of the wild relatives of domestic livestock

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The wild-living relatives of domestic livestock fall into two groups, namely the wild congenerics and the feral conspecifics. The wild congenerics of sheep, goats and cattle (Macdonald, 1984) are mostly rare and have generally been studied in small populations under difficult conditions. Such studies have usually been descriptive and oriented towards conservation management. In contrast, wild pigs, including the progenitor (and conspecific) of the domestic pig, namely the wild boar *Sus scrofa* are not generally rare. Nevertheless these species have not been extensively studied (NRC, 1983; Mauget et al., 1984).

There are several instances where feral conspecifics have played a part in destroying ecosystems, and this has been particularly clear on certain islands, for example, cattle on Amsterdam Island, southern Indian Ocean (Daycard, 1990); goats on islands generally (Rudge, 1984); sheep on Santa Cruz Island, California (van Vuren and Coblentz, 1989); pigs on Isla Santiago, Galapagos (Coblentz and Baber, 1987). Studies such as these have naturally concentrated on applied ecology and population dynamics and ethological studies of these populations are lacking.

In Britain, by various historical accidents, certain feral and semi-feral populations of cattle, sheep and goats are to be found, which appear not to degrade the habitat, and these have been studied ethologically to a depth not seen elsewhere. Though feral and wild pigs are not found in Britain, experimental studies of pig community structure (Kerr et al., 1988) have provided a link between farm animal ethology and the behaviour of the wild conspecific, which may be strengthened by the advent, in Britain, of the husbandry of wild boar (Booth et al., 1988).

The feral populations in question are the mixed species (pony, cattle, goat and red deer) community of Rhum (Clutton-Brock and Ball, 1987), several feral goat populations (Bullock, 1991), the semi-feral native sheep of North Ronaldsay, Orkney (Paterson, 1987; Paterson and Coleman, 1982), and the two populations which will be the main topics of this paper, the Soay sheep of St. Kilda (Jewell et al., 1974; Jewell, 1989) and the Chillingham cattle (Hall, 1989a,b for references).

The Soay sheep have provided many of the data that have permitted comparisons among wild congenerics, feral conspecifics and husbanded populations of sheep (Shackleton and Shank, 1984). Field observations of oestrous Soay ewes being courted and mounted, first by young rams, then at mid-oestrus by dominant rams, and again by young rams towards the end of oestrus, suggested the hypothesis that the middle of oestrus is the optimum time for natural mating and a multiple mating experiment showed this to be so (Jewell et al., 1986).

The Chillingham cattle are one of the very few feral cattle populations extant. Field studies from 1977 to 1981 dealt with the ecology, population dynamics and genetics of this herd (Hall, 1989a,b for references). Ethological studies addressed the questions of how social hierarchies and individual and group affinities operate during winter hay feeding (Hall, 1986), how time is allocated among social and maintenance behaviours by animals which breed all year round (Hall, 1989c) and how patterns of vocalisations may have developed (Hall et al., 1988).

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The importance of field studies for the domestication of new animal species

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INTRODUCTION

I am a veterinary surgeon who was privileged to spend three or four years carrying out field work with red deer; this involved making some ethological observations. Subsequently I have attempted to commercialise the husbanding of red deer. I have been asked to write a paper on the value of this early fieldwork in the domestication process. In an attempt to make my presentation useful I have generalised from my experience. I have no original scientific data to present and the paper will be highly eclectic.

THE NEED FOR NEW DOMESTICANTS

Except for those societies, largely dependent on hunting or founded on a grazing economy, meat has, since the advent of domestication, been subordinate to crops in human diet. Even within Europe, the keeping of livestock for meat production, prior to industrialisation, was limited. Yet we often assume that new domesticants will be created, if at all, for meat, particularly among African ungulates (Crawford, 1968; Jewell, 1969; Kyle, 1987). Worldwide it is doubtful, however, if new animal domesticants, particularly grazing species, are required for food. The problems of feeding the rocketing human population are more likely to be resolved by improved crop production techniques and the development of commensal domesticants such as poultry, fish or pigs.

Within the more affluent, temperate countries there is, however, a probable demand for novelty meats to parallel the diversity of plant products now available. This is especially so if the meats are lean and produced in ways to suit the public perception of what is "environmentally friendly"; i.e. probably from grass not grain.

PREREQUISITES FOR A PROSPECTIVE NEW ANIMAL DOMESTICANT

i) Physiological. If we narrow our viewpoint to the search for a meat-producing species then we must consider the available substrates. In temperate climates this is, most economically, grass, so it is necessary to select only those species capable of thriving on a grass-based diet. Hofmann has classified ungulates by the degree to which the anatomy of their digestive tract is adapted to digesting grass. Those which are so adapted are classified as "bulk feeders" or grazers, in contrast to "concentrate selectors" with a higher feeding frequency that are predominantly browsers (Hofmann, 1985). On this basis cattle, sheep and several species of deer would be physiologically feasible choices.

Reproductively the candidate should be as fecund as possible but, within a temperate climate, it should also be a seasonal breeder (i.e. of temperate origins itself) to permit synchronisation of periods of high nutritional requirement, especially lactation, with maximum food availability. Other physiological considerations relate to longevity and age at puberty.

ii) Ethological. Zeuner stated that all domesticated animals other than the cat have pack or herd-forming wild relations (Zeuner, 1963). This is especially important for grazing domesticants, although territoriality is perhaps undesirable (Jewell, 1969). Fortunately bulk feeders are likely to be gregarious. Prior to the introduction of wire fencing, herd forming was even more essential in a potential domesticant. Gregariousness will confer advantages for the semi-intensive farmer not only in ease of herding but also in conferring some resistance to diseases of intensification e.g. ingested helminth parasites.

Polygamy is a further behavioural trait almost indispensible in a domesticant together with the physiological characteristics of that life style.

iii) Commercial. This is the most important consideration in assessing potential domesticants. Unless there is adequate demand for the product at a price at which it can be profitably produced, there is no point in attempting domestication. Even where the biological efficiency of converting vegetation into meat is superior to existing systems, as has been frequently avowed in African game production (Dashmann, 1964; Jewell, 1969; Kyle, 1972; Field 1984; Skinner, 1989), exploitation may fail unless the market for the product is adequately developed. This is true even where ethological factors are in favour of husbandry, e.g. in the case of oryx (*Oryx sp.*) (Stanley-Price, pers. comm.).

On the other hand, where demand for a product is extremely high the domestication of quite unsuitable species may be economically worthwhile. For example the musk deer (*Moschus sp.*), which is threatened by hunters seeking musk, the secretion of its preputial gland, might be less threatened if extraction could be carried out from tame animals (Green, 1989).

RED DEER HUSBANDRY

Differences in the efficiency with which species adapted to consume grass convert this into meat are in practice likely to be small: all use the same biochemical pathways. In the case of red deer (*Cervus elaphus*), venison production is at a similar level of efficiency to beef or lamb production but the perceived value of venison in the market place is higher, so that venison production probably remains profitable (Fennessy and Taylor, 1989; Fletcher, 1989). The longevity of deer is greater than for conventional livestock but the cost of containment is higher, the creation of an industry infrastructure is more expensive, and government support tends to be directed, at least in Britain though not in many other countries, towards cattle and sheep meat production.

ETHOLOGICAL CONSIDERATIONS IN RED DEER FARMING

i) Calving. Wild red deer hinds seek solitude at calving time and calves select secluded sites to lie up (Clutton-Brock and Guinness, 1975). Surprisingly, farmed hinds seem well able to adapt to calving at high density, up to 200 hinds on 10 hectares, with no cover other than rye-grass dominant sward. Although mismothering and cross suckling occur, neonatal mortality levels are substantially less than in the wild.

ii) Rutting. Fighting between stags is a seasonal problem, as field studies might lead one to expect, but antlers are removed on farms to reduce injuries and the linear dominance hierarchy described by Lincoln et al. (1970) remains stable throughout the winter. Breeding stags running with hinds are best separated from bachelor groups or other harems by an electric fence or an empty field.

iii) Wintering. It is the management of farmed red deer during the north European winter which is most likely to create behavioural problems. Though field studies might not indicate it, red deer are not well insulated and have a very high requirement for shelter. Farmers often use buildings to obviate this difficulty and to avoid pasture damage. Agonistic behaviour between housed deer can cause problems and farmers have found that these are minimised by running the deer in large groups and avoiding mixing deer between groups. This represents the most serious behavioural problem in managing farmed red deer in northern Europe.

CONCLUSION

Ethological field studies have had little effect on the management techniques applied to farmed red deer. But such studies would be of great value in developing management systems for species less easily husbanded, e.g. musk deer. They are also likely to be useful in improving the management of species in zoological collections. In considering potential new domesticants biologists should remember that the mundane economic realities of marketing, distribution and packaging are likely to be as important as ethological and ecological factors in assuring the viability of new domestication enterprises. Ethological studies on farms are likely to be more effective in improving the management and welfare of new domesticants.

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Back to nature: the use of studying the ethology of free-ranging domestic animals

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Most scientists agree that the speciality of ethology, as compared to other animal behaviour sciences, is the focusing on the normal behaviour of the species in their ecological and evolutionary context. Yet, in applied ethology, domestic breeds are seldom studied in a natural situation, although such studies have long been advocated (e.g. McBride et al., 1967; Hartsock, 1982). Even though some people do, indeed, believe that the natural environment of a hen is a cage and that of a pig is a pen, I prefer to believe that the main reason for the lack of naturalistic studies of domestic animals is a combination of limited resources and an uncertainty as to how to interpret and use the results for applied purposes.

In this paper, I will present some selected results from studies of poultry and pigs in natural surroundings and give my approach as to how they should be applied. Free-ranging or feral hens have been studied extensively by e.g. McBride et al. (1969) and Wood-Gush et al. (1978), while pigs have been studied in the pioneering work by Stolba and Wood-Gush (e.g. Stolba and Wood-Gush, 1984) and later by myself and my colleagues (e.g. Jensen, 1988). I will focus on two aspects of behaviour; the social behaviour and nesting behaviour preceding laying and farrowing respectively. The chosen examples represent two different dimensions of the ethology of a species. I will limit myself to the perspective of animal welfare when considering the application of the results, although many other applications for practical husbandry exist.

SOCIAL BEHAVIOUR

Both hens and pigs show varying social organisation with time of year and the reproductive cycle. During the breeding season hens are mainly territorial and in non-breeding periods the territories overlap (McBride et al., 1969). In this study by McBride et al., the hens had two clutches per year. Prior to breeding the birds lived in harem flocks, typically comprising a dominant male, four to six hens, pullets and subordinate males. During the breeding season the males lived on their own or with a single hen, defending fixed territorial borders. When broody, the hens nested in the territory of their males, but otherwise moved freely over larger areas. After the mother-young bonds were broken, the hens gradually returned to their flocks. Later, the young joined the flock.

Pigs are much more difficult to observe under true feral conditions. While the centre of the territories of feral hens may be between 60 and 150 m apart (McBride et al., 1969), home ranges of feral pigs may vary between about 150 to 500 hectares (Kurz and Marchinton, 1972). Under such conditions, pigs typically form groups of eight animals or less (Hanson and Karstad, 1959). Non-breeding groups generally consist of only females, sometimes with a single boar (Kurz and Marchinton, 1972).

The boar is otherwise mostly solitary. Some time before farrowing, the sow isolates herself and remains isolated with the piglets for a period after the birth (Kurz and Marchinton, 1972; Jensen, 1988).

NEST BUILDING

It appears that no detailed description exists of nest building of hens in natural environments. Duncan et al. (1978) noted that nest sites were usually chosen in well hidden and covered places. In semi-intensive situations, the hen will often choose a corner and construct a nest by picking up litter and throwing it over her back. By crouching, rotating and scratching she produces a depression and a circular wall (McBride et al., 1969; Wood-Gush, 1975). Hens tend to use the same nests for subsequent eggs, but often improve it every day (Wood-Gush, 1975).

Starting at about 12-20 hr before parturition, a sow constructs a nest in an isolated and protected place outside the normal home range by first excavating a shallow hole, which is then filled with grass and other soft material (Jensen, 1988). The nesting follows a rather stereotyped pattern, but it appears more flexible in some parts than others.

HOW TO APPLY THE RESULTS

I suggest a "three-stage rocket" as a theoretical model, for the application of the results in welfare contexts (Jensen, 1988). The findings in the natural or semi-natural situation, according to the model, are only raw-material for the generation of hypotheses or questions, which is the first stage in the rocket. It is self-evident that as the hypotheses (regarding, for example, the motivational control of a behaviour) improve, the better are the data from the naturalistic studies. Too often studies in natural situations are purely descriptive and qualitative. The more quantitative and thoroughly sampled the data are, the better the questions that can be asked.

The studies referred to above may give rise to questions like: How do the preferred social groups of hens and pigs differ during different reproductive seasons? When is the best time for re-integrating a sow to a group? Does the nesting pattern change according to the quality of the nest site? Rigid quantitative descriptions in the natural situation may provide one or more plausible hypotheses for each such question.

Stage two of the model involves a traditional experimental examination of the hypotheses. Only such experiments can provide reasonably reliable answers to the questions. Some experiments can be carried out in the natural situation (see, for example, Stolba and Wood-Gush, 1984), but usually they would have to be made under strictly controlled experimental conditions.

Once the results from the experimental studies are available, the third stage becomes possible. This involves the actual application of the findings. In this stage the data can be used, for example, to construct new housing systems or to modify old ones.

Too often, the second stage is left out, and applications are based directly on what is found in the natural environment.

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Adaptation of cubicle-housed dairy cows to their housing and management

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INTRODUCTION

Behavioural studies of farm animals can provide insight into the adaptation of the animals to their housing and management. Examples of dairy cows' behaviour under some modern housing and management conditions are presented. Firstly, the results of the experiments are discussed in terms of the interaction between housing and management and the cows' behaviour. Secondly, the adaptation of the cows to their environment is briefly discussed.

SOCIAL DOMINANCE

Social dominance in dairy cattle was studied because the concept of social dominance is still discussed regularly. Information on social dominance in dairy cows and the influence of housing and management was collected in four experiments with seven different groups of cows in total.

The investigation showed that stable dominance relationships between animals do exist, but that a subordinate animal could displace a dominant animal or might not yield to a dominant animal. Both housing and management greatly influenced the occurrence of these so-called contradictory displacements. Social dominance plays only a limited rôle in the distribution of important resources between the members of a group (Figure 1). This might be partly due to various disturbing factors resulting from both housing and management at the farm, but in general the rôle of social dominance is limited under normal conditions (this is also true for other species). However, social dominance is important because the existence of stable dominance relationships means that often animals can reliably predict the result of an interaction in which they are or could become involved.

SIGNIFICANCE OF CUBICLES

A large variation is found in the daily time spent lying down by dairy cows. Both individual cow variation and differences between housing and management are known to affect the time spent lying down.

The consequences of some details of the housing system and of over- and understocking on the time spent standing and lying in the cubicles were studied in five experiments with nine different groups of cows in total. The primary aim of these studies was to determine the significance of cubicles for resting and for hiding.

On average, the cows spent about 13 hr lying down and 2.5 hr standing in the cubicles per 24 hr. When the cubicles were smaller, and also when the cows could hide from confrontations with group-mates in other places, the time spent in the cubicles was less. Overstocking resulted in a reduction of time spent in the cubicles, whereas with understocking, the time spent in the cubicles was only slightly more. In particular, with high levels of overstocking (50%, 55%) low-ranking animals did not succeed in achieving their normal lying times. When extra cubicles were available (understocking), the cows' lying and eating times were slightly more synchronized and the animals lay down widely dispersed throughout the cubicle house. This gave the animals the opportunity to lie down more comfortably. It is concluded that lying down, and thus the use of a cubicle, is particularly important to the cows. However, it was concluded that extra space is not a prime necessity for cows.

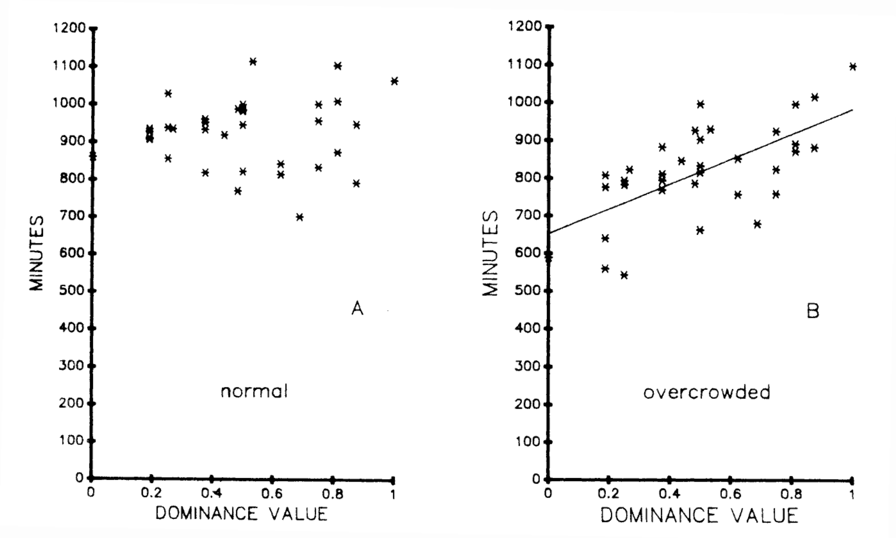

Figure 1. Time spent in the cubicles per 24 hr for each individual cow from two groups of 17 cows each; under normal conditions (one lying place available for each cow) and under overcrowded conditions (55%: 11 lying places for 17 cows.)

AUTOMATIC FEEDING OF CONCENTRATES

The behaviour of dairy cows when fed concentrates with an automatic feeding system was investigated to obtain insight into the cows' adaptation to such systems. Both the visits to the feeding station and the general activities of the cows were investigated. The factors which affected behaviour just before and immediately following a visit and the information a cow used to decide when to visit the feeding station at a certain time, were analysed in detail. Three experiments with three different groups of 20 dairy cows were carried out, in which four different systems for automatic concentrate feeding (fixed-7, fixed-11, fixed-3 and variable-time systems) were compared with feeding concentrates at the feeding rack.

Each of the feeding systems tested evoked a typical pattern of intake of concentrates (e.g. in terms of timing and number of visits). Generally, the cows adapted quickly to each new feeding system, by eating the concentrates as soon as they were available (Figure 2).

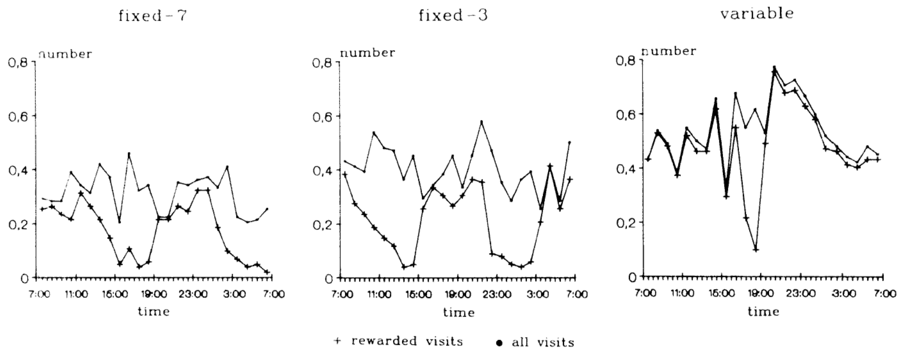

Figure 2. Daily rhythm of number of visits (rewarded and total)/cow/hr to the concentrates feeding station for three different automatic feeding systems tested (fixed-7, fixed-3 and variable time systems).

Time spent at the feeding rack and time spent lying in the cubicles was sometimes affected by the feeding system; with the fixed-11 time system, the low-ranking cows sometimes had to wait a long time before they could enter the feeding station, resulting in reduced lying time. The behaviour of the cows just before a visit to the feeding station was affected by the time of the day, but hardly at all by their chance of receiving concentrates. The cows simply seemed to fit their visits into their normal daily routine. A cow's decision to visit the feeding station was based only to a limited extent on information from the feeding station; a rewarded visit was followed more and more consistently by another cow's visit than an unrewarded visit. The cows mainly chose a strategy of regularly visiting the feeding station throughout the day and night because little effort was needed to make such visits and the reward was sufficiently high.

ADAPTATION OF DAIRY COWS TO THEIR HOUSING AND MANAGEMENT

Stable dominance relationships are important, because they mean that the animals can reliably predict the outcome of a confrontation with a group-mate. The occurrence of contradictory displacements could be seen partly as an adaptation of the low-ranking animals (increased chances of obtaining important resources), whereas the disadvantages for the high-ranking animals do not seem to be significant.

The actual time spent standing and lying in the cubicles varies considerably, both within and between animals. Cows respond to variations in housing and management. With very high levels of overstocking (50%, 55%) the low-ranking cows in particular did not succeed in adapting to the situation. Between 0% and 50% overstocking, the cows have to "work hard" to adapt to achieve their normal lying times.

It was concluded that there was no evidence that the cows experienced problems in adapting to the concentrate feeding systems. Generally, the cows fitted their visits into their normal activities like eating, drinking and resting.

The experiments have shown that dairy cows are capable of adapting to the housing and management systems studied.

The effect of non-traditional lighting on the behaviour of domestic fowl

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There is an increasing trend to keep poultry under non-traditional lighting regimes which are claimed to improve production efficiency in various ways. However, little information is available on how they might affect behaviour. Two studies are described which investigated the behaviour of domestic fowl under two different forms of non-traditional lighting.

INTERMITTENT LIGHTING

It has been suggested (North and Bell, 1990) that the use of intermittent lighting regimes improves broiler productivity by increasing food conversion efficiency and by reducing the incidence of "fast growth problems", such as sudden death syndrome, ascites and leg problems. The mechanisms governing these problems are unknown, but are likely to be mediated through behaviour.

We compared the performance and behaviour of broilers on an intermittent regime (1hr light : 3hr dark, repeated) with that of broilers on a conventional regime (23hr light : 1hr dark) in an attempt to reveal the mechanism.

The birds on the intermittent regime grew more slowly initially and then more quickly, ending up at a similar weight and with a similar food conversion ratio at slaughter time to the birds on conventional lighting. The birds on intermittent lighting were very much more active during their light periods than the birds on conventional lighting and feeding, drinking and maintenance activities were performed at a much faster rate. Periods of resting were more frequent in the birds on conventional lighting. The possible mechanisms controlling productivity will be discussed. An infra-red camera revealed that the birds on intermittent light began to feed for some minutes before the lights came on and they continued to feed for some minutes after the lights went off. This warns that the ratio of light to dark of 1:3 may have been too extreme.

The results suggest that less extreme intermittent regimes may result in improved bird welfare without compromising productivity. For example, it has been suggested that all animals require a certain minimum amount of rest (Dawkins, 1980) and that animals in fairly barren environments on very long days may have problems in "finding something to do" (Hughes and Duncan, 1988). Lighting programmes with shorter light periods should alleviate both of these problems, provided that they allow enough time for essential activities such as feeding.

FLUORESCENT LIGHTING

There has been a trend in recent years to move from traditional incandescent lighting for poultry to fluorescent lighting (Carey, 1987). Fluorescent lights flicker at twice the rate of the electrical supply frequency but are normally perceived as being of steady brightness by human beings because the human critical fusion frequency (cff.) is usually lower than this. However, certain people develop headaches under fluorescent lighting because they have a particularly high cff. Birds have a much higher cff. which has been measured as 150Hz in the pigeon (the highest frequency recorded in vertebrates) (Dodt and Wirth, 1953). Thus the possibility exists that, although good production performance may be obtained under fluorescent lighting (Siopes, 1984; Hulan and Proudfoot, 1987; Zimmerman, 1988), nevertheless it may be aversive to the birds.

A two-roomed chamber was built in which each room could be illuminated by either incandescent or fluorescent lights. The rooms were joined by a small dark compartment with offset doorways leading to the two rooms. This formed a very effective light baffle. The level of illumination in the two rooms was carefully matched and other resources such as food, water and nest-boxes were available in both rooms. Two such chambers were placed side by side and lit by the same lights.

Sixteen light hybrid laying hens were used in the experiment. During rearing they experienced only incandescent lighting. From 18 weeks of age they were kept in a deep litter pen and the lighting was switched from incandescent to fluorescent every two days. The level of illumination in the home pen was carefully matched with that in the test chambers. The experiment started when the birds were 24 weeks old and they were tested individually. Each bird was given one 6 hr day in the chamber to habituate followed by two 6 hr test days, all separated by a day in the home pen. Overhead video cameras recorded the position and the behaviour of the birds throughout testing. The experiment was balanced so that half the birds had incandescent lighting and half had fluorescent lighting in the home pen on the day before testing.

All the hens used both rooms for most activities. There was no tendency to avoid the room lit by fluorescent lights, suggesting that the birds did not find this aversive.

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Social behaviour of farmed blue foxes

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The arctic blue fox (*Alopex lagopus L.*) is a medium-sized carnivore (family Canidae) which is normally used to a rather solitary life, except during the breeding season and nursing. Under controlled conditions in captivity, however, it can form a clear social organization with more or less superficial rank orders when reared in groups. The main objectives of this investigation were (i) to describe social hierarchies and interactions of arctic blue foxes, (ii) to clarify their possible scent-marking systems, and (iii) to test their reactions to familiar and unfamiliar odours.

Two experimental groups were formed: (1) a group of four foxes (two males, two females) which was housed in a large enclosure measuring 11 m long x 8 m wide x 2 m high, and (2) a group of six foxes (three males, three females) raised in an enclosure measuring 17 m long x 8 m wide x 2 m high. Behaviour patterns of the animals were monitored by direct observations continuing for 24 consecutive hours each. Various samples of urine and faeces were collected for the testing of familiar and unfamiliar odours. A marking response was recorded when the subject urinated or defaecated within 30 cm of the sample after a visit.

The social rank status of the animals developed very quickly: in most cases, it could already be observed 1-4 days after the foxes were placed in the enclosure. The data on feeding orders for the animals also indicated that hierarchies developed rather soon, although estimation of their hierarchical position at feeding was not always quite clear. Males were normally dominant over females, and showed a rather linear hierarchical structure. In females the hierarchy was more ambiguous. The animals exhibited a rich repertoire of visual signals which they employed to denote status and intent. Social interactions were more common between the males than between the females. The dominant and the subdominant male were very active scent markers. So, the entire enclosure area was marked by urination or defaecation very evenly. There also existed, however, certain sites in which most markings were concentrated during the course of the experiments. Urination reactions to familiar and unfamiliar odour samples were pronounced. Social status of the animals was not necessarily correlated with the urination frequency. Behavioural patterns of the animals were normal, and rather similar to those observed for blue foxes in conventional farm cages. Daily activities typically consisted of shorter or longer bursts of locomotor activity alternating with rest periods. Rest or inactivity, however, was the most common of observed circadian behaviours.

It can be concluded that although the arctic blue fox in nature is rather solitary, it easily forms a fixed social group in conditions such as housing in large enclosures.

Cross-sucking during the milk period and after stopping the provision of milk replacer

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The aim of the first study was to investigate some aspects of cross-sucking behaviour in calves. The aim of the second study was to examine how the frequency of cross-sucking was affected by a change in feed i.e. stopping the provision of milk replacer. The first experiment was done on 91 Swedish Red and White bull calves. They were observed on 20 different mornings for 3 min following their milk replacer meal. The second experiment was done on 56 Swedish Red and White bull calves. Each pen was observed on days 4, 3 and 1 before and days 1, 3 and 4 after stopping the provision of milk replacer for 20 min following their milk replacer.The frequency of cross-sucking did not change with age. Once the provision of milk replacer had stopped the frequency of cross-sucking decreased significantly (Figure 1). The frequency of cross-sucking decreased with time after milk feeding and after 15 min it was at a level equal to those calves being fed concentrate (Figure 2). Most of the cross-sucking was directed towards the mouth and ears, some towards the scrotum and only rarely towards the prepuce and other parts of the body of pen mates. Slightly more than 1/3 of the calves concentrated 80-100% of their cross-suckings towards one body part of other calves. Of all possible pair-relationships 16% showed a significant preference of one calf for another. There was a significant positive correlation between frequency of cross-sucking received and weight of the calves after the observations had stopped. There was a significant negative correlation between frequency of cross-sucking performed and treatments with antibiotics against coughing, fever and reduced health.

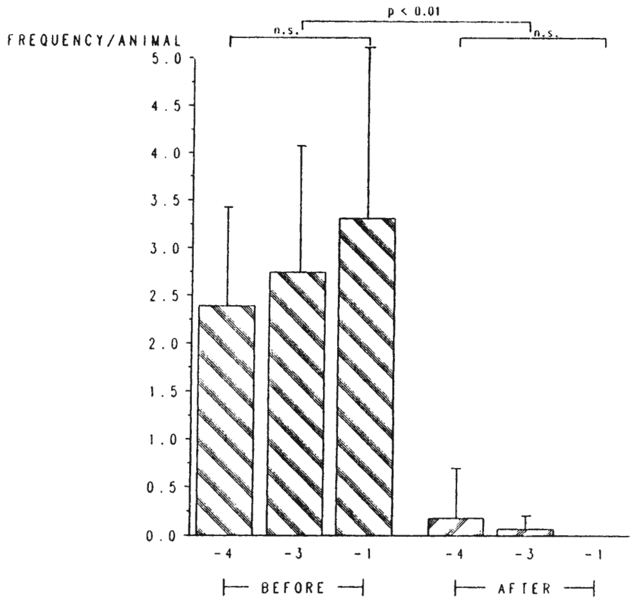

Figure 1. Mean frequency per calf (±1 SD) of cross-sucking on each of the three days before and each of the three days after stopping the provision of milk replacer (Wilcoxon Signed Rank Test)

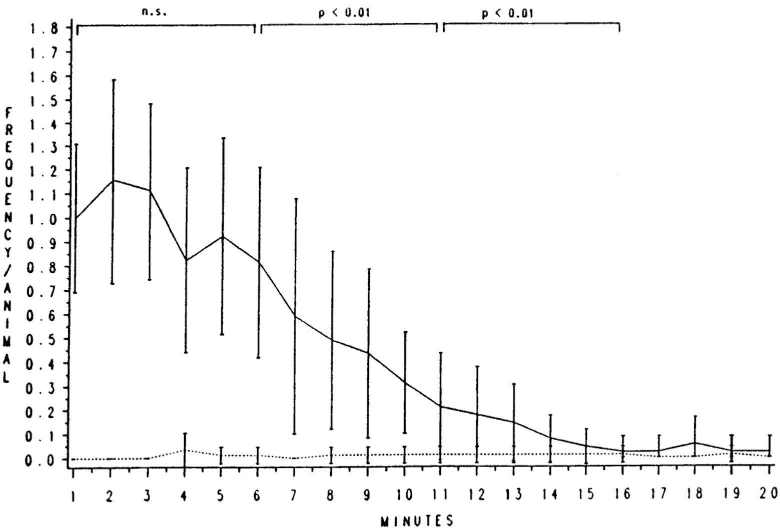

Figure 2. Mean frequency per calf (±1 SD) of cross-sucking with time after 3/4 of the calves had stopped drinking milk or eating concentrate. Each curve gives means for the three days, — before stopping the provision of milk replacer, ···· after stopping the provision of milk replacer (Wilcoxon Signed Rank Test)

Behavioural and physiological changes around parturition in tethered and loose housed sows in Chinese and European breeds

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Fourteen tethered sows (seven Large White, LW, and seven Meishan, MS) and 20 sows (nine Great Yorkshire x Dutch Landrace, F1, and 11 MS), housed individually but unrestrained in straw-bedded pens, were observed continuously from day 111 of gestation to 24 hr postpartum. Progesterone and prolactin plasma concentrations were measured from day 105 of gestation to 48 hr postpartum in an additional 12 tethered sows (six LW and six MS).

Activity level increased as farrowing approached in all sows. Loose housed sows were more active than the tethered ones. MS sows in both housing conditions performed more floor activity (rooting and nestbuilding) than LW and F1. Floor activity was higher in loose housed sows than in tethered ones (Table 1). During farrowing the total lying time was high and greater in the European breeds (tethered LW 98%; loose F1 94%) than the Chinese one (tethered MS 91%; loose 87%). MS sows had more contact with their piglets than LW or F1 sows. During the first 24 hr after farrowing the sows were mostly lying down (more than 90% of total observation time in tethered sows; more than 78% in those loose housed) (Table 2). In the loose housed condition, MS sows spent more time on nursing than F1 ones, while in tethered sows resting behaviour exhibited by litters occurred more often at the udder in MS than LW litters. MS sows showed better maternal behaviour after farrowing than LW and F1 sows. The differences became especially clear under loose housing conditions.

Plasma concentrations of progesterone and prolactin followed the same pattern in MS and LW sows (Figure 1). Prolactin levels increased during the 48 hr prepartum, from their baseline level of 20 ng/ml, and reached maximum values immediately prior to parturition (approx. 120 ng/ml). In both breeds, prolactin concentrations remained significantly higher over the 60 hr postpartum (at approximately 100 ng/ml), compared to the prepartum period. Progesterone levels remained high until 48 hr prepartum (approximately 23 ng/ml) and decreased thereafter (greater than 5ng/ml). MS sows showed slightly but significantly higher concentrations than LW sows over the period from 12 hr before, until farrowing itself.

TABLE 1
Percentage of time spent on different behaviours around parturition (Day 0) in LW, F1 (GY x DL) and MS breeds (medians)

	Tethered		Loose				
Breed	MS	LW	MS	F1		P<	
Day -2	n=6†	n=6†	n=11	n=9	MS/LW	MS/F1	MS/MS
Active	9.3	18.4	13.9	21.3	ns	*	ns
Floor Act.	2.1	0.6	5.2	6.6	**	ns	ns
Lying side	79.6	71.6	72.9	67.0	ns	ns	ns
Lying belly	7.2	14.7	10.1	7.7	ns	ns	ns
Day -1	n=7	n=6†	n=11	n=9	MS/LW	MS/F1	MS/MS
Active	24.7	41.2	34.4	30.9	ns	ns	ns
Floor Act.	9.0	2.0	25.6	13.6	**	*	**
Lying side	63.3	47.5	42.2	57.2	ns	ns	ns
Lying belly	11.7	27.7	8.5	12.3	*	ns	ns
Day +1	n=6†	n=7	n=11	n=9	MS/LW	MS/F1	MS/MS
Active	2.9	4.4	8.2	11.0	ns	ns	ns
Floor Act.	0.8	0.1	2.9	3.3	*	ns	ns
Lying side	95.8	95.4	80.0	78.8	ns	ns	ns
Lying belly	1.0	4.6	2.8	4.1	ns	ns	ns
Nursing	33.3	33.1	35.5	23.8	ns	**	ns

†Because of technical problems one observation was missed
* = P<0.05, ** = P< 0.01, ns = P>0.05

TABLE 2
Performance and behaviour during farrowing in LW, F1 (GY x DL) and MS breeds (medians, ‡means)

	Tethered		Loose				
	MS	LW	MS	F1			
Breed	n=6	n=7	n=11	n=9	MS/LW	MS/F1	MS/MS
Lying	85.0	94.0	86.8	94.2	*	ns	ns
Total number piglets‡	14.2	9.0	13.6	9.7	**	*	ns
Number piglets alive‡	13.6	8.6	12.2	8.0	**	*	ns
Farrowing min/piglet‡	8.4	26.6	9.8	23.3	*	*	ns
Nursing	40.2	35.2	36.5	36.7	ns	ns	ns
Number of nose contacts	9	4	16	14	*	ns	ns

* = P<0.05, ** = P< 0.01, ns = P>0.05

TABLE 3
Comparison of litter behaviour at Day +1 in LW and MS breeds (medians)

	LW	MS	
Behaviour (% of time)	n=6	n=6	P
Total resting	53.7	57.5	ns
Udder resting	15.7	32.8	<0.05
Suckling activity	36.9	34.4	ns
Total time at the udder	58.6	74.8	<0.05

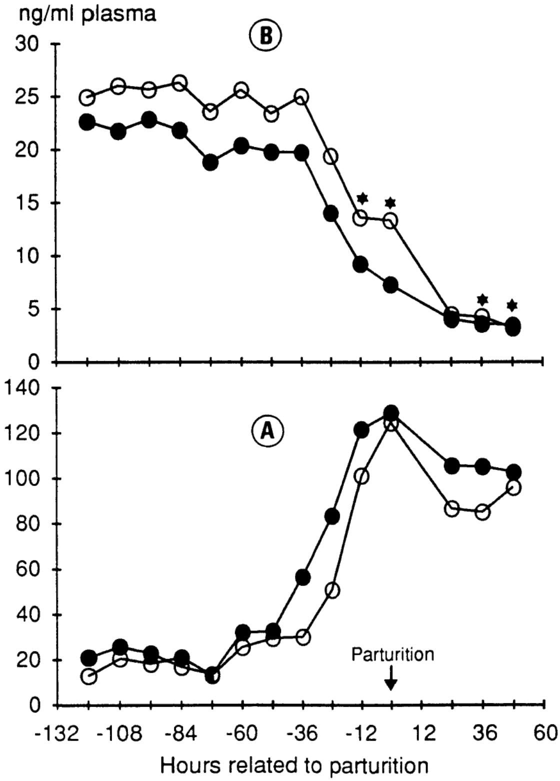

Figure 1. Prolactin (A) and progesterone (B) levels around parturition in MS (-o-) and LW (-•-) sows.

Social, behavioural and physiological functions of allo-grooming in cattle

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We observed social licking in a rearing herd, a fattening herd, a beef suckler herd, and a dairy herd, in order to discuss the various functions of allo-grooming in cattle. In this paper, we report social licking in a dairy herd consisting of 20 Holstein cows.

1) *The influence of social factors.* A milking herd was observed in a loose barn for 54 days from 16:30 hr to 18:30 hr when social licking was particularly frequent. Table 1 shows that social licking was frequently performed to dominants, relatives and familiar cows (similar age).

TABLE 1
Influence of social factors on social licking times (sec/108hr) in a dairy herd (least-square analysis of variance)

Independent variable	Category	Least-Squares Mean ± SD	P
Rank	to dominant	142 ± 9	0.002
	to subordinant	85 ± 9	
Closeness in Birth	within 3 mo.	172 ± 20	0.008
	within 1 yr.	88 ± 16	
	other	80 ± 13	
Kinship	above 0.25	134 ± 9	0.024
	under 0.25	92 ± 9	
Difference in Dominance Value	0-10	111 ± 11	0.606
	10-20	124 ± 11	
	>20	105 ± 11	

2) *The relationships between social licking and spatial distribution and aggressive behaviour.* After a social licking survey, the spatial distribution of cows was recorded during grazing every 15 min and during lying once per day for seven days. The relationship between the number of times being selected as nearest neighbours and time receiving social licking was analysed. Social licking was performed more to the cows being frequently the nearest neighbour (Table 2). Aggression during feeding was not suppressed even if the cow had received frequent social licking.

3) *The heart rate change of cows receiving social licking.* The heart rates of three cows were recorded before, during and after receiving social licking. Table 3 shows that the heart rate decreased while it was receiving social licking.

TABLE 2

Time performing social licking to cows selected as nearest neighbours (total observation number = 50)

No. Selected	Time spent social licking (sec/108hr)	No. Pairs
Within 1m		
0	67 ± 135 ab	180
1	63 ± 143 a	105
2-3	88 ± 123 b	77
≥4	208 ± 387 c	18
Within 5m		
0	71 ± 151 ab	74
1	56 ± 118 a	97
2-3	74 ± 138 a	135
≥4	115 ± 227 b	74

Mann-Whitney U test (figures with different letters are significantly different at P<0.05.)

TABLE 3

The heart rate of three cows before, during and after receiving social licking (times/12sec)

Cows	Before	During				After
	(2 min)	-12sec	-24sec	-36sec	-48sec	(2 min)
A(9)	17.3±2.9 a	16.7±0.9 b	16.6±0.9	16.6±0.8	14	16.9±1.4
B(1)	20	17	16	16	17	17.1±0.7
C(1)	15.7±1.0	15	14	16	15	15.5±0.7

Figures in parentheses are the number of observations.
Figures with different letters are different (t-test, P<0.05)

4) *The relationship between social licking and milk yield.* Milk yield during 166 days and the time receiving social licking correlated significantly, though correlation coefficients among the time spent social licking, dominance value and weight were also significant.

TABLE 4

Correlation coefficients between milk yield, time spent social licking (TSL), parity, body weight and dominance value (DV).

		(2)	(3)	(4)	(5)	(6)
Milk Yield	(1)	0.65**	0.55*	0.41**	0.68**	0.88**
TSL (Receive)	(2)		0.18	0.29	0.78**	0.82**
TSL (Emitt.)	(3)			0.28	0.23	0.39
Parity	(4)				0.57*	0.54*
Body Weight	(5)					0.82**
DV	(6)					

* = P<0.05 ** = P<0.01

Reducing feather pecking in laying hens by behavioural methods

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Feather pecking still seems to be a major problem in the keeping of laying hens, including in alternative systems. In the present experiment two potential methods to reduce feather pecking in laying hens were tested on 1280 White Leghorns in a 2x2 factorial experiment. The first factor was rearing on a dark sand/peat substrate (+R), as opposed to the normally-used cut straw (-R). This is known to be more attractive for pecking and dustbathing in young chicks and is supposed to draw away attention from the other birds' feathers. The other factor was giving the adult hens access to cut straw from a perforated plastic basket (+S). This has been shown significantly to reduce feather pecking in general. The birds were beak trimmed at day-old and reared in two separate groups in the same house until 18 weeks of age. In the laying house they were kept in 16 groups of 80 hens (10 hens/m^2); four groups of each treatment.

Two methods were used to evaluate the level of feather pecking:
1. Direct observation by focal-animal technique.
2. Scoring of the plumage according to the "Tauson-scale" (max.: 20 points), at 28, 45, 59 and 72 weeks of age.

Although there was a general deterioration with time, both factors had considerable beneficial effect on the plumage, and furthermore the effects seem to be additive (Table 1). This could be verified until 45 weeks of age. Thereafter the pattern is somewhat obscured, because the birds with the most damaged plumage show local growth of new feathers on totally denuded areas of the body. There was a tendency for reduced feather pecking in the groups with one or both treatments. However, the number of feather pecks was not significantly influenced by the treatments, because of big individual differences. It is suggested that at least two motivational systems are involved in feather pecking: general exploratory pecking ("food pecking") and ground pecking related to dustbathing.

TABLE 1
Mean number of featherpecks and mean total plumage score for hens of the four different treatments. Different letters in each row denote statistical significant differences (P<0.05, Analysis of Variance).

Treatment	+R+S	+R-S	-R+S	-R-S
Featherpecks/bird/hr	12.3 a	11.3 a	15.1 a	22.3 a
Plumage score, 28 weeks	17.8 a	15.1 b	14.8 b	12.4 c
Plumage score, 45 weeks	11.7 a	8.8 b	9.4 b	8.0 c
Plumage score, 59 weeks	10.8 ab	12.0 a	9.5 b	10.0 ab
Plumage score, 72 weeks	11.7 a	12.4 a	11.5 a	10.9 a

Rearing domestic rabbits in breeding groups: a contribution to animal welfare in rabbit farming

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In traditional and commercial rabbit breeding does and bucks are kept isolated in cages and mating and weaning of their offspring follow various breeding schedules. Conversely the domestic rabbits' ancestors, the European Wild Rabbit (*Oryctolagus cuniculi L.*), live in breeding colonies where does are fertilized post partum.

Based on the social behaviour of domestic rabbits kept under semi-natural conditions a new concept of rabbit breeding was realized in a group housing system (Figure 1) for four to five does, one buck and their offspring up to weaning at 28 days. Environmental key features which were crucial for the actual and ultimate success of the behaviour performed were integrated into the housing system. The total area of 12.7m^2 was subdivided into areas for feeding, resting, hiding and nesting. The nesting area was supplied with straw and six nestboxes.

Behavioural disorders of bucks, mothers and young, cannibalism and high losses of pups, which are known in traditional rabbit breeding, did not occur in nine breeding groups (New Zealand White). Sexual behaviour was often restricted to the first hour following parturition. The 13 does that were observed were mated 7 min (median value) after having left the nest with the new-born litter (six bucks involved). Thus, post partum mating led to a successful gestation in 77% of 44 occasions. Another 13% of fertilizations occurred within 96 hours.

Mothers, bucks and alien does were never aggressive towards pups. Mother-young contacts initiated by does were extremely rare (1-3 per 24 hr). After the young had left the nest (day 17-20) daily nursing occurred after dusk (83%; n=38) and lasted for 3.6±1.6 min. Sixteen of 21 mothers observed also nursed alien young. The rearing success of more than 88% of all young born alive (n=795 in 94 litters, nine groups) was much higher than in commercial rabbit breeding. Scattering of young was rare (less than 2%).

Continuing research on the economic value of our group breeding concept shows good results after a three year period of production (17 farmers involved). Further research is being conducted at the universities of Bern, Stuttgart-Hohenheim, Witzen-hausen, Wageningen and Vienna as well as at the German Health Ministry in Berlin and in the Swiss Pharmaceutical Industry for the production and keeping of laboratory rabbits.

This concept meets the conditions required in Animal Protection Legislature better than any commercial rabbit cage. Moreover, keeping rabbits in permanent breeding groups could also satisfy the farmers' and the consumers' interests. However, it definitely satisfies the rabbits' needs to a greater extent and thus contributes to the welfare of rabbits being farmed or produced for experimental purposes.

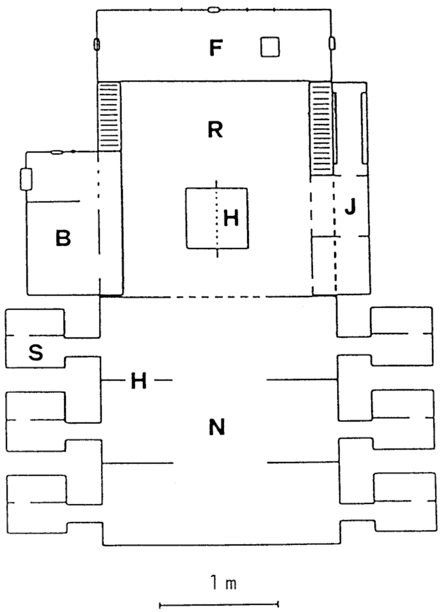

Figure 1. Rabbit housing system for breeding groups.

B = cage for temporary isolation of an animal (with window to arena)
F = elevated feeding area
H = structures for hiding
J = resting and feeding place for pups (no access for adults)
N = nesting area
R = resting area
S = nestbox with tunnel-like entrance from arena

The effect of two different milk feeding regimes on the behaviour of dairy calves

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The aim of this experiment was to investigate how the calves' sucking and investigatory behaviour were influenced by feeding milk with a computer controlled feeding system several (up to 12) times a day (TR) or twice a day in ordinary teat-buckets (TB). Twenty-four 4 day old dairy calves, given colostrum from teat-buckets, were allotted to the two treatments, making 12 calves in each group. Both groups were fed the same restricted amount of milk (up to 6.0 litres/calf/day) until weaning at 15 weeks of age, and had free access to concentrates and hay. The calves' general activity (standing, lying and eating) was recorded for two consecutive days (24 hr time-lapse video recording) at 2, 6, 10 and 14 weeks of age. At 6 and 10 weeks of age the calves' investigatory and sucking behaviours were scored at 1 min intervals for 2.5 hr on three consecutive afternoons by an observer. In addition, all visits to the feeding station were recorded. The calves spent nearly 17 hr/day lying, and there were no differences between treatments. Also, the activity rhythm was remarkably similar, with characteristic peaks at the morning and afternoon feedings. The number of unrewarded visits to the feeding station decreased gradually from 37.7/calf/day at 3 weeks of age to 20.9 at 14 weeks. After the milk feeding was terminated at 15 weeks, the calves soon lost their motivation for visiting the station. The rewarded visits were relatively equally distributed over the 24 hr period, but the unrewarded visits showed the same peaks at feeding times like the activity rhythm. Sucking and licking other calves was rarely observed, and there was no difference between treatments.

Periparturient behaviour of silver-fox vixens in traditional and improved breeding boxes

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Farmed silver foxes are known to show quite variable reproduction. Our research on this species aims at investigating this individual variation by behavioural methods and finding appropriate measures to improve their reproductive ability. Special attention is given to various changes to improve welfare. This paper reports on the behaviour in traditional breeding boxes and in boxes improved to incorporate some of the features of natural dens. The behaviour of 38 silver-fox vixens (21 primiparous) was recorded from one day before to three

days after parturition by an infra-red sensitive video camera mounted on top of the breeding boxes. Instantaneous sampling of 75 behaviour categories every 5 min was performed. A breeding box with an open entrance was given to 22 vixens, whereas 16 vixens had a box with one or two narrow entrance tunnels. The vixens spent more time in the breeding box if it was provided with tunnels, especially during parturition and the first day after. They also spent more time grooming their offspring in this box type. The primiparous vixens spent more time resting in the tunnel box than in the traditional box. In a production experiment on 1411 vixens, those which had a breeding box with an entrance tunnel weaned on average 3.5 cubs, whereas those which had a traditional box weaned 3.0 cubs. The difference was due to lower cub mortality in the tunnel boxes. The behaviour and production results indicate that providing breeding boxes with entrance tunnels could improve the welfare of foxes.

Veterinary Ethology in a classical context

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Starting with Epicurus and Lucretius, then Robert Burton and Sir Charles Lyell, quotations are given which tell that living things have been born (obscurely, it has as yet to be admitted) with certain structural and behavioural attributes. Those which happen, by chance, to be born with attributes which enable them to succeed in their ambient environment may survive. Thus, the much discussed dolichomorphic giraffe was born in an environment which suited it. The environment is diversified and domestic animals are diversified. Adding to Lyell's concept of sudden change, the concept that such change is local provides an explanation of the many mammalian similarities in horses and cattle and, at the same time, the many specific differences, as in the presence of the richly-patterned omasum in cattle and its absence in horses, and their differences in mutual grooming and in the manner of rising up from recumbency. Robert Burton's account of Epicurus being born wise provides an explanation for some of the observations of the late James Milne. Milne found that lambs, when their customary adult-sheep protectors were removed, found cattle, grazing in the same pasture field, to have protective value.

Types of artificial nurse: influence on adaptive capacity and productive performance of artificially reared lambs

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A six week trial was carried out in order to evaluate the effect of artificial nurse type on adaptive capacity and productive performance of 24 Gentile di Puglia male lambs. The animals were divided into three homogenous groups, each consisting of eight subjects, reared in boxes on straw and fed by three different mechanical nurses: (I) Ewe-robot; (II) Ovimatic cylinder; (III) Kitè bucket. On the whole, nurse type did not significantly affect subjects' adaptive capacity; however, the Ewe-robot initially aroused more interest in lambs ($P<0.05$) and caused a slight reduction in time taken for adaptation. Group I also showed significantly higher ($P<0.05$) daily weight gains than the others throughout the trial. In contrast, no differences in dry matter intake and feed efficiency appeared among the groups, whereas the lambs fed by Ewe-robot showed a significantly greater ($P<0.05$) milk replacer intake in the last three experimental weeks.

Investigations into the factors influencing the utilisation of computerised feeding systems by dry sows

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Sows use electronic feeders in a varied and dynamic manner. In order to assess the welfare of sows in these systems and to aid in their management, the aim of this study was to investigate in detail how sows in a commercial herd utilise electronic feeders. Using multivariate analyses, the sows were classified into four distinct groups. Subsequent analyses of variance showed that the mean duration of feeding visits varied between groups ($P<0.0001$), as did mean daily visit frequency ($P<0.0001$) and amount of food eaten per visit ($P<0.0001$), all groups differing from each other (see Table 1). Whilst sows differed greatly with respect to the above variables, the rate at which they consumed their meals was not so distinct: Group 3 sows were significantly slower than Groups 1 and 2 ($P<0.001$), but no other differences were found. These results demonstrate clear differences in the way in which sows utilise this type of feeding system and underline the importance of focusing attention on the individual animal rather than basing management decisions on herd averages. Our current work is aimed at identifying the factors underlying these sow groupings.

TABLE 1

	Group 1	Group 2	Group 3	Group 4
Mean duration (min)	11.63	8.95	17.92	2.62
Mean food eaten per visit (g)	1996.93	1468.35	2408.11	434.24
Mean no. of feeding visits	1.22	1.68	1.14	3.82
Group size	56	26	28	1

Open-field behaviour of rabbits reared in cages or ground pens

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The aim of the research was to assess the behaviour, in an open-field test, of rabbits (2-3 months old) reared in cages or in ground pens at different densities. The first experiment was carried out on 108 rabbits kept in cages at different densities from 700 cm^2/animal (3 rabbits/cage) to 580 cm^2/animal (4 rabbits/cage) and in a ground pen (850 cm^2/animal). In the second experiment 36 rabbits were kept in cages (580 cm^2/animal, 4 rabbits/cage) and in a ground pen (580 cm^2/animal). Rabbits were weighed and individually tested twice and the following behaviours were recorded: total squares entered, escape attempts, alarm reactions, freezing, grooming, standing and exploration. There were no differences between males and females during the repetitions in the two experiments. Weight did not seem to be related to behaviour in the open-field. The main differences were found in total squares entered and freezing times. Total squares entered diminished in the second repetition in ground-pen rabbits kept either at low or high density; moreover, ground-pen rabbits showed a significant ($P<0.004$) lower number of total squares entered than caged rabbits. Freezing times seemed to be related to the density of the rabbits, in both cage and ground-reared animals. In rabbits kept at the same density (580 cm^2/animal) freezing times were lower in caged rabbits than in ground-kept rabbits and the latter had greater freezing times in the second repetition. In contrast, freezing times in ground-kept rabbits at the low density (850 cm^2/animal) diminished in the second repetition. Principal Component Analysis showed that the behaviours could be divided into the following categories: orientation, exploration and freezing. This last behaviour was always negatively correlated to total squares entered, escape attempts and exploration. It seems that freezing could be an adaptive reaction related to distress.

Farm animal ethology, welfare and sustainable agriculture

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The objective determination of farm animal welfare is a complex, interdisciplinary undertaking which, until the advent of applied farm animal behaviour (ethology), has relied too much on the limited criteria of productivity, morbidity, and mortality. A wider recognition of the importance, therefore, of designing husbandry systems and practices that reduce animal stress and distress and which provide more fully for the animals' behavioural requirements, will do much to enhance their overall health, well-being, productivity and profitability. The following "four pillars" of farm animal health and welfare can be considered to be the basic rights of farm animals (to which we should add the right to receive appropriate veterinary treatment when needed). These are also the four Rs of veterinary preventive medicine and health-care maintenance, namely: *right breeding*; *right feeding*; *right environment*; and *right relationship* (in terms of the stockman's attitude, skills and sensitivity). For false reasons of economy, husbandry practices and systems have evolved that violate these four Rs to varying degrees. Alternative animal husbandry practices that are less drug-dependent, therefore, enhance food quality and safety. Further enhancement of food quality and safety and in animal health can be accomplished through feeding animals agricultural by-products, grains, and forages that have been raised either organically or that are minimally contaminated with pesticides and other agrochemical and food-processing residues. Improvements in farm animal welfare and in the safety and quality of their produce to consumers are two of the four cornerstones of *Humane Sustainable Agriculture*. The other two cornerstones are concern for the farmer's well-being, especially of equity and social justice; and more attention to minimizing the environmental and ecological impacts and hidden costs of food animal agriculture, notably in the areas of waste management, livestock overpopulation and over concentration, and overall loss of biodiversity.

Influence of genetic selection for dustbathing behaviour on reactions of Japanese quail towards unfamiliar substrates

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Thirty six female Japanese quail (*Coturnix coturnix japonica*) without dustbathing experience and of lines genetically selected for 16 generations for high or low dustbathing behaviour were used in the study. The birds were exposed to normal sand, green (dyed) sand or wood shavings and their dustbathing behaviour was recorded. Tests were made in the home cage or the hen was placed in an "open field". In addition, tonic immobility reactions of the quail were measured. In general, birds used undyed sand more readily for dustbathing than green sand or wood shavings. Hens from the lines selected for high dustbathing activity exhibited more dustbathing even in less preferred substrates. The test conditions (home versus "open field") influenced the reactions significantly, with less dustbathing occurring in the unfamiliar environment. The interplay between fear induced by the unusual substrates and/or environment and possible genetic changes in dustbathing motivation due to the exerted selection is discussed.

Behaviour of laying hens in three types of aviary and a battery cage system

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This paper reports on behavioural studies during the first production cycle of the Norwegian project "Alternative housing systems for laying hens". Three aviaries, Marielund, Voletage, and the Tiered Wire Floor (17 hens/m^2 floor) were compared with a three-tiered battery cage system with three hens/cage (700 cm^2/hen). The hens were Norwegian light hybrids, not beak-trimmed and reared on the floor with perches. Movements between tiers were recorded on a flock basis, whilst individual distribution and behaviour were recorded by focal animal sampling. A cradle test was used to investigate tonic immobility (TI). The birds distributed themselves throughout the aviary systems, although there was considerable individual variation in both distribution and behaviour. Caged birds showed TI of longer duration than birds from aviaries. Aviary birds spent longer periods lying, drinking, eating, preening and dustbathing than did caged birds, but spent shorter periods sitting and standing. During the light period, 60 week old aviary hens dustbathed less and

retreated from other hens more than 40 week old hens. The older hens spent more time in nests and less time on the floor than did the younger ones. The levels of general aggression increased between 40 weeks and 60 weeks of age. These results indicate that the caged hens were more restless than hens in the aviaries. The aviary hens utilized the system facilities as intended.

Effect of mixing "peaceful" or "aggressive" pigs at abattoirs on their behaviour and meat quality

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The aim of this work was to investigate the effect of mixing "peaceful" or "aggressive" pigs (determined from the established social groups in the pig unit) on aggressive behaviour during lairage at the abattoir and its effect on skin damage and meat quality. In each of 12 replicates, 36 pigs were selected and allocated to three experimental groups (12 in each) according to an aggression index established in the pen environment: "most aggressive", "aggressive", and "peaceful" pigs. On average the "most aggressive" pigs displayed the most aggression when mixed with other pigs at the abattoir. Those pigs categorised as "most aggressive" showed more violent aggression, more frequent biting, pursuit, biting with pursuit, and often bit other pigs' mid-area, hindquarters, or all over the body compared to other pigs. The "peaceful" pigs, on the other hand, very seldomly attacked the mid-area, hindquarters, or all over the body, and normally only threatened other pigs very mildly, which often resulted in no reaction from the receiver. The more frequent and more violent aggression among the "most aggressive" pigs resulted in more skin damage in the shoulder area, mid-area and hindquarters, higher pH-values (greater tendency to DFD-meat), as well as lower optic probe values compared to the mixed "aggressive" and "peaceful" pigs. Blood splashing in the *long. dorsi* muscle as well as boar taint (skatol) were not significantly different between experimental groups. An interesting point to note with the "most aggressive" pigs was that in their social group, they were only aggressive at intervals. Thus, sometimes the "most aggressive" pigs showed no aggression during lairage at the abattoir in a mixed group.

The effect of space on feeding and social behaviour of gilts

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Twelve gilts, with an average weight of 98.3kg, were involved in this experiment. Three space treatments were used: (1) small space (1.8 m x 3.25 m); (2) large space (2 x small space); (3) large space with a half-pen-width division across the middle of the pen. Food was provided at 08:30 hr and 16:30 hr. The 12 gilts were allocated into three groups; each group was observed for 24 hr in each of the three space treatments, after allowing them two days to settle down. Gilts tended to have longer total feeding time and lower eating speed when kept in the pen with small space, although these results were not significant. Similarly, however, both eating time during the first hour and total fighting time during 24 hr were significantly higher for gilts in the pen with small space.

Effects of a selection unit for automatic milking on dairy cow behaviour

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To facilitate full automation of the milking process in future, methods have to be developed to get cows to visit a milking robot at regular intervals. The use of a selection unit is a promising method. When a cow enters such a unit she is automatically identified and the computer then decides whether to allow her access to the automatic milking system. Several types of selection are possible. In *passive* selection the cow decides whether to visit the selection unit. In *active* selection the cow *has* to go there, because the equipment has been arranged in such a way in the cowshed that the only route from the lying area to the feeding area is through the selection unit. Three trials were conducted with 20 cows (HF x FH) in each, kept in the cubicle house of "De Ossekampen" experimental farm of Wageningen Agricultural University. Passive and active selection were compared with each other and with a reference situation without a selection unit. Moreover, for passive selection it was investigated whether dispensing a larger amount of concentrates would induce more visits to the selection unit. A milking robot was simulated in a concentrate feeder. The cows could enter the feeder through a selection unit only. The research aimed to elucidate the cows' use of the selection unit and their welfare. The main results to date are that the use of a selection unit, passive or active, does not change the day and night rhythm of the cows. In the case of passive selection, a larger amount of concentrates resulted in more visits to the selection unit. Nevertheless, the total number of visits to the selection unit was not as high as in active selection and the cows seemed to spend significantly more time standing on the slatted floors in the feeding area.

Pre-dustbathing vocalizations of hens as an indicator of a "need"

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In domestic hens the vocalization 'Gakeln' (Baeumer, 1962) is claimed to signal an expectation or "need". An increase of 'Gakeln' is found after food or nest deprivation (Schenk et al., 1985). 'Gakeln' was analysed in relation to dustbathing in six White Leghorns and six Warren hens. The hens were individually housed and were given access to a dustbath at 14:15 hr. They were then deprived of the dustbath for 1, 2, 4 or 7 days and pre-dustbathing 'Gakeln', dustbathing latency and duration were measured. An increase in the amount of pre-dustbathing vocalizations was found after the long deprivation, particularly in the White Leghorn hens. Deprivation had a highly significant effect on dustbathing latency (means for Warrens and Leghorns respectively on day 1: 1279 sec and 1053 sec, on day 2: 1353 sec and 470 sec, on day 4: 899 sec and 71 sec and on day 7: 432 sec and 61 sec). Although the Leghorns were faster entering the dustbath, the duration of dustbathing was greater for the Warrens. There was an intra-individual correlation between the number of pre-dustbathing vocalizations and the latency to dustbathe for Leghorns, but not Warrens. Furthermore, hens that produced many vocalizations had a short latency to dustbathe (inter-individual correlation). It is concluded that the 'Gakeln' vocalization is a good indicator of the motivation to dustbathe in laying hens.

An introductory study of dairy cow behaviour while using the milking station of a milking robot as a concentrate dispenser

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The prospect of the introduction of milking robots in the near future makes it necessary to find ways of encouraging cows to come to the milking robot voluntarily at the proper time. Different technical applications combined with computer control have to be tested on cows and then either approved or modified. Parallel with research on the possibilities of influencing the movement of cows in a loose housing system (Ketelaar de Lauwere, this conference), another study was commenced in the cowshed, where a milking robot has been installed. The behaviour of cows was observed in the following situations: (I) free movement of cows between the lying and feeding sectors, through two gates located between these sectors; (II) one-way movement of cows through these two gates (in I and II, concentrates were given in the concentrate dispenser in the cowshed); (III) free movement of cows between the lying and feeding sectors, plus concentrates given at the milking station of the milking robot, which was accessible only via a selection gate. The cows were not yet milked in the milking robot system in this study. The movement of cows through the gates in these three situations was monitored for 24 hr daily by two video cameras. The durations of episodes spent in the lying and feeding sectors were then analysed. This was combined with an analysis of computer data on the rewarded and unrewarded visits for concentrates. The time and frequency at which cows drank water were also studied. The total numbers of movements from the lying to the feeding sector and vice versa were: (I) 338/day, (II) 227/day and (III) 493/day. In situation (I), 81% of movements from the lying to the feeding sector were through the gate closer to the concentrate dispenser, and 87% were directly associated with a visit to the dispenser. Enforcing one-way movement of cows in situation (II) reduced the total number of movements between sectors, but cows still visited the concentrate dispenser immediately on entering the feeding sector in 75% of cases. In situation (III), 80% of all movements took place through the selection unit and the nearby gate, where the important resources of concentrates and water were located. Use of the selection unit in situation (III) increased the frequency of short-lasting stays in the feeding and lying sectors, but frequency distribution of long-lasting stays in both sectors remained the same as in situation (I). As regards the total time spent in the two sectors and the number of stays in each, significant differences were found only between situations (II) and (III). The number of visits to the feeding sector and the amount of concentrates eaten were significantly correlated only in situation (III) ($r=0.75$, $P<0.01$). In situation (II) the number of unrewarded visits to the concentrate dispenser was significantly higher than in the other two situations. When the selection unit was used for dispensing concentrates in situation (III), total occupation time of the milking station was less than that of the traditional concentrate dispenser in situations (I) and (II). Cows took 27 sec to pass the selection unit when no concentrates were provided, but 94 sec when concentrates were given.

Increasing photoperiod and toe clipping alter behavioural time budgets of heavy tom turkeys

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An experiment was conducted to examine the influence of increasing photoperiod (IP; 8L:16D, 1-4 weeks, increasing by 2 hr light/day every 2 weeks to 20L:4D, 14-16 weeks, and 23L:1D, 16-18 weeks) versus constant photoperiod (CP;

23L:1D) and intact toes versus clipped toes (digits 1 and 2) on the behavioural time budgets of heavy tom turkeys. Six poults were reared in each of eight floor pens (two pens/treatment) and video cameras sensitive to infra-red light were used to monitor their behaviour. Scan samples made at 30 min intervals over 24 hr periods at two week intervals from 2-18 weeks indicated that turkeys spent a higher proportion of their time standing up (versus lying down) when reared on IP (32.3%) than CP (28.2%; $P<0.01$) and that turkeys with intact toes spent more time standing up (31.6%) than those with clipped toes (28.9%; $P<0.05$). Time spent feeding (7.7%) and drinking (2.2%) while standing did not differ significantly between treatments. Standing, feeding and drinking declined with increasing age ($P<0.01$). Turkeys reared on IP spent more time standing, feeding and drinking during the photoperiod than the scotoperiod. The results indicate that total activity over 24 hr periods was higher under IP than CP, and that toe clipping had long term effects on behaviour.

Postnatal thermoregulatory behaviour in poultry: a new view for optimal climatic conditions

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In climatic chambers with temperatures between 10˚C and 40˚C, heat production and colonic temperature were measured in one to 10 day old chicks of domestic fowls, Muscovy ducks and turkeys. The calculated thermoneutral temperatures and biological optimum temperatures were compared with the simultaneously determined preference temperature (PT) using a 2.5 m long channel with an air temperature gradient between 45˚C and 15˚C. It was shown that the birds had different PTs during different behaviours (resting, locomotion, feeding and drinking). Generally the PT for resting was higher or similar to the thermoneutral temperatures and the birds preferred an air temperature near the biological optimum temperature during locomotion. The results will be discussed in relation to the optimization of climatic conditions during the brooding period.

TABLE 1
Influence of age on thermoneutral temperature (1), biological optimum temperature (2), preference temperature during resting (3) and preference temperature during locomotion (4) in investigated bird species

Age	Fowls				Muscovy ducks				Turkeys			
(days)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
1	38.4	36.6	39.1	37.3	37.1	35.6	37.2	-	37.7	37.2	40.6	38.3
5	33.4	35.2	35.2	33.6	33.5	32.7	33.7	-	35.4	33.8	38.2	33.1
10	34.6	30.5	35.0	31.2	31.5	29.7	33.1	-	33.5	30.8	37.4	32.4

Stereotypy frequency in halothane$^+$ and halothane$^-$ Landrace sows

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Thirty-one behaviours, of which eight were stereotypies, were observed in a blind trial in 14 halothane$^+$ (H^+) and 14 halothane$^-$ (H^-) Belgian Landrace sows during a total of 1176 sow-days. The sows were loose-housed in partially slatted pens (maximum group size of six sows) when they were not in farrowing crates. Observations took place between 10:00 hr and 15:00 hr every 15 min, using a one-zero scan-sampling (10 sec/sow) technique. Data were analysed by ANOVA and Duncan-Kramer tests using the following variables: individual differences, halothane status, time of day and reproductive status. Generally, H^+ sows did not stereotype more than H^- sows, but they performed more weaving and opening of the mouth. Most stereotypies occurred more frequently prior to feeding. The various patterns occurred at different frequencies according to reproductive status.

Development of group-housed dairy calves' behaviour and the effect of separation from the mother five days post partum

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Dairy dam-calf pairs were kept in a group with other pairs from day 1 post partum. The mothers were removed from the group on the 5th day and the calves on the 10th day. The behaviour of calves was recorded on days 1 to 10. The time spent lying/standing and the amount of play behaviour changed with age independently of the mothers' presence/absence. Calves suckled only from their own dam when she was present, but changed to suckling from alien dams within hours of the removal of their mothers. Suckling decreased by 60% and vocalizations increased nine fold in the afternoon following dam removal. These behaviours returned to pre-separation levels within two days. It is concluded that calves seem to quickly adapt to the removal of their mother five days post partum, if other dams and calves are present.

Wildlife Management

The rôle of behaviour studies in wildlife conservation management

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The purposes and objectives of conservation have traditionally been imprecisely defined and only recently, under the increasing pressure of human population growth, resource exploitation and pollution, have attempts been made to achieve a more rigorous approach. Maintenance of biological diversity is the current underlying theme with the implicit assumption of usefulness to humankind. However, there is still considerable indecision over units of diversity to be conserved (populations, species, communities, ecosystems etc.), how much to conserve and whether to consider short-term survival or long-term evolutionary potential.

Improved conservation management within and outwith reserved areas requires more detailed understanding of the behaviour of the species concerned and this short paper is an attempt to identify some of the main areas in which behaviour studies have an important contribution to make.

CONSERVATION MANAGEMENT WITHIN RESERVES

Reserved areas are increasingly becoming isolated units, surrounded by areas that offer little or no suitable habitat. Opportunities for movement between adjacent reserves are becoming restricted. The problem basically becomes one of population size for the rarest species with the lowest chances of dispersal. These will often include species with important ecological rôles, such as top predators, pollinators and seed dispersers. With no management intervention, populations of such species must be self reliant and their loss can have important implications for ecosystem function. Small populations may become more vulnerable to extinction through natural or man-induced catastrophe and environmental and demographic stochasticity and may be susceptible to deleterious genetic effects arising through genetic drift and inbreeding (Frankel and Soulé, 1981).

Detailed research is needed on dispersal behaviour from the viewpoint of numerical stability and gene flow, and on the use and design of dispersal corridors (e.g. Saunders, 1990). A better understanding of minimum viable population sizes and of methods of genetic management of populations at risk is needed (Frankel and Soulé, 1981). Minimum viable population size calculations must take account of the effective population size (N_e) concept (Kimura and Crow, 1963), quantification of which needs a detailed knowledge of social organisation, mating systems and population turnover rates. Traditional perceptions of breeding systems may have to be revised in the light of more objective evidence from DNA fingerprinting. For example, in a study of Sparrowhawks, *Accipiter nisus*, a species considered to be monogamous, a significant proportion of young were the result of extra-pair copulations (McGrady, 1991).

Other important areas of management within reserves that benefit from behaviour studies include the problems of population limitation through territorial behaviour (Patterson, 1980) with the consequent difficulties of surplus animals that cannot disperse and the effects of overcrowding leading to the management of culling or translocation programmes. In many reserves, rare, important species (e.g. Indian rhinoceros, *Rhinoceros unicornus*) often become agricultural pests of surrounding areas, a problem that can only be solved by detailed behavioural analysis.

REINTRODUCTION PROGRAMMES

Captive propagation followed by release to the wild has proved to be a useful conservation tool in extreme cases where extinction or reduction to very low numbers has occurred (e.g. Fyfe, 1978; Delroy et al., 1986). However, severe behavioural difficulties can be encountered in both the captive breeding and return to the wild phases. Captivity may encourage genotypes possessing behavioural traits that are disadvantageous in the wild. Many species, particularly predators and primates, may need extensive training in predator avoidance, food acquisition, movement on natural substrates, orientation and navigation and interaction with conspecifics, before release (Dietz et al.,1988; Kleiman, 1989). An understanding of natural social groupings and social organisation will usually also be important in determining appropriate release methods.

RESPONSES OF WILDLIFE TO HUMAN DISTURBANCE

Wildlife is an important revenue-earning resource and the demand for increased wildlife viewing facilities is high. Other forms of countryside-based recreation such as climbing, backpacking and water sports are also increasing. Responses of animals to these activities vary; in some cases habituation occurs but more often flight responses are elicited. In some situations this may become significant and may jeopardise conservation objectives.

Breeding birds are often particularly vulnerable; disturbance may cause disruption of complex mating systems such as leks, while complete desertion of eggs and temporary abandonment of nests can increase mortality rates of eggs and young through predation, chilling or overheating (Kury and Gochfeld, 1975, Anderson and Keith, 1980). Reptiles may also be affected; tourist boats visiting breeding areas of Nile crocodiles *Crocodilus moliticus* in the Murchison Falls National Park, Uganda caused females to take to the water, resulting in significantly increased predation of eggs and young by monitor lizards, *Varanus niloticus*, and olive baboons, *Papio anubis*, (Cott, 1969).

Non-breeding animals can also respond adversely to disturbance. Following the introduction of winter sailing, the numbers of teal *Anus crecca* and wigeon *A. penelope* using London reservoirs decreased significantly (Parr, 1974; Bathen, 1977). Goldeneye *Bucephala clanga* were also sensitive, taking flight at 300-400 m (Hume, 1976). The fate of disturbed birds was not investigated but it is likely they were forced into less favourable habitats.

Studies of mammalian responses to disturbance are less extensive but tend to demonstrate similar effects. Snowmobile disturbance to white-tailed deer *Odocoileus virginianus* has been shown to disrupt winter energy conservation strategies by altering activity patterns and habitat selection (Huff and Savage, 1972; Mohen, 1976).

The above examples illustrate some of the potential complexities of reactions to disturbance and argue for detailed behaviour studies in cases where conservation and human recreation activities are likely to be in conflict.

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The control of disease in wildlife

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The protection of wild animals against important mortality factors affects their population dynamics and may also alter their population density. This again will bring changes for the species on which they prey, their competitors, and their predators and parasites. In the case of mass vaccination the increased host herd immunity will also exert novel selection pressures on the disease agent. A great number of related concerns have been expressed (e.g. Tiedje et al., 1989). One may therefore conclude that it is not wise to interfere with traditional or natural mortality patterns of wild animal populations. But we have to accept a few exceptions to this general rule: a) when an introduced disease is endangering native species (e.g. avian malaria in Hawaii), and b) when a zoonosis is gaining considerable public health importance (e.g. rabies, brucellosis, tuberculosis). So far rabies is the only wildlife zoonosis brought under some degree of control.

The ultimate goals of rabies control are the protection of human health and the avoidance of economic losses; both can be achieved by prophylactic vaccination of domestic animals. A far more ambitious task is the control of the disease in wildlife hosts. Theoretically, rabies can be eliminated either by drastic decimation of populations or by mass immunization of the main hosts. Decimation has been attempted in all the main hosts, but it is nearly impossible to reduce those populations below the threshold where rabies transmission ceases. Their ability to avoid many methods of population reduction, their high reproductive potential, and high carrying capacities in rural and urban habitats, often make control efforts ineffective.

More promising is the mass vaccination of the main hosts. Wildlife vaccination methods have to be simple and efficient, so that it becomes technically and economically possible to establish the herd immunity required to eliminate rabies. Wildlife rabies control should locally eliminate the disease, or inhibit its spread to uninfected areas. The desired herd immunity can only be established in a population when the following requirements are met: use of vaccines that are safe and potent for field application, and use of vaccine delivery systems that assure mass immunization of target species.

The initial discovery by Baer and co-workers (1971) that foxes could be immunized by oral administration of SAD strain, triggered research projects aimed at the application of oral immunization of carnivores. A team of veterinarians and zoologists at the University of Berne participated in WHO-coordinated international efforts to develop methods for wildlife rabies control. The SAD strain was checked in the laboratory for immunogenicity by the oral route in foxes, stonemartens and dogs, and for innocuity in the same species and in additional domestic and wild animals. Chicken heads were used as baits. A vaccine container was developed which delivered the vaccine into the mouth of a fox which chewed the bait. The immunizing capability of this system in laboratory trials proved to be excellent. By

1978 the upper Rhone Valley, lined by high mountain chains of the Swiss Alps, was threatened by fox rabies, which was advancing along the lake of Geneva toward the Valley. This appeared to be an ideal epidemiological situation for testing the efficacy of fox immunization. In October, 1978, 4050 vaccine baits were distributed over a 335 km^2 area at the Valley entrance. The disease did not cross this "immune barrier". Vaccination campaigns were repeated in the spring and autumn of the following years. The experiment had to be duplicated in other similar situations, where an "immune barrier" could be created in the expected pathway of an epizootic front wave since there was no direct proof that the spread of rabies was stopped by the presence of immune individuals. Between 1978 and 1982 the repetition of field trials in Alpine valleys freed large areas of the Swiss Alps from rabies. By the end of 1986 Switzerland became free of rabies except for a few areas that border on highly endemic zones in neighbouring countries (Wandeler et al., 1988). In West Germany, vaccine was applied for the first time in 1983. Switching from the chicken head bait to a machine manufactured bait in 1985 allowed an extension of the field trials in Germany, and export of baits to other European countries. International cooperation among European countries has been supported by WHO and the European Common Market. In North America the cooperation between industrial vaccine producers, the Ontario Ministry of Natural Resources, Agriculture Canada, and some Canadian Universities has led to a great deal of experience. Field experiments with ERA (SAD) in fox rabies areas of Ontario, Canada, started in 1986.

The most important conclusion to be drawn from these first field applications of vaccine baits is that it is possible to immunize enough animals by bait in order:

- to stop the spread of the disease into rabies-free areas
- to eliminate the disease from an enzootic area.

In European areas where this goal was achieved a minimum of 50% and often 80% of the fox population had been immunized. In areas freed of fox rabies the disease also disappeared from all other species. The disease did not re-appear spontaneously from an undetected reservoir after fox vaccination campaigns were discontinued, but rabies was occasionally able to re-invade a fox population from infected contiguous areas.

The technologies and attenuated rabies vaccines presently being used for field application which are effective in foxes are generally not adequate for the control of the disease in other carnivores. Great efforts are being put into developing vaccines for other species. A vaccinia rabies glycoprotein recombinant virus has been extensively tested in the laboratory, and field trials for its applicability to control raccoon rabies in the Mid-Atlantic States of the USA are in progress. The same vaccine has already been in use (for foxes) in limited field experiments in Belgium since 1988. Adenovirus rabies glycoprotein recombinants are presently being developed and tested in Canada for vaccinating skunks by the oral route.

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Crop damage by wildlife

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INTRODUCTION

There is not the slightest doubt that many species of rodents, birds and mammals cause localised and sometimes widespread damage to crops. It is not the intention in this paper to present an exhaustive list of species and the extent of damage done by each. Rather, an attempt is made to illustrate the importance of understanding the ecology and behaviour of the species causing damage in designing strategies to avoid or minimise damage by non-lethal methods. Population eruptions of species like *Mus musculus* causing plagues are not considered.

DAMAGE: APPARENT OR REAL?

The mere presence of large numbers of birds or rodents in a crop does not necessarily mean that crop yields will be severely reduced. Many crops are able to compensate during growth and seed maturation to overcome a period of herbivory. For example, Keare (1970) showed that grain yields of winter wheat and winter oat crops in Britain were unaffected by 24,000 hours of goose usage per hectare for three days a month from December until April. Edgar and Isaachsen (1974) found that even when 81% of lettuce seedlings were severely pecked by skylarks, and considered a 'write-off' at the time by the grower, a good crop was produced. Sunflowers can compensate for the removal of 15% of the seeds during the soft dough stage (when normally attacked), by increasing the size of the remaining seeds (Sedgewick et al., 1986). Bullfinches can remove up to 20% of buds on pear trees before yield is reduced (Summers and Pollock, 1978). However, beyond a certain level of herbivory, reduction in yield will occur. Reduction of seedling density in cereal crops due to feeding by rooks can reduce grain yields (Feare, 1974), yield reduction being related to rook numbers (Figure 1). Crops attacked at maturity cannot recover. Carrot crops in Lancashire can be devastated by pink-footed geese (*Anser brachyrhynchus*) (Wright and Isaachsen, 1978). Birds (e.g. robin *Turdus migratorius*, northern oriole *Icterus galbula*, mockingbird *Minus polyglottos* and brown thrashers *Toxostoma rufum*) can take 50% of blueberries each week as the crop ripens (Conover, 1982). Meadow and pine voles (*Microtus pennsylvanicus, M. pinetorum*) were estimated to have killed 123,000 apple trees in the USA in 1978 (Swihart and Conovor, 1988). In parts of Western Australia, silvereyes (*Zosterops lateralis*) can damage 95% of grapes prior to harvest (Knight and Robinson, 1978). Little Corellas (*Cacatua sanguinea*) and magpie geese (*Anseranas semipalmata*) were estimated to have eaten 758 tonnes of sorghum grain from one farm in a developing irrigation area in Western Australia (Beeton, 1977). In yet other crops, significant damage can be done by a sequence of birds, as illustrated in Figure 2 for sugar beet in England (Dunning, 1974).

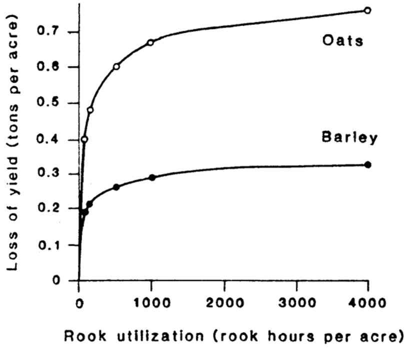

Figure 1. Calculated curves showing the relationship between loss of yield at harvest and the utilisation of spring sown oat and barley fields by rooks. Source: Feare (1974).

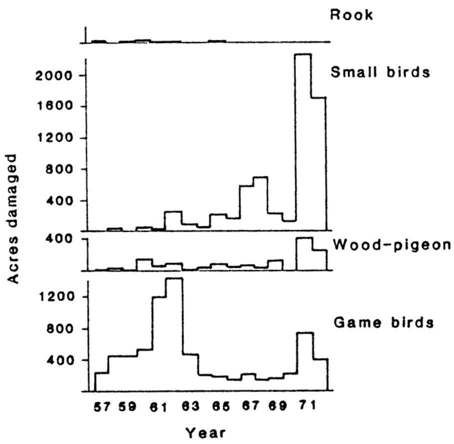

Figure 2. Relative annual damage to sugarbeet crops. Source: Dunning (1974).

AVOIDANCE OR DETERRENCE?

Three approaches have been taken to reduce damage to crops. The first is poisoning the wildlife responsible. This will not be considered here to any extent. It does, however, require an understanding of the social and feeding behaviour of the species to design an effective poison distribution and delivery system. The second approach, adopted more recently, is to use fear provoking or aversive conditioning. The third is to use knowledge of the species' behaviour to change aspects of crop agronomy to avoid damage. This last approach includes the use of alternative (decoy) crops to attract the wildlife species causing damage.

Aversive conditioning has failed to give good and consistent protection to crops. Damage may be reduced in treated areas, sometimes, but no bird species has been shown to exhibit aversion to feeding in untreated areas as a consequence of feeding in treated areas. Likewise, fear induction has failed. For example, Conover (1985) found that a hawk-kite predator model fluttering 30 m above a blueberry field deterred only some species from feeding. Feare (1974) showed that a range of scaring devices failed to prevent rooks feeding in cereal crops. Starlings were found to ignore totally a commercial sonic electronic scarecrow (Bomford, 1990). However, there is a rôle for scaring birds from favoured feeding sites to spread their impact over a wider area and utilise the ability of crop plants to compensate for herbivory.

Crop management strategies, based on knowledge of the pest species' ecology and behaviour are the least costly and, often, only effective way of avoiding or minimising damage. The planting of susceptible crops in the main flight paths to roosts of blackbirds in the USA is an obvious strategy, but may not be economically feasible because of the distances these blackbird species travel daily to feed.

In southwestern Louisiana, blackbird damage to sprouting rice crops can be substantially avoided by delaying seeding in spring until the birds have a wider variety of food sources available (Wilson et al., 1989). Similarly with maize and sweetcorn, use of late maturing varieties avoids damage by blackbirds. Early maturing varieties are eaten because they are at the right stage of maturity for feeding on just when the birds change from insectivory to granivory. The preferred seeds are weed seeds which are available when the late maturing crops are ripening.

The use of alternative foods can be used as a management tool e.g. planting a sacrifice crop for voles (Sullivan and Sullivan, 1988) or parrots feeding in orchards (Forde, 1989). Artificial clawing posts can be used to prevent woodchuck damage to fruit trees (Swihart and Conover, 1988). These workers also showed that vole numbers in orchards can be reduced by keeping the ground cover low and of an unpalatable type.

Crozier (1987) found repellants substantially reduced browsing by rabbits, hares and possums on tree seedlings. But with deer, repellants can be effective or unreliable (Figure 3) depending on deer density and type of crop. Fencing to keep out deer (Hygnstrom and Craven, 1988) and kangaroos (Arnold et al., 1989) can be highly effective, but costly. Both classes of animal are forest or woodland dwellers, so the animals usually do not venture far from the cover of forests or woods. Thus planting damage-susceptible crops away from their natural habitat avoids damage.

DISCUSSION

Biological factors affecting the control strategy for birds were reviewed by Flegg (1980). He concluded that:

> "Overall, before effective damage-control strategies can be designed, much more detailed information is needed. The general ecology of pest species in proximity to

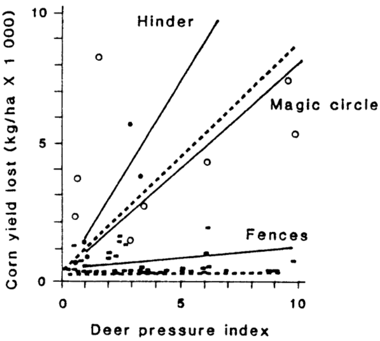

Figure 3. Relationship between level of deer pressure and deer damage in cornfields protected by single strand electric fence ( ) and repellants (Hinder) [•] and Magic Circle [o] in central Wisconsin 1984-85. Dashed lines indicate a completely ineffective treatment (slope = 1.0) and a completely effective treatment (slope = 0.0). Source: Hygnstrom and Craven (1988).

> crops, the rôle of the various items in their diet and their behaviour all require investigation. Studies to obtain such information may often be specific to one pest/crop/locality combination. For many avian pest situations, more forethought, based on ecological considerations, in positioning crops or in land-management techniques may effectively reduce the cost of damage. It would also reduce the difficulties inherent in devising effective strategies for crop protection by the use of deterrents, population control measures, or physical means, against adversaries which, by their evolution and behaviour are well-equipped to exploit our crops".

Swihart and Conover (1988), who have studied crop damage by a wide range of species in the USA, conclude that:

> "When choosing a control strategy, an understanding of the behaviour and ecology of the pest species is helpful. Past techniques which have ignored these facets of a species' biology often have failed. In addition, an understanding of the pest population as a dynamic, constantly changing group of individuals is important. For instance, dispersing animals may quickly settle into an area following a population decline. Because of this removal techniques usually offer only short-term solutions. Modifying the animal's behaviour and devising ecologically sound control measures offer considerable promise for longer-term solutions to pest problems in orchards".

It is my view that these conclusions are general. Each pest species requires a specific analysis of its ecology and behaviour if a deterrent is to be found. An example of this is the work of Knight and Robinson (1978) with silvereyes attacking grapes. These birds appear to need vocal communication when feeding, which was blocked by sound of particular frequencies radiated across the vineyard. It is highly effective in preventing silvereyes from feeding within range of the sound (Figure 4). However, it must be coupled with planting alternative food sources (e.g. eucalypts that flower when grapes are ripening) since birds must eat and if no alternative food source is available, the sound will not deter them.

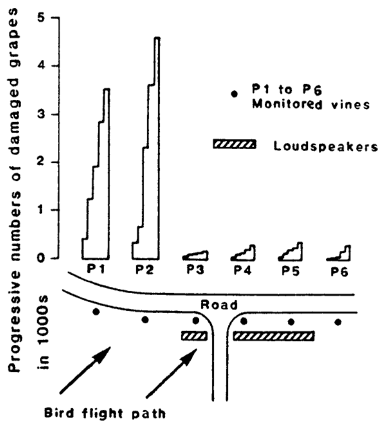

Figure 4. Diagram showing layout of sound apparatus at Mateljan Vineyard and bar graphs of cumulative counts of damage to individual vines. Source: Knight and Robinson (1978).

In the area of chemical repellants, much basic research needs to be done. The literature abounds with reports on the effectiveness or otherwise of repellants. However, there has been virtually no research on the sensory physiology of pest species, and little controlled experimental work on repellants. Birds and mammals have totally different olfactory, gustatory and digestive systems. It is unlikely that a chemical that deters deer through an adverse olfactory response will deter blackbirds in the same way because birds exhibit very little olfactory discrimination. However, it is more likely that a chemical that causes sickness in monogastric mammals will also do so in birds. Thus broad spectrum aversive conditioners might be found. The use of pheromones as deterrents to mammalian pests are being investigated, but undoubtedly these will have to be species specific. Ethologists need to be involved in such work alongside chemical ecologists and physiologists.

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Animal Welfare

Assessment of pain in animals

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Although there is no general agreement as to what is meant by animal pain I will assume that animals can have an experience which has the same rôle, if not the same level of complexity, as human pain. I will also assume that it can be studied by testing the hypothesis that animal pain occurs in intact, conscious, aware animals; that it is an aversive sensory experience and that it can be caused by actual or potential injury, by intrinsic neural activity triggered by pathological changes, or possibly as a result of mental activity triggered by memory of prior painful experiences. Animals avoid this experience, given the opportunity, and their physiology and behaviour are modified in ways which are similar, in some respects, for animals of all species including humans but which may differ in other respects for different species and even for individuals of the same species when subjected to the same type, intensity and duration of painful stimulation.

In order to test the main aspects of this hypothesis we have been investigating the use of behavioural and physiological changes to assess the pain which results from the routine husbandry practices of castration and tail docking of lambs by application of rubber rings. The main aim of the studies is to improve the scientific basis of legislation to regulate these practices and thus improve the welfare of lambs.

In order to develop and assess the validity of behavioural and physiological indices we have related quantitative changes of the measured parameters to alternative estimates of the pain experienced. Several approaches are available to obtain such independent estimates, but none provide a secure quantitative measure and some used in humans cannot be applied to animals. For example, it is not possible to obtain a direct subjective estimate of the pain experienced by asking the animal to complete a McGill Pain Questionnaire or to choose points on a Visual Analogue Scale. Experimental procedures such as self administration of analgesics or procedures which rely on teaching the animal to indicate the intensity of the pain in other ways have, however, been developed e.g. Vierck et al. (1989).

In our first approach we have related the rank order of behavioural and physiological changes to the rank order of the severity of the various procedures which provoke them, as estimated from knowledge of the anatomy and physiology of the nociceptive mechanisms involved and the effects of local anaesthetics. This is an extension of the work of Mellor and Murray (1989). Our second approach has been to attempt to use analgesic treatments to show a dose dependent effect on the behavioural and physiological changes produced by castration and tail docking. This has been unsuccessful, so far, due to our inability to obtain evidence of hypalgesia with morphine, etorphine or xylazine in young lambs subjected to castration.

To illustrate the first approach I will briefly describe one experiment. Six procedures were ranked as follows:

(1) Castration with rubber rings (CN).

(2) Castration with rubber rings but with 0.3 ml of lignocaine injected into each testis immediately after application of the rubber rings (CNLAT).

(3) Short scrotum castration for which the testes were pushed up into the inguinal canals and the rubber ring was applied around the neck of the empty scrotum (SCN).

(4) Castration with rubber rings but with 2.0 ml of lignocaine infiltrated just distal to and after application of the rubber ring (CNLADR).

(5) Short scrotum castration as in (3) but with 2.0 ml lignocaine infiltrated as in (4) (SCNLADR).

(6) Control handling for which animals were handled as if to be castrated with manipulation of the testes and scrotum for a similar time (CH).

Each procedure was carried out on six lambs 4-6 days of age housed inside in 2 m x 2 m pens with their dams and siblings. After treatment behaviour was recorded at intervals over a period of three hours and blood samples were taken for later R.I.A. of plasma cortisol levels.

Results of ranking the procedures according to the incidence of behaviours not seen in the control animals (referred to as abnormal behaviours) and according to the magnitude of the increase in plasma cortisol are shown in Table 1.

TABLE 1
Rank orders of severity of procedures obtained by three different methods (see text for abbreviations)

Predicted from tissue involved and effects of local anaesthetic	Changes in behaviour	Changes in plasma Cortisol
CN	CN	
CNLAT	CNLAT	CN/CNLAT/CNLADR
SCN	CNLADR	
CNLADR	SCN	SCN
SCNLADR	SCNLADR	
		SCNLADR/CH
CH	CH	

The rank order according to the increases in plasma cortisol was less clear than that obtained by reference to changes in behaviour. The plasma cortisol permitted separation into three levels of response: CN, CNLAT and CNLADR could not be separated statistically ($P > 0.05$); SCN showed a significantly greater response than CH but the increase in plasma cortisol of SCNLADR was not significantly greater than that of CH nor significantly less than that of SCN.

There was a discrepancy between the predicted ranking and the experimental ranking when both behaviour and plasma cortisol changes were considered. In the predicted ranking CNLADR was placed after SCN because it was expected that the local anaesthetic would block all neural activity from distal to the ring. If, however, the local anaesthetic did not block all afferent activity from the testes, epididymis, spermatic cord etc then it would be reasonable to place CNLADR above SCN in the predicted rank order. The differences, in incidence of abnormal behaviours, between these two procedures were small.

From these results it appears that behavioural changes may be able to provide a sensitive measure of differences in the pain produced by such procedures. Plasma cortisol changes generally support the rankings obtained by using behavioural measurements, but it appears that significant increases in plasma cortisol are only obtained with relatively severe procedures and that when the severity exceeds a moderately high level, changes in plasma cortisol could not be used to discriminate between the severity of the procedures.

Since the behavioural measurements used here appear to provide a sensitive basis for ranking pain intensities we feel justified in using such measurements as an initial standard against which to check new methods of assessment, including more sensitive measures of behaviour. Further quantitative analysis will be necessary before appropriate weighting can be attributed to different kinds of abnormal behaviour and we are aware that any pain rating scale derived from such an analysis may only apply when the same stimulus, age and species of animal is involved. There appears, however, to be no reason why such studies should not be extended to other types of pain and to other species.

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Development of the concept of stress and its application to farm animal behaviour research

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Exposure of an organism to aversive stimuli is an integral and unavoidable part of life. The reactions that result from this exposure help the organism avoid or adapt to the aversive stimuli and are absolutely essential to its survival. However, since the activation of these stress reactions interferes with other body functions (e.g. metabolism, reproduction, and resistance to disease), a negative 'side effect' may occur when certain (imaginary) boundaries of the exposure are exceeded, possibly resulting in increased weight loss, infertility, or disease rate.

Particularly because of the stress-disease connection, stress has been the subject of intensive investigation throughout this century. Beginning with Cannon's (1970) 'Fight and Flight' reaction emphasizing the rôle of adrenalin from the adrenal medulla, and Selye's (1973) 'General Adaptation Syndrome', emphasizing the rôle of the glucocorticosteroids from the adrenal cortex, attention has gradually changed towards psychological involvement in stress reactions. This is particularly due to Mason's (1974) 'Cognitive Mediator Concept' and, most recently, Henry and Stephens (1977) 'Coping-Predictability Concept'. Furthermore, as most clearly demonstrated by Mason's work, stress reactions involve not only activation of the sympathoadrenomedullary and the hypothalamo-pituitary adrenocortical systems but also numerous other neuroendocrine systems that react in an organized and integrated fashion. The involvement of endogenous opioid peptides in stress represents the most recent example of the complexity and diversity of the body's reactions to aversive stimuli. This is, perhaps, best described by the so-called hourglass model of Veith-Flanigan and Sandman (1985): stress has evolved to encompass all possible extra-individual events capable of evoking a broad spectrum of intra-individual responses mediated by a complex filter labeled 'individual differences'.

In farm animal behaviour research, the inclusion of physiological investigations has often been emphasized (e.g. Dantzer and Mormède, 1983; Smidt, 1983) with the argument that behaviour observations alone are insufficient to diagnose pain, suffering, or other kinds of reduced well-being in farm animals. Consequently, over the past two decades analysis of hormone secretion has increasingly been used to support interpretation of behavioural results. As most clearly pointed out by Rushen (1991), however, the results of such studies are often contradictory, without any consensus between different studies. In fact, rather than aiding interpretation, physiological data often do little more than add to the general confusion. The main reasons for these difficulties are due to the complexity of the operating mechanisms and to their sensitivity to various intervening factors. As in other 'real life' situations, many of these intervening factors cannot be controlled, causing a considerable amount of variation in the results and making comparison between different studies (or even between replicates of studies) difficult.

Using the hourglass model as a starting point, some of the major sources of variation are as follows.

Stressors: In many studies too little attention is paid to the 'extra-individual events' supposed to act as stressors and, particularly, to the context in which these stimuli are applied. Although some stressors can be measured quantitatively (e.g. electric shock, heat), most stressors in farm animal husbandry are a conglomerate of different factors (e.g. transport stress consisting of social disruption or isolation, novel environment, noise, darkness etc.; tethering consisting of lack of locomotion and straw bedding, reduced social contact, boredom, etc.) making an exact definition of the stressor impossible. Moreover, a slight variation in the context of a stressor (e.g. whether an animal is kept in its usual surroundings or moved to a novel area) may exert a major effect on the reaction to the stressors. Therefore, a better understanding of how these intervening variables affect the animals, e.g. in the form of systematic investigations of a range of different stressors, would greatly help interpretation of physiological results.

Individual Differences: Large variation between individuals is a well-known problem in behavioural research, particularly where physiological correlates are concerned. This variation is due partly to genetic predisposition and partly to the earlier experience of the animals. The logical solution to this problem, to increase the number of experimental animals, is not always possible, because of the labour intensive nature of physiological experiments. Instead, other methods must be applied, such as using animals that are related (e.g. siblings or specifically bred lines of animals) and reared under identical conditions, preferably also prenatally. Investigating experimental animals both under control and stress conditions or preselecting animals for an experiment are further means by which the effect of individual variation can be reduced. For instance, increased insight can sometimes be gained when sub-groups of animals with extreme reactions are created prior to the study (Borell and Ladewig, 1989). Although those subjects that react intensely to a stressor are often the most interesting, subjects that do not react can be just as informative.

Stress Reactions: Over the years many physiological reactions to stress have been used as 'stress indicators', primarily hormones (e.g. Glucocorticosteroids, ACTH, Catecholamines, Growth Hormone), and, to some extent, organ specific enzymes (e.g. creatine kinase, alkaline phosphatase), or hematological reactions (e.g. eosinophil leucocytes).

Before the 'stress signal' can be analyzed in a stress reaction, however, it is necessary to keep in mind that most systems are affected not only by stressors but also by stress-independent factors. Most hormones, for instance, are released in an episodic fashion (Ladewig and Smidt, 1989) giving rise to both ultradian and circadian variation. Furthermore, most stress reactions are chains of events originating in the central nervous system and affecting structures that are increasingly peripheral (e.g. the hypothalamo-pituitary adrenocortical system affecting eosinophil leucocytes). Apart from the time factor involved, peripheral reactions are increasingly affected by confounding factors, often making the behaviour-physiology connection unclear.

Finally, most stress situations in farm animal behaviour research (as well as in 'real life') consist of a repetition of acute stressors, a situation referred to as chronic intermittent stress (Burchfield, 1979). Since stress reactions may change after repetition, either due to adaptation (i.e. reduction of the response) (DeBoer et al., 1990) or to sensitization (i.e. enhancement of the response) (Konarska et al., 1990), different number of repetitions (or different durations of chronic intermittent stress) may be another source of variability between studies (Natelson et al., 1988).

In conclusion, although physiological investigations in farm animal studies have often failed to help interpretation of behavioural results, this state of the art is not because physiological stress reactions are too insensitive or too erratic, but rather due to the fact that we know too little about the mechanisms involved. Therefore, the only conclusion from applied studies that all investigators so far agree upon can also be the conclusion of this paper: more research is needed.

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Stress and neuroscience

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Stress is a very popular concept which can explain nearly everything in life, from bad things (dystress) to happy moments (eustress). Hans Selye had the great inspiration to pretend that stress is engraved into life. It starts at birth and ends at death. Dystress is disastrous since it can lead to disease. Therefore, the only way to cope with stress is to transform dystress into eustress, the recipe for which can be found not only in Selye's writings but also in your usual weekly magazines.

Stress theory was one of the few non-specific theories of disease described in pathology textbooks in the fifties and sixties. It is therefore not difficult to understand why it became so popular amongst animal scientists and veterinarians who were confronted with performance or health problems which could not be explained by single factors such as pathogens, nutritional deficiencies or climatic conditions. Simple theories call for simple explanations. Stress was claimed to occur because animals had been made stress-susceptible by genetic selection (predominance of anabolism over catabolism), confinement and nutrition. Such stress-susceptible animals were by definition more sensitive to the range of stressors that occur during the life of a farm animal, from weaning stress to transport stress and slaughter stress. What could stress-susceptible animals do in the face of so many stressors besides developing morbid stress disorders which called for anti-stress medicines?

However, what could have been a nice story quickly became a very deceiving issue when it turned out that the so-called stress-susceptible animals were not as susceptible as the stress theory was predicting. The key factors for stress, in the form of pituitary-adrenal hormones and catecholamines, hardly differed between stress-susceptible and stress-resistant animals. As a result, this field of research should have died in the mid-seventies from lack of evidence if preoccupation for welfare issues had not taken over by that time.

Stress and suffering are the negative counterparts of welfare. Since stress was supposed to be easier to assess than welfare and since biochemical measures that are carried out in test tubes tend to appear more objective than behavioural measures, it was tempting to equate lack of stress with welfare. Based on this reasoning, naïve stress physiologists believed at the beginning that it was sufficient to measure plasma levels of stress hormones to assess the welfare of farm animals. However, they found higher levels of stress hormones in animals which were supposedly kept in excellent conditions (e.g. on straw with ample space for usual activities) in comparison to animals which were kept in confinement.

These negative findings should have had detrimental effects on the future of stress in welfare. However, stress came back to life once more, thanks to the concept of coping. Coping refers to the strategies used by an individual to cope with the situation with which (s)he is confronted. Coping started as a psychological concept. It gave rise to lengthy discussions concerning the taxonomy of coping strategies, from emotion-focused coping to problem-focused coping, and the best ways to assess these strategies in clinical psychology. However, this concept rapidly invaded other disciplines related to psychology thanks to the elucidation of the key variables that modulate the effects of stressful experiences on the organism. These key variables are prediction, control and social support. In health psychology, these dimensions have been identified as relevant to subjective experiences and possibly health status of individuals in different settings. In the case of domestic animals, there is enough evidence to support the concept that they are also playing an important rôle in the way animals perceive and respond to their environment.

The nuts and bolts of these phenomena are supposed to be objects of study for neuroscience. However, because of its reductionist tendency, this discipline has a long record of difficult relationships with psychology and behaviour. This situation is partly responsible for the existence in Europe of two separate scientific societies, the European Neuroscience Association and the European Brain and Behaviour Society. At a practical level, the interest of neuroscientists in stress and adaptation has mainly revolved around key-words such as pituitary-adrenal hormones and anti-stress or more exactly "anxiolytic" drugs, with the implicit hope of discovering *the* transmitter or hormone of stress. CRF (corticotrophin releasing factor) is the latest avatar of this quest and it has replaced endogenous opioids. However, in accordance with its apellation, applied ethology is lagging behind by a few years, which explains why it is still holding great faith in the magical power of endogenous opioids (cf. the enthusiasm for the so-called self narcotizing properties of stereotypies).

Neuroscientists are not yet fully ready to join their efforts to those of psychologists for studying complex mental processes, except perhaps in the trendy field of cognitive neuroscience. However, if it is agreed that the future of psychology as a scientific discipline is in biopsychology, behaviourists cannot ignore what is going on in the field of neuroscience. In particular, the irresistible movement coming from neuroscience will have profound implications for our understanding of the minimal structural requirements for consciousness (what are the subjective states open to animals according to their brain development?) and of neural regulation of bodily functions such as the immune system (how does stress affect the immune system?).

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Animal boredom: do animals miss being alert and active?

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The question of whether animals are capable of experiencing boredom in impoverished environments is related to the question of long-term suffering. Current models for the explanation of so-called abnormal behaviours such as stereotyped behaviour often hypothesize that animals may be capable of temporary suffering, but not of permanent suffering (e.g. Dantzer, 1986; Wiepkema, 1987). It is assumed that, providing that the animal survives physically, its adaptive mechanisms prohibit the occurrence of long-term suffering.

I will argue that although an animal may succeed in adjusting to one particular environment (passive adaptation), it may not succeed in maintaining its capacity for behavioural flexibility, i.e. its capacity to fulfil its own goals in a variety of different environments (active adaptation, or adaptability). Abnormal behaviours may be adaptive in a passive sense, but not in the active sense. They might be indicative of the impairment of an animal's adaptability; such impairment may give rise to permanent suffering in the captive animal.

The flexibility of goal-directed behaviour is dependent upon the normal functioning of attentional processes. Animals must be able to "switch on" their attention either in order to concentrate upon a goal generated by motivational systems, or to deal with novel or unexpected events in their environment. Alertness may be regarded as a central attentional state representing the capacity to integrate perceptive and motor processes into adaptive, goal-directed behaviour (Kahneman, 1973; Pribram and McGuinness, 1975). Orientation behaviour may be regarded as a major behavioural correlate of alertness. Such behaviour can be said to represent the process of decision-making (Kimble, 1975) or "hypothesis-formation" (Krechevsky, 1937; Tolman, 1948).

Research has indicated that animals need to be able to engage in spontaneous, so-called voluntary interaction with the environment in order to enhance behavioural flexibility and alertness (Ferchmin et al., 1975; Ferchmin and Eterovic, 1977; Ferchmin et al., 1980). In voluntary interaction, an animal experiences, and consequently gathers information about, the contingency between its own behaviour and sensory change. Such experience allows it to improve the integration between its own behaviour and perceived sensory change, resulting in an increased capacity to show behavioural flexibility (Fagen, 1982).

The hypothesis that the maintenance of alertness through voluntary interaction is valued by animals as an end in itself may be supported by observations on play and exploration. Animals continue to pay attention to environmental change produced by their own play and/or exploration much longer than they do to externally induced environmental change (e.g. Harlow et al., 1950; Butler and Alexander, 1955). Furthermore, animals appear to prefer to work for their food above receiving it for free; the contingency of perceived sensory change with own behaviour seems to be an important factor in determining the animals' preference for "earned" food (Singh, 1970; Osborne, 1977; Overmier et al., 1980).

The concept of competence seems to encompass the notion that alertness is important for well-being. Originally conceived by White (1959), the concept of competence implies that it is not only the homeostatic end-product of a certain behavioural sequence, but also the active interaction with the environment through which the end-product is achieved, which induces a sense of well-being in the animal during its performance of goal-directed behaviour.

In intensive housing systems, animals are generally deprived of stimulation which is meaningful and/or complex enough to elicit full-fledged species-specific behaviour. Restriction of movement may further prevent the development of a variable, versatile behavioural repertoire. Interaction between animal and environment as defined above will be gradually replaced by the execution of behavioural routines that may develop into stereotyped motor patterns (Stolba et al., 1983; Cronin and Wiepkema, 1984).

Several studies concerning the responsiveness of captive animals to novel stimulation suggest that the general decrease in the variability of behaviour shown by these animals (including the development of stereotyped behaviours) implies an increasing incapacity to respond appropriately to novel or unexpected stimulation (e.g. Berkson et al., 1963; Kiley-Worthington, 1977; Wood-Gush et al., 1983). Such data suggest that the attentional processes of animals housed in impoverished environments may not just be temporarily switched off, as is the case in normal habit-formation, but may come to be seriously, if not permanently, impaired. The performance of redirected and stereotyped behaviour patterns may be adaptive in a passive sense in that they prevent the development of abdominal ulcers (Wiepkema, 1987), yet such behaviours are at the same time, I suggest, indicative of the deterioration of an animal's capacity for active adaptation (Wemelsfelder, 1989).

An explanation of stereotyped behaviour which refers to impairment of attentional processes need not contradict other explanations of such behaviour. It has been shown, for example, that an environmental stressor such as food restriction induces stereotyped behaviour in tethered sows (Appleby and Lawrence, 1987); furthermore, individual animals may differ in the way they react to environmental stressors, for example in the kind and degree of stereotyped behaviour which they develop (cf. Benus, 1988). In a normally enriched environment which leaves alertness intact, however, animals might not develop any abnormal reaction to environmental stressors to begin with. The deterioration of behavioural flexibility in impoverished environments may be a major factor determining how vulnerable an animal will be to other stressors such as food restriction, excessive noise, careless handling, etc. An explanation referring to attentional impairment therefore encompasses, not contradicts, explanations referring to specific environmental stressors.

Animals may suffer seriously as a consequence of the gradual break-down of their normal state of alertness. The earlier stages of a process of break-down may be experienced as a feeling of boredom, representing a need for "something to do" in general and a growing incapacity to attend selectively to adequate stimuli. Redirected behaviour, such as shown by piglets housed in an environment without straw (McKinnon et al., 1989), for example, may be regarded as evidence of boredom. Furthermore, animals might at this stage cease to interact actively with a novel stimulus, but instead explore it hesitantly (cf. Renner and Rosenzweig, 1986), or react fearfully (Wood-Gush et al., 1983). Increasingly, the animal will respond to new events in an inadequate manner. The later stages of this process may be experienced as apathy or anxiety, or a combination of both (cf. Rowan, 1988; van Putten, 1989). It would be conceptually meaningless to assume that such states could in any way come to be experienced by an animal as "normal" or "adapted". Behavioural flexibility represents the very capacity to achieve well-being or adaptation; impairment of such capacity presumably leaves an animal in a helpless state of continuous suffering.

The occurrence of different stages in the break-down of alertness may be experimentally validated by the introduction of a new object into the cage of an animal at subsequent points of time. A detailed description of the orientation behaviours which the animal performs towards the novel stimulus will be necessary to classify changes in alertness. Closely related concepts for suffering such as frustration, boredom and apathy may be operationally defined in relation to different classes of orientation behaviour (Wemelsfelder, 1990).

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Behavioural deprivation: are there substitutes for the real thing?

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Animal welfare legislation in many countries reflects the presumed value of a varied behavioural repertoire to the physical and psychological health of confined animals. Typically, the range of behaviour shown by animals in captivity is reduced relative to their counterparts in the wild as a result of physical restraint or the absence of suitable environmental stimuli. Hence, the term behavioural deprivation is used (Dawkins, 1988).

A high frequency of anomalous behaviour patterns seen in some confined animals suggests that the inability to perform a wide range of behaviour can lead to poor welfare (Broom, 1988). An improvement in animal well-being is reported when the environment is altered to allow greater behavioural variability (Chamove, 1989). Much current research on the welfare of farm and zoo animals is aimed at identifying those particular behaviour patterns essential for good welfare in captivity (e.g. Bryant et al., 1988).

BEHAVIOURAL DEPRIVATION

The concept of behavioural deprivation has been helpful by implying that we can look to natural settings for behaviours that might be particularly important in captivity. Unfortunately, a number of other implications of the concept may have been less helpful:

1. Behavioural deprivation implies that an animal is adversely affected whenever the full range of behaviour typical of conspecifics in the "wild" is not shown (Dawkins, 1988). Taken to the extreme, behavioural deprivation implies that even the most trivial activities must be permitted to occur in order to ensure high standards of welfare.

There are practical difficulties in specifying all of the essential elements in every activity. In addition, available evidence suggests that good welfare can be maintained in confined animals where a limited number of activities are seen (Stolba and Wood-Gush, 1984; Chamove, 1989). In addition, some behaviour patterns such as anti-predator activities would seem unnecessary in captivity, while others such as aggressive behaviour may be detrimental (Woolverton et al., 1989).

Thus, by implying that all natural behaviour is essential, the concept of behavioural deprivation may have hampered the search for those behaviour patterns that are particularly important.

2. The concept does not take into account the variety of mechanisms that control behaviour, and the fact that the welfare consequences of not performing a particular activity may vary with the type of controlling mechanism. For example, variations in behaviour in different environments occur as a result of genetic changes (Beilharz

and Zeeb, 1981) and lifetime experiences (Matthews and Kilgour, 1980). Animals in captivity may not have the same genetic makeup (or requirement to learn) as those in the wild. Therefore, it cannot be assumed that a diminished behavioural repertoire is necessarily indicative of poor welfare.

3. The concept implies that there is no redundancy in the behavioural or other mechanisms available to an animal when environmental conditions change. Research would suggest otherwise. For example, in response to low temperatures, birds alter eating patterns or body posture, increase their metabolic rate or become hypothermic (Rashotte and Henderson, 1988). While one response may be preferred, the other options may be equally effective (or almost so). This means that the absence of any one response does not necessarily lead to poor welfare.

In summary, research to identify behaviour important for good welfare is unlikely to be based on the concept of behavioural deprivation alone.

ASSESSMENT OF ESSENTIAL BEHAVIOURS

A variety of approaches have been used to assess the relative importance of different activities to animals. Techniques based on the concept of behavioural deprivation measure the frequency of occurrence of "vacuum" and other anomalous activities when an animal is kept in relatively barren environments (Broom, 1988). High rates of the occurrence of anomalous behaviour patterns indicate that an animal is unable to perform a valued activity. Alternatively, the tendency to perform a behaviour pattern following a period of deprivation may indicate the importance of that activity (Nicol, 1987).

Preference testing provides a more direct measure of the relative values of particular activities. Preferred environments and associated activities are assumed to be the most important to the animal (Temple and Foster, 1980).

An important limitation of all these techniques is the lack of a logical yardstick for gauging and quantifying "importance" (Dawkins, 1990). A particular disadvantage with preference tests is that choices vary with the amount of effort required to make a choice. Hursh and Natelson (1981) reported that an initial preference for electrical brain stimulation over food was reversed when the amount of work required to obtain the two stimuli was increased.

However, the way preference changes as work load increases provides the basis for a simple and quantitative means for measuring the importance of activities and associated environmental stimuli. The principles of this approach are derived from economic demand theory as described by Lea (1978) and Dawkins (1983). When total income is held constant, consumers usually buy less of a particular item as its price rises. The slope of the function relating changes in consumption to changes in price is called demand elasticity. For some commodities the fall in consumption is slight as price rises (slope close to zero) and demand is said to be inelastic. For other items the fall is great and demand is elastic. Typically, items showing inelastic demand are rather important (necessities such as food) and those showing elastic demand tend to be less important (luxuries) (Winkler, 1971).

In experiments with animals, Lea (1978) has suggested that the analogue for price is the amount of work required to obtain access to an item, and the analogue for consumption is the amount of the item obtained. Logically, the procedure can used to assess the importance of behaviour associated with a commodity as well as the commodity itself.

A number of studies have demonstrated the usefulness of demand function analyses in quantifying the relative importance of various activities to animals. Matthews and Ladewig (1985) showed that the demand elasticity by pigs for eating was zero and that for social interaction was 0.5. This result, together with those from similar studies on other animals (e.g. Hogan et al., 1970), confirm that demand for food or eating (a necessity) is highly inelastic and can serve as a yardstick for rating the importance of other activities.

Ladewig (pers. comm.) has shown that pigs have inelastic demand for rooting in straw and exercise. Dawkins (1990) reported that hens show inelastic demand for eating, contact with other hens and for the opportunity to peck and scratch in litter. The demand function approach suggests that the welfare of captive animals would be improved by allowing animals to perform those behaviour patterns that show inelastic demand. The results of other studies support this interpretation. For example, pigs (Appleby, 1991) and monkeys (Chamove and Anderson, 1988) show a decreased incidence of abnormal behaviour as time spent eating or foraging increases.

BEHAVIOURAL SUBSTITUTION

It may not be necessary to provide opportunities for animals to engage in all behaviour showing inelastic demand. As mentioned earlier, some activities (all of which may show inelastic demand) readily substitute for each other. An example would be eating from either of two highly-valued food sources (Lea and Roper, 1977). Provision of either alternative would probably meet the animal's requirements for that activity. However, there are many activities such as eating and drinking that do not substitute for each other (Hursh, 1978). Captive environments should cater for all non-substitutable activities (with inelastic demand), and for at least one of each family of substitutable activities.

Substitutability can be measured readily using a variant of the demand function approach. Demand functions are determined for a particular activity in the presence and absence of other potentially substitutable responses. Substitutability is revealed by an increase in demand elasticity in the presence of the alternative activities (Lea and Roper, 1977). For example, hens showed relatively inelastic demand for the opportunity to consume wheat (Blackman, 1990). However, the demand for wheat became more elastic (steeper functions) in the presence of other (substitutable) activities such as consumption of maize, pellets and bran.

Collier et al. (1990), using a similar procedure, showed that demand by rats for drinking and eating was quite inelastic and demand for nesting and wheel running was more elastic. Two activities appeared somewhat substitutable: wheel running and bar pressing for food.

The tendency for animals to work for food in the presence of free food (Osborne, 1977) has been quoted as evidence of the strong requirement for confined animals to engage in additional activity (Chamove, 1989) or in foraging activities (Dawkins, 1990). However, a reanalysis of the data from two early studies (Carder and Berkowitz, 1970; Tarte and Vernon, 1974) shows that demand for "work" is relatively elastic and that alternative behaviour patterns substitute readily for the responses involving more effort.

Thus, the demand function approach provides the necessary objectivity in research to identify the essential and non-substitutable behavioural requirements of confined animals.

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Sucking behaviour affects the post-prandial secretion of digestive hormones in the calf

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Cross-sucking is a problem among group-housed calves and is often thought to be non-functional. However, non-nutritive sucking by infants may induce a vagal stimulation that contributes to the post-prandial hormonal response (Marchini et al., 1987; Uvnas-Moberg et al., 1987). We attempted to determine whether sucking a dry teat increased post-prandial secretion of cholecystokinin (CCK), gastrin and insulin in the calf.

Ten calves were fitted with portal and jugular vein catheters and were fed a milk replacer diet by bucket. Following some meals, the calves were allowed to suck on a dry teat. Blood samples were taken 10 min before the meal and then at -2, +1, +5, +10, +30, +60 and +90 min when the calf was not allowed to suck. Plasma concentrations of CCK, gastrin and insulin were determined by radio-immunoassay.

Concentrations of all three hormones in jugular and portal blood increased significantly after feeding ($P<0.05$). The increases in insulin and CCK in portal blood were significantly higher when the calves were sucking on the dry teat (Figures 1 and 2). Sucking did not affect portal gastrin concentrations or hormonal concentrations in jugular blood.

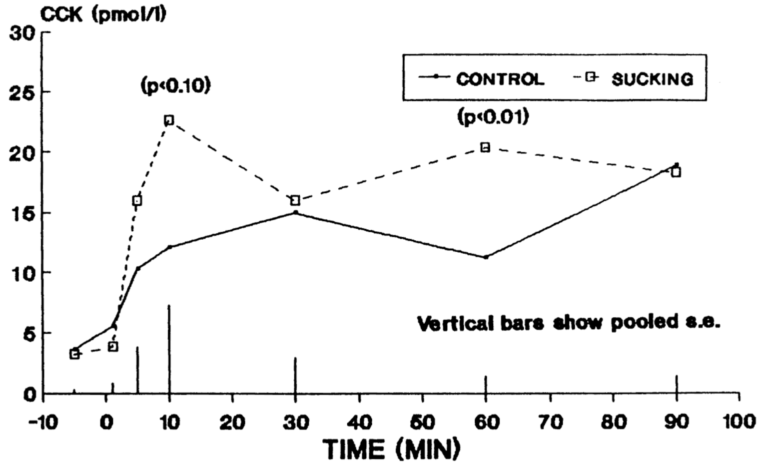

Figure 1. Mean CCK concentration in portal blood after feeding with and without non-nutritive sucking.

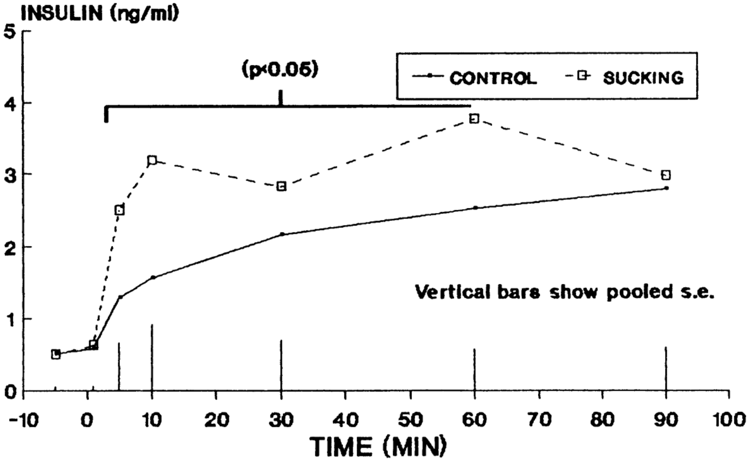

Figure 2. Mean insulin concentration in portal blood after feeding with and without non-nutritive sucking.

Non-nutritive sucking behaviour contributes to post-prandial hormonal changes in calves indicating that non-nutritive sucking may have a function by influencing digestion and satiety.

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Towards an understanding of litter bathing quality in hens

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Hens perform two activities in dustbaths; tossing the litter, with fluffed feathers, facilitates the penetration of particles; rubbing, which is always preceded by tossing, enhances the contact between these particles and feathers. Contact affects the amount of lipids on, and the fluffiness of feathers, which seems to depend on the nature of the litter (van Liere and Bokma, 1987; van Liere et al., 1990). The purpose of the first experiment was to determine the relative effects of the use of wood-shavings, sand or peat over a 5-month period, on lipid content and fluffiness of proximal feather parts, and plumage surface temperature (as an indication of thermo-insulation). Lowest feather lipid content and surface temperature, and the greatest height of the rachis carried by down barbs ('fluffiness') was found in hens on peat. Hens on wood-shavings were at the other extreme in all these measures, with hens on sand at intermediate levels (Figure 1). Moreover, peat and sand baths, on the one hand, and wood-shavings baths on the other hand differed. In the first two, dust accumulated between the feathers and on the skin, while rubbings of at least 1 min in duration were performed. In the second, particles only adhered to the distal feather parts, and rubbings of 0.5 min were repeatedly alternated with reinitiated tossings. If these features imply that wood-shavings are inadequate, then this litter should not reinforce bathing markedly: in particular, hens reared on wood-shavings ought to show an ambiguous preference at first access to unfamiliar sand and peat as well. This was tested with hens given prior experience with wood-shavings, or with sand, or with no prior litter experience (four groups of four hens per treatment). At initial exposure to the choice, those with experience of wood-shavings preferred wood-shavings; in contrast, those with no experience did not prefer the barren floor, although as much time was spent on familiar substrate (Figure 2). This suggests that bathing in wood-shavings does have some reinforcing value. However, (i) over the first 1.5 hr, hens with wood-shavings sampled widely and frequently over the range of substrates, as occurred in the hens with no experience, while (ii) thereafter, hens of both treatments sampled the substrates in a comparable way, shifting their long-term preference towards peat (though some hens developed a stable preference for sand; Figure 2). On the other hand, most sand-experienced hens maintained their preference for sand throughout the 26 days of testing despite comparable presence scores between treatments (Figure 2). These data are consistent with those of the condition of the proximal integument, and of the rubbings during a bath, and confirm that wood-shavings are inadequate.

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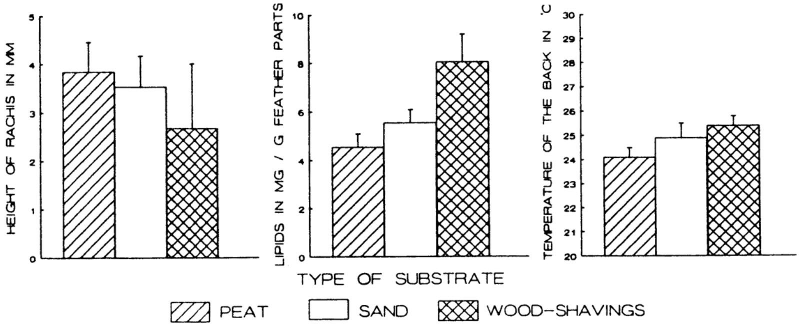

Figure 1. Median height of the rachis carried by down barbs, and amount of lipids on proximal parts (with third quartile deviations) of back feathers, and average temperature (with s.d.) of the surface of the back plumage (at 20°C ambient) in three groups of 16 hens housed on peat, sand, or wood-shavings.

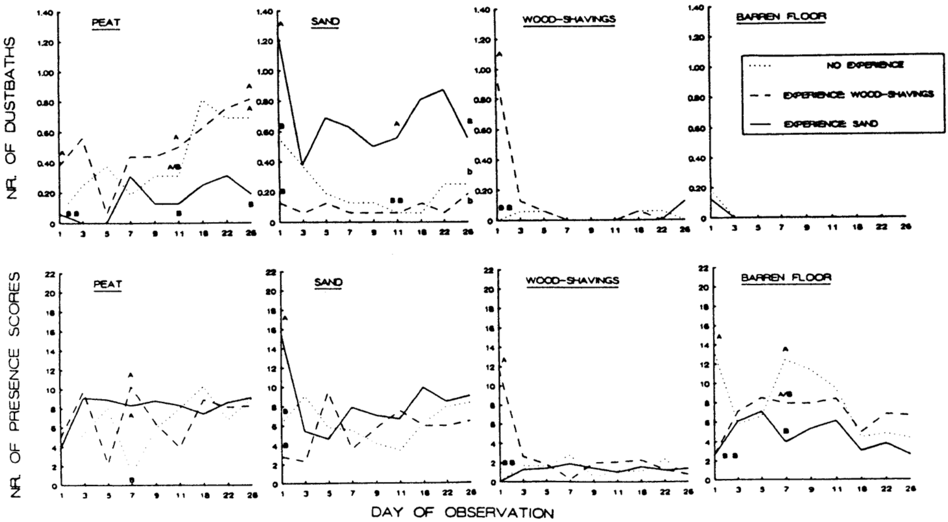

Figure 2. Average number of dustbaths/hen and day in peat, sand, wood-shavings, or on the barren floor (top graphs), and number of presence scores/day over 22 successive 2 min interval observations (bottom graphs) during 26 days following experience of no litter, wood-shavings, or sand respectively. Duncan's multiple range test probabilities: different lower case letters: 0.05<P<0.10; different capitals: P<0.05; per treatment: N=4 (groups of four hens each).

Feed restriction and the welfare of poultry

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Meat-type poultry intended for breeding stock must be severely feed restricted throughout development in order to ensure adequate fertility and hatchability. We have conducted several studies on the effects of such restriction on the welfare of broiler breeder males. In the first studies, males were fed either ad libitum (AD) or placed on a skip-a-day (SK) or limited-every-day (LIM) feed regimen from 3-16 weeks of age. Aggressive behaviors were recorded during three 15 min observation sessions/week. Blood samples were drawn biweekly for the determination of plasma corticosterone. The results are shown in Figure 1. Aggressive pecking occurred more frequently ($P<0.05$) in LIM birds and SK birds on feed-off days than in AD birds or SK birds on feed-on days. Corticosterone levels were higher ($P<0.001$) in SK than in AD or LIM birds. Providing restricted feed on alternate days therefore results in both increased aggression and elevated corticosterone levels, while providing restricted feed daily results only in increased aggression. In other studies, we have found that feeding a diet containing two, three or four times the recommended dietary levels of tryptophan (0.19%) decreases aggression in males placed on a SK feed regimen (Figure 2), an effect that is probably mediated through increased central levels of serotonin. Corticosterone levels of SK birds are not decreased by the administration of tryptophan. These results suggest that the stress associated with feed restriction can be reduced by modifying the feed delivery schedule and the composition of the diet.

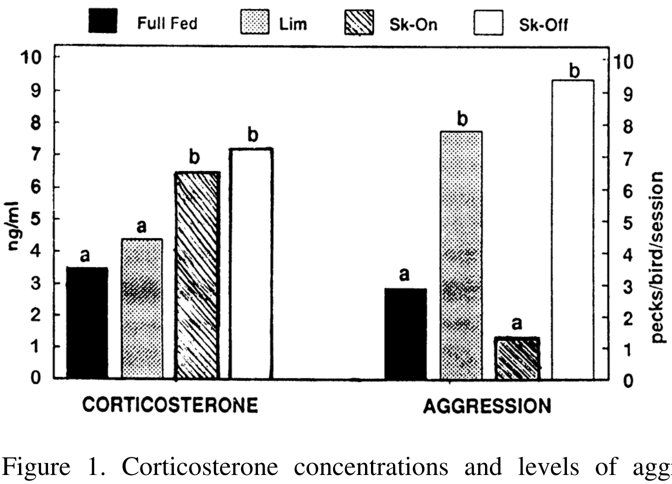

Figure 1. Corticosterone concentrations and levels of aggressive behaviour in broiler breeder males fed restricted feed either daily (LIM) or on alternate days (SK) as compared to fully-fed males.

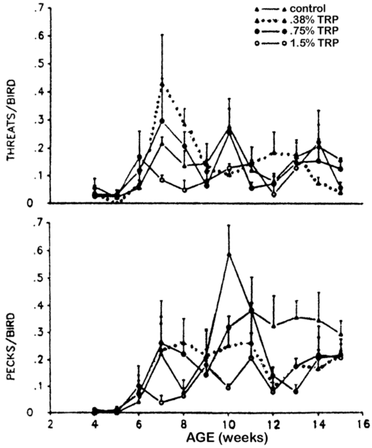

Figure 2. Frequency of threatening and pecking behaviour among skip-a-day fed broiler breeder males fed varying levels of dietary L-tryptophan.

Enhanced stress hormone release in dehydrated sheep: implications for welfare?

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Since water is not normally provided for farm animals in transit, the thirst experienced during long journeys may aggravate the effects of transport stress. The sheep, however, is well-adapted for survival during drought and may not suffer to the same extent as other species. Thus, the question posed by this investigation is whether the endocrine responses of sheep to physical stress are influenced in any way by dehydration.

Eight adult wethers were prepared, under local anaesthesia, with indwelling jugular vein catheters. They were then subjected to mild physical stress (restraint in a canvas sling within sight of other sheep) for 120 min after a 48 hr period in which water was freely available or withheld. Normal or dehydrated sheep were also given intravenous injections of ovine corticotrophin releasing factor (CRF), a peptide known to play an important rôle in the brain, and also at the pituitary, in the co-ordination of the stress response. All treatments were administered using a randomized block design. Blood samples were taken from the animals at frequent intervals throughout the experiment and the plasma analysed to determine concentrations of vasopressin, cortisol and prolactin.

Dehydration produced the large, expected, increase in plasma vasopressin but no rise in cortisol or prolactin. This indicates that 48 hr dehydration is not stressful to sheep. Restraint raised plasma concentrations of cortisol and prolactin but the increase in the latter was not statistically significant. However, when the same procedure was administered to the sheep after dehydration, significantly higher levels of both hormones were observed. The cortisol response to CRF was also enhanced by dehydration whereas prolactin secretion was unaffected (Figure 1).

Although exogenous CRF stimulates cortisol release through a pituitary action, the results show that the pituitary secretion of prolactin is not influenced by CRF. However, the effect of CRF on cortisol secretion and the cortisol and prolactin responses to restraint were significantly greater when the sheep were dehydrated. Therefore, it is probable that the endocrine effects of other physical stressors, e.g. transport, may be exaggerated if water is withheld. Although this phenomenon seems to involve an increased responsiveness of the hypothalamo-pituitary axis, it is not clear whether dehydrated sheep also experience greater distress in response to unpleasant physical stimuli. It will be necessary to determine whether water deprivation also increases the behavioural response to stress before any such conclusions can be drawn.

ACKNOWLEDGEMENT

S.G. Matthews is supported by a scholarship from the Animal Health Trust.

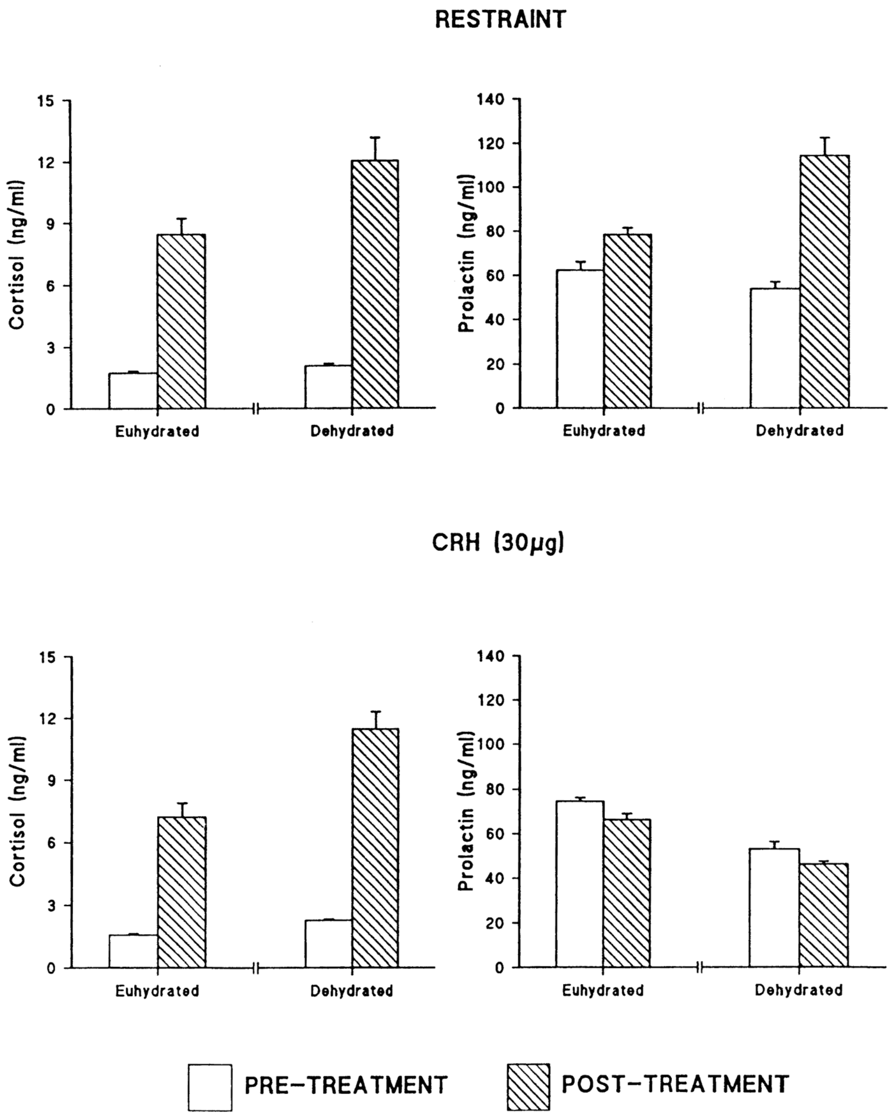

Figure 1. Effect of dehydration on stress hormone release.

Stress-induced analgesia and endogenous opioids help pigs cope with stress

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Stress makes animals less sensitive to pain (Amit and Galina, 1986) and this stress-induced analgesia (SIA) suggests that endogenous opioid peptides (EOP) are involved in the response to stress. However, only a non-opioid SIA has been found for pigs (Dantzer, 1986). EOPs also inhibit pituitary-adrenocortical responses to stress (Estienne et al., 1988). We looked for an opioid SIA in pigs which could inhibit their behavioural and physiological responses to restraint stress.

Sixteen pregnant gilts were restrained with a nose-snare for 15 min following saline and naloxone (i.v. 1.32 mg/kg body weight) treatment. Vocalization was rated (0 - none, 9 - high or prolonged vocalization). Blood samples were taken every 15 min and plasma assayed for cortisol. Pain sensitivity was measured by how long the pigs took to flick their tails in response to a source of thermal energy (Rushen et al., 1990). A high tail-flick latency indicates low sensitivity. Gilts were also injected with naloxone or saline while not restrained.

Tail-flick latencies increased significantly 5 min after the end of restraint (Figure 1: $P<0.01$). This effect was absent after 30 min and was blocked by naloxone. Naloxone increased vocalization scores during restraint (median scores: 5, under naloxone, and 3, after saline; $P<0.01$). The cortisol response to naloxone depended on whether pigs were restrained or not (Figure 2: $P<0.001$). Naloxone elevated cortisol levels in unrestrained gilts for less than 60 min, but elevated cortisol levels in restrained gilts for more than 85 min. Naloxone delayed the return of cortisol levels to baseline levels.

Pigs become transiently less sensitive to pain after restraint stress, and this has an opioid base. EOPs also decrease the pigs' vocalization and pituitary-adrenocortical responses to the stress and so represent one neurochemical mechanism for coping with stress.

ACKNOWLEDGEMENT

J. Rushen thanks Alexander von Humboldt and his foundation.

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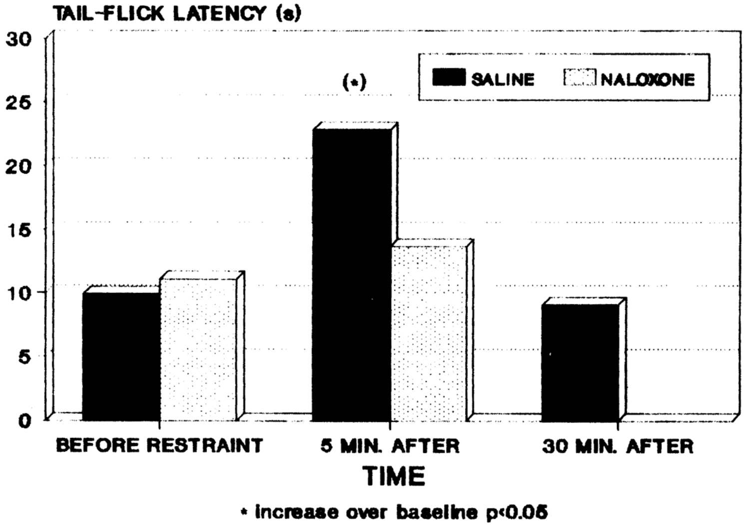

Figure 1. Effect of restraint on sensitivity to pain (tail-flick test)

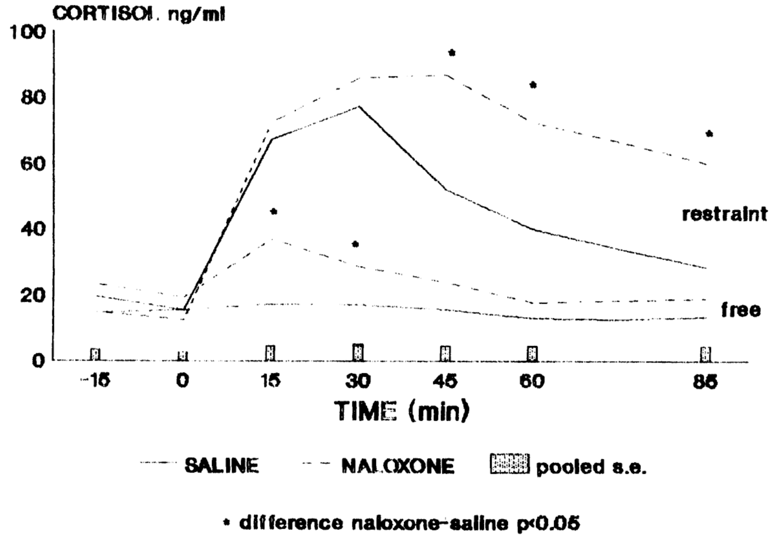

Figure 2. Cortisol response to naloxone and restraint

Changes in opioid receptors of sows in relation to housing, inactivity and stereotypies

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It has been suggested that some animals kept in close confinement try to cope with difficult conditions by using endogenous opioids, perhaps to self-narcotise. Behavioural responses to confinement in pigs include inactivity and unresponsiveness and stereotypies such as bar-biting and sham-chewing. A link between stereotypies and opioids has been established by Cronin et al. (1986) who found that the opioid antagonist naloxone inhibited stereotypies in sows which normally spent long periods showing such behaviour. In this study, opiate receptor densities and affinity in tethered sows on commercial farms were related to their behaviour and compared with those in group-housed sows.

The behaviour of seven tethered sows was directly observed and video-recorded in late pregnancy. Slaughter samples (brain, pituitary and adrenal glands) were collected from these and from four group-housed sows within 30 min of stunning and kept at -70˚C. Frontal cortex and caudatum were used for homogenate binding studies, and sections cut for autoradiography. The binding assay described by Hunter et al. (1989) was employed, using Dagol, DPDPE and CI977 as tritiated ligands for Mu, Delta and Kappa receptors, respectively.

Tethered sows varied considerably in the amount of tongue rolling and sham chewing (Figure 1a) and levels of activity (Figure 1b) they displayed. Tethered sows had a significantly higher density of Mu receptors in the frontal cortex than group-housed sows (Figure 1c). This was the only significant effect of housing on maximum binding capacity. The time that individual tethered sows were inactive was positively correlated with Dagol binding to frontal cortex (Figure 1d), indicating a relationship between activity and Mu receptors. CI 977 binding to frontal cortex was inversely correlated with performance of stereotypies (Figure 1e), suggesting that regulation of Kappa receptors by endogenous mechanisms may be related to the occurrence of stereotypies. Both Dagol and CI 977 binding to frontal cortex correlated negatively with the performance of tongue-rolling ($r_s = -0.78$), while sham-chewing showed a negative relationship with CI 977 binding to frontal cortex (Figure 1f). A variety of speculations are offered concerning the mechanisms underlying these relationships.

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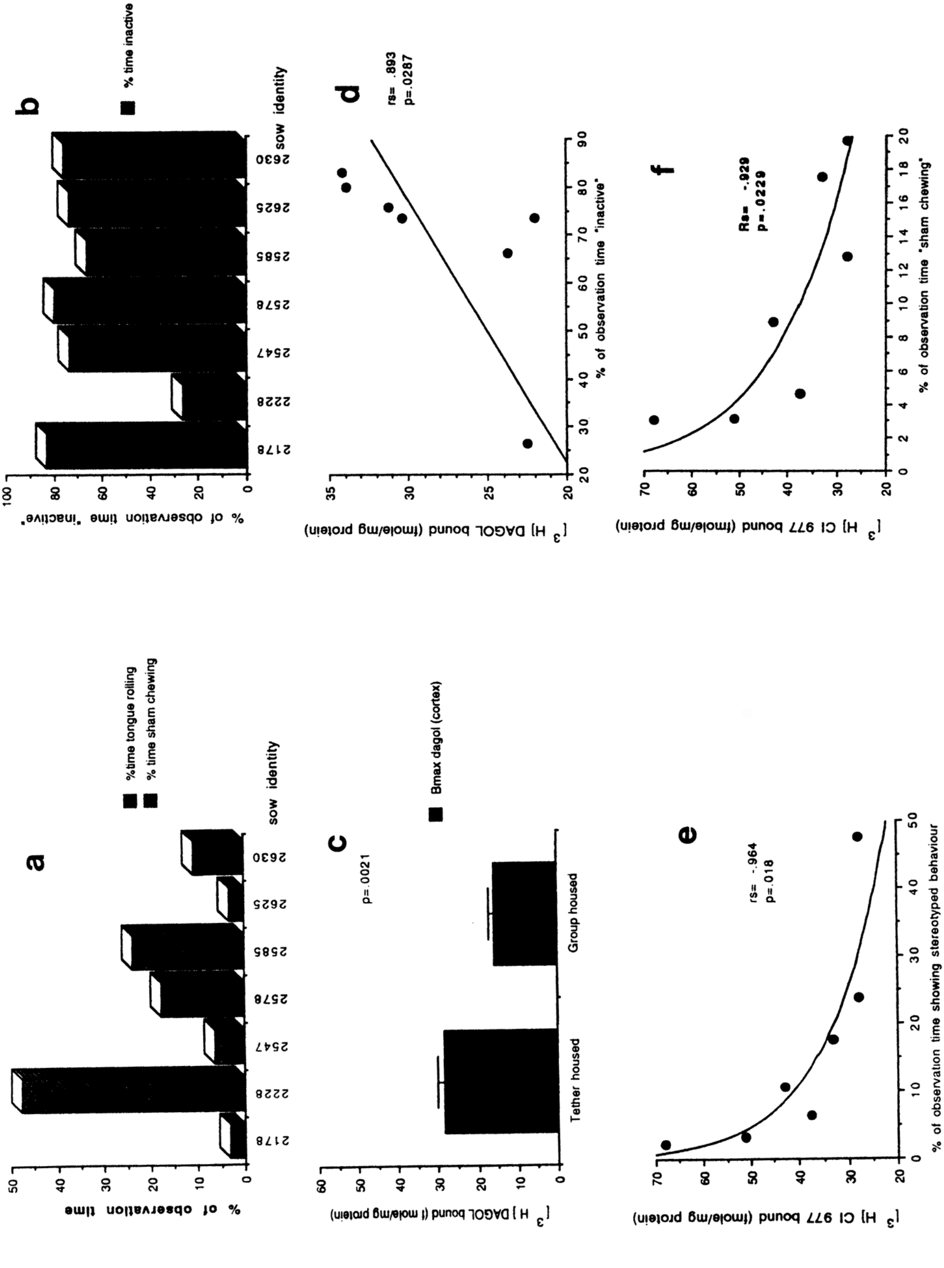
a
% of observation time
% time tongue rolling
% time sham chewing
sow identity
2178
2228
2547
2578
2585
2625
2630
b
% of observation time "inactive"
% time inactive
sow identity
c
p=.0021
Bmax dagol (cortex)
[3 H] DAGOL bound (f mole/mg protein)
Tether housed
Group housed
d
rs= .893
p=.0287
[3 H] DAGOL bound (fmole/mg protein)
% of observation time "inactive"
e
rs= -.964
p=.018
[3 H] CI 977 bound (fmole/mg protein)
% of observation time showing stereotyped behaviour
f
Rs= -.929
p=.0229
[3 H] CI 977 bound (fmole/mg protein)
% of observation time "sham chewing"

Figure 1 a-f.

The emancipation of stereotypies with age

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It appears that older, established stereotypies are harder to disrupt than the developing behaviour (Cronin, 1985). We investigated this phenomenon by transferring bank voles (*Clethrionomys glareolus*) at various ages (2, 4, 6, 8, 14 and 16 months of age) from a small, barren cage, in which they had been reared since weaning, to a larger cage enriched with straw and twigs, where they lived for two months, before return to the original small cage. The voles' behaviour was recorded in two ways; as direct observation following an arousing stimulus (a biro rattling along the cage top), and estimated over 24 hr using a combination of video and automatic counter in a fresh, small barren cage. Transfer to the enriched cage stopped stereotypy in voles up to 8 months of age (Table 1), whereas most older stereotypers continued to stereotype in response to the biro rattle. All stereotypers resumed the activity in the final small, barren cage. In the 24 hr estimate, stereotypic behaviour increased in the youngest (2 and 4 month old) voles (t-test; $n=18$, $t=2.16$, $P<0.05$) during the four months' duration of the experiment, and overall was positively related to age (Regression; $n=96$, $F=6.07$, $P<0.05$). These results show that there is an increased incidence of stereotypic behaviour with age and that in older animals the performance of stereotypic activities may have become independent of some of its original causal factors.

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TABLE 1
The occurrence of stereotypic behaviour in bank voles, following arousal by a rattling biro, in a small, barren cage before transfer to a larger, enriched cage (Start), in the first week of exposure to the enriched environment (First week), in the remainder of their two month stay (Later), and following their return to the original small, barren cage (End).

		Number of Stereotypers			
Age on Transfer to Enriched Cage	Number of Voles	Barren Start	Enriched First week	Enriched Later	Barren End
2 months	9	5	0	0	5
4 months	9	4	0	0	4
6 months	7	2	2	0	2
8 months	7	2	2	1	2
14 months	8	4	3	2	4
16 months	8	6	5	6	6

Stereotyped pecking in individually housed laying hens

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Although the causes of abnormal stereotyped behaviour are still not properly understood, it is generally accepted that stereotypies indicate a suboptimal or undesirable environment. Consequently, concern for animal welfare has lead to renewed interest in stereotypies. Several types of stereotypies are found in poultry e.g. pacing, spot pecking, stereotyped feather pecking etc. These can be produced by restricted feeding and a barren environment. In this study litter-reared hens were housed in individual cages on a restricted feeding regime and this reliably induced the performance of stereotypies. Observations took place between 17:00 hr and 18:00 hr in the 20th week after caging. Individual birds spent as much as 70% of the observed time (60 min) performing stereotyped pecking, although there were large individual differences which were consistent over days. It is, therefore, suggested that there are "high peckers" and "low peckers".

Effects of diet and feeding regime on behaviour of group housed pregnant gilts

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Feeding sows higher levels of fibrous diets might reduce the level of activity and abnormal behaviour patterns often seen in dry sows on conventional restricted feeding systems. In this experiment the effects of a high fibre diet (containing 50% unmolassed sugarbeet pulp) fed at a restricted level (R) (2.0 kg/day) or ad libitum (A) and of a standard diet (C) restricted fed (2.0 kg/day) on the behaviour of pregnant gilts were studied. For each treatment three groups of six gilts, housed in deep straw pens with feeding stalls, were observed. Every group was observed during three sessions of 2.5 hr, starting at feeding time (07:30 hr) . The data are described for two subsessions: the first 1.5 hr and the last hour. In the first 1.5 hr gilts on the high fibre diet spent more time feeding (R 62 min, A 21 min and C 14 min) and more of the non-feeding time lying (19 min, 44 min and 40 min (69%, 64%, 52%) for R, A and C respectively). C gilts spent more time in oral behaviours; 13 min licking the trough, 9 min licking the floor, 7 min bar-biting, 9 min sham-chewing or sham-drinking, compared with 3 min and 1 min (R and A respectively) both licking the trough and floor (no barbiting, sham-chewing or sham-drinking was observed) for the fibre fed gilts. During the last hour the C gilts remained more active; for C, R and A respectively standing times were 49 min, 28 min, and 7 min and lying times were 3 min, 17 min and 39 min. C gilts again engaged in more oral behaviours: 7 min and 4 min licking trough, 6 min and 2 min licking floor for C and R respectively, 2 min bar-biting and 3 min sham-chewing or sham-drinking (C) and spent more time rooting straw 22 min, 12 min and 4 min (C, R and A respectively). Fibre fed gilts still spent some time feeding; R 5 min and A 13 min. Information on the daily activity pattern will be obtained from 24 hr video recordings, the analysis of which is still in progress. In conclusion, fibre fed gilts spent more time feeding and after feeding were less active and engaged in less oral behaviours. R and A gilts showed similar behaviour, but A gilts spent more time lying in the last hour of observation. C gilts were more active and performed more oral and abnormal behaviours. Each C gilt could be recognised by her own oral behaviour, which was consistently shown in all observations for a considerable amount of time.

Pre-slaughter welfare of farm animals

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A review of recent work undertaken at a commercial slaughterhouse is presented. Behavioural observations of cattle and sheep have been used to identify possible welfare problems and to determine the optimal procedures for the pre-slaughter handling of animals. The main results of the following studies are presented:

1. The resting behaviour of cattle in a slaughterhouse lairage.
2. The pre-slaughter handling and behaviour of cattle.
3. The pre-slaughter factors affecting the occurence of bruising in sheep.

Cattle that arrived at the lairage direct from farms took longer to lie down than those from markets. Cattle direct from farms lay down less than those from markets. Most groups of cattle kept overnight in the lairage did not spend the majority of their time resting. The main problems identified with the movement of cattle from the lairage to the stunning pen were the routine use of driving instruments, contact with structures and delays caused by stoppages in the slaughterline. A study of the relationship between handling and behavioural problems of sheep at the slaughterhouse and the occurrence of recent bruising indicated that at least three-quarters of the bruising occurred before the sheep arrived at the slaughterhouse. The greater proportion of severely bruised carcases in lambs from markets compared with those direct from farms suggested that handling procedures in markets should be studied.

The handling and behaviour of sheep at a slaughterhouse and the occurrence of bruising

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The pre-slaughter handling, behaviour, and subsequent bruising were observed in groups of sheep in a commercial slaughterhouse. A greater percentage of severely bruised carcasses was found in lambs from markets than in those from farms. Significant correlations were found between the occurence of recent bruising and wool-pulls during unloading, riding by another sheep, and hits and squashes against structures at the slaughterhouse. However, only about one quarter of the bruising was attributed to handling problems at the slaughterhouse. Eighty-eight percent of all bruises were estimated to have been caused by handling problems during loading on the farm, during transit and particularly at markets.

Effect of pre-slaughter handling on the behaviour and blood composition of cattle

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The pre-slaughter handling, behaviour and blood composition of cattle at the time of slaughter were studied in a commercial slaughterhouse. The main problems identified were the routine use of driving instruments and delays caused by stoppages in the slaughter line. The plasma concentration of cortisol at the time of slaughter was positively correlated with the time spent in the pre-stun pen. The proportions of cattle observed struggling, vocalizing and defaecating were greatest when they were confined in the race and pre-stun pen.

A behavioural study and welfare assessment of loose-housed horses

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Six horses (three geldings and three mares) were studied in a group of 58 (33 geldings and 25 mares) in a covered straw bedded yard at a stocking density of 1 horse/14 m^2. The horses were given ad libitum big bale wheat straw and on a daily basis three big bales of silage and one big bale of hay. Their behaviour was observed and recorded using a scan sampling technique in six, 24 hr periods during the months of December and January; observations were at 30 sec intervals for 15 min every two hours. Time budgets were constructed and compared with those obtained with six horses kept in a 1.5 hectare paddock during a six week period in July and August. The differences measured in behaviour (%) between the loose-housed and grazing animals were ingestive (-8.9), standing (+13.5), lying (-5), social (+4.1), locomotion (-2.7) and investigative (-1). Loose-housed horses showed a 3.7% overall increase in agonistic behaviour of which 34% of the interactions involved bites or kicks as compared to 3% in horses at grass. An association was observed, in individual horses, between time spent standing or lying and aggressive behaviour; the more aggressive horses spent more time lying and less time standing, whereas the less aggressive individuals spent more time standing and less time lying at rest.

The behaviour of cattle in a head-restraint stunning pen

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In UK slaughterhouses cattle are usually stunned by captive bolt pistol as they stand free in a solid-sided pen. The new legislation will make it compulsory, after July 1992, for cattle to be stunned only when their heads are restrained in some way. The behaviour of some 250 cattle have been observed in a head-restraint stunning pen. When used with the restrainer fully open, only some 25% of the animals voluntarily put their heads into the device and 75% of these pulled their heads back out when the device was activated to try and hold them. The cattle putting their heads into the restrainer did so, for the first time, an average of 11.1 sec from entry into the pen. The average time from entry to stun in the non-head restrained animals was 25.6 sec. Effort, sometimes considerable, had to be used to persuade non-volunteering cattle to use the head restrainer. It is suggested that the total sum of

distress may be greater when the legislation is implemented in July 1992 than in the present 'stun-free-in-the-pen' situation.

The laying hen's requirements for space

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Operant conditioning techniques were used to investigate the extent to which domestic hens were prepared to work in order to change the size of the cages in which they are housed. The results of these experiments showed the following points:
1) The amount of work done to increase cage size from 1600 cm^2 was small.
2) Decreasing the size of the reward (the increment in cage size per operant task performed) did not lead to an increase in the amount of work done.
3) The amount of work done to increase cage size from 2500 cm^2 was the same as that done to increase cage size from 1600 cm^2.
4) The amount of work done to increase cage size from 4500 cm^2 was much less than that done to increase cage size from 1600 cm^2 or 2500 cm^2.
5) Hens did not work to decrease the size of their cages.
6) Hens reared on the floor in large pens worked more to increase cage size than hens reared in battery cages.
7) After six weeks in battery cages, hens reared on the floor in large pens appeared to have habituated and did not work more to increase cage size than hens reared in battery cages.
8) Groups of hens appeared to vary in their cage size preferences.

In a study in which each of eight groups of 4 hens was able to determine the size of its cage; 2 groups consistently used small cages, 4 groups appeared to be indifferent to the size of their cage and 2 groups consistently used large cages. Points 4, 5 and 6 above indicate that hens are able to relate the operant conditioning task (key pecking) to the reward (a change in cage size). These results are interpreted as indicating that laying hens do not have a particularly high requirement for space.

Aggressiveness in pigs: implications for welfare

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Aggressiveness can be regarded as a method of coping. An investigation is being carried out to test whether intraspecific aggressivity in pigs can be related to the individuals' way of coping within a given group, or whether it changes with the circumstances eg. group composition. The type and frequency of aggressive interactions, in which the individual pig is involved, are recorded through several re-groupings. The behavioural data are compared with the pigs' adrenocorticoid response to repeated restraint and blood sampling.

Requirement for resting platforms and their use by farmbred foxes

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According to recommendations drafted by animal welfare organisations, a resting platform with a solid surface should be provided for farmbred foxes kept in wire mesh cages. We have evaluated the extent to which platforms offer protection against cold and the animals are willing to use them. The platform provided more thermal protection than the wire mesh only when dry. However, the platforms are not generally dry under farm conditions. Even if the animals do not urinate on the platform, it absorbs moisture from the air. Wet, and especially frozen platforms, possess considerable thermal capacity. Each time the animal settles down on the platform it has to heat it to about 20˚C and, if frozen, to melt the ice. In addition the fur coat of the animal is compressed more on the platform than on the wire mesh, and this compression reduces the thermal insulation of fur. Blue foxes used the platforms 6.8 ± 1 % of their daily time. The platforms were used more during the working day, (when short visits were also most common) than during evening/night hours. The animals slept only occasionally on the platform. Open platforms were used more than platforms with walls (150 min/day versus 15 min/day). The platforms were used more at or above freezing temperatures than when the temperature was below freezing (120 min/day versus 67 min/day). Wind did not increase the use. The results for silver foxes are similar to those observed for blue foxes. For comparison, raccoon dogs used the platforms a lot, especially for sleeping. For all species studies, inter-individual differences contributed most of the variance of use (59% for blue foxes), followed by the type of platform (walls versus no walls) and temperature. The results do not support the hypothesis that the platform functions as shelter. Rather, the present results support the conclusion that the platform serves as an extra material which reduces bareness of the environment and in this way would decrease frustration.

Increased plasma cortisol response to ACTH in tethered gilts

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The influence of tethering on the reactivity of the adrenal cortex to ACTH was investigated in the pig. Six cycling gilts (mean body weight 119 kg) were fitted with a jugular vein catheter in order to collect blood without disturbing the animals, and housed individually in pens (1.4 m x 3.5 m) on straw. After five weeks the animals were tethered by a neck-chain and kept tethered for a period of 20 weeks in the same pens, but without straw and with an extra partition placed to reduce floor space to 0.62 m x 2 m and further restrict the animals' movement. In order to investigate possible changes in the reactivity of the adrenal cortex, the plasma cortisol response to synthetic ACTH(1-24) (10 g/kg body weight; I.V. bolus) was determined one week prior to and after six and 20 weeks of tethered housing. During the challenge, 13 blood samples were collected in cooled EDTA-tubes, between -45 min and 285 min, and centrifuged. Plasma was stored at -20°C until determination of cortisol by radioimmunoassay. ACTH treatment induced a time-dependent increase in plasma cortisol. A considerable variation in the response was found between individual animals. All animals showed a significant increase in cortisol response (area under the curve, magnitude) after six weeks and after 20 weeks of tethering as compared to pre-tethering ($P<0.05$; Wilcoxon). No significant difference was found between responses at six and 20 weeks. These results indicate that the steroidogenic capacity of the adrenal cortex had increased during tethered housing, probably due to prolonged activation of the pituitary adrenal axis, and suggests, in line with other data on behavioural and cardiovascular parameters, that tethered housing represents a chronic stressor for the animals. In a previous experiment in which gilts were tethered in the same pens, but without reduction of floor space, an increased steroidogenic response to ACTH(1-24) was found after 20 weeks, but not after six weeks of tethering. The earlier onset of the effect in the present experiment suggests that housing variables, other than tethering, (e.g. floor space) may contribute to the development of adrenocortical hyper-responsiveness and, therefore, to the stressful nature of the animals' environment.

Physiological and behavioural effects of long-term intermittent stress in the pig

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The physiological and behavioural effects of intermittent stress are being investigated in growing pigs and in prepubertal gilts. The experiment includes measurement of diurnal variation in cortisol and ACTH by continuous blood sampling, in undisturbed behaviour, in adrenocortical response pattern, and in the response to acute stress measured by plasma ACTH, plasma cortisol, activity, exploration, and aggression after three to six days of stress and after four to five weeks of stress. The response to boar introduction is measured by plasma ACTH and plasma cortisol at the age of puberty (160 days) and oestrous behaviour and physiology are followed at the first pubertal oestrus. Some of the preliminary results will be presented.

Behaviour of lambs post castration and tail docking: effect of age and method

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Lambs at 5, 21 or 42 days of age were castrated and tail docked (referred to as castration) by either surgery with cauterisation (S), the application of a standard rubber ring (RR) or application of a burdizzo clamp after rubber ring application (B) (group n=7). The lambs' behaviour was recorded at 2 min intervals for 96 min and for a further 84 min at 6 min intervals. Acute pain in castrated lambs was assessed by comparing the behaviour responses of treated lambs with responses in lambs of the same age handled (H) for 2 min. Lateral lying (LL), ventral lying with hind legs extended (V) and abnormal standing were postures rarely adopted by healthy, untreated lambs but were frequently adopted in the first 2 hr post treatment. The use of correspondence analysis showed that restlessness, the postures LL, V and grossly abnormal standing were associated with RR castration. Abnormal standing was associated with RR, S and B castration and normal ventral lying posture with animals castrated by surgery and burdizzo as well as with the handled group. Restlessness was high in lambs of all ages castrated by RR. The peak restlessness score occurred 12 min post castration and returned to normal values within one hr. Abnormal standing postures were noted in lambs of all ages after all methods of castration, while abnormal lying was significantly elevated in lambs of all ages castrated by RR and in 1 week old lambs surgically castrated. After RR castration, peak abnormal lying behaviour occurred between 12 and 60 min post castration. The method of castration and tail docking had more effect on the acute behavioural responses of lambs than the age of lamb at treatment.

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Stereotyped pacing in caged Japanese quail

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Japanese quail males (n=10) and females (n=10) were transferred from batteries into individual cages at the age of 5 weeks. The occurrence of stereotyped pacing along the walls of cages was evaluated at 2, 6, 8 and 10 weeks after the transfer. The behavioural record was based on 10 min samples from each hour of the light phase of the 16L : 8D photoperiod. Two weeks after the transfer a relatively high incidence of stereotyped pacing was observed, especially in males, and the percentage of time spent in this behaviour was further increased. From the 6th week after transfer the time spent in stereotyped pacing stabilized. The stability of inter-individual differences (analysed by Spearman rank correlation between the behavioural records) increased with increasing length of stay in cages in both sexes. No systematic diurnal variation in stereotyped pacing was found, probably as a result of the great inter-individual variability. In the second part of the experiment, one half of each sex group was injected subcutaneously with saline, while the second half was injected with 1 mg of naloxone 3 weeks later. A slight decrease in stereotyped pacing was recorded in males, but not in females, after the 1 mg naloxone treatment. After injection with 5 mg of naloxone/kg body weight a slight decrease in stereotyped behaviour was observed in both sexes.

The assessment of stress in animals

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An extensive literature review on stress assessment has been carried out by the author during the last two years. The review is aimed at users of laboratory animals, but the results are of relevance to welfare studies of other animals. Stress is defined as a state in which an animal encounters adverse conditions that cause a disturbance

of its normal physiological and mental equilibrium. It is possible to measure the degree of disturbance from "normal equilibrium" as follows:
Behaviour: precise observation of stressed animals; the use of specific tests e.g. to measure a reduction in exploratory behaviour.
Endocrinology: measurement of glucocorticoids; ACTH and other pituitary hormones; catecholamines and their metabolites.
Physiology: measurement of heart rate and blood pressure.
Immunology: measurement of total and differential white blood cell count; also more sophisticated tests of lymphocyte function.
Pathology: description of stress-related lesions and the relevance of certain organ weights at necropsy.

It is recommended that stress assessment should ideally include behavioural observations as well as measurement of parameters of the sympathetic/adrenal medullary system and the pituitary axis. However, the use of invasive techniques, which may cause stress in themselves, are to be avoided. This work was sponsored by the RSPCA, Horsham, West Sussex, from whom a copy can be obtained.

Stereotypies and suffering

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Stereotypies often develop in circumstances that seem to cause poor welfare. They appear to reflect motivation to show a behaviour pattern (e.g. escaping, foraging) that, in captivity, cannot be performed normally or to completion. So does the degree of stereotypy indicate the extent to which well-being is impaired? Not necessarily. This would require stereotypy levels to reflect simply the strength of the motivation to escape, or to forage, etc. In fact, levels of stereotypy are likely also to be influenced by:
(i) the animal's tendency to respond to its environment with active behaviour rather than in a more inactive way;
(ii) the animal's general propensity to develop inflexible behavioural routines;
(iii) the age of the behaviour; as a stereotypy develops and becomes more "habit-like" it may be performed more often and in more situations.
For example, caged mink perform "restless" running and other apparently purposeless activities, some of which are very stereotyped. Females with high levels of the least-stereotyped, "restless" behaviour produce smaller litters than less active females. This is not the case if the behaviour is more stereotyped (de Jonge and Mason, in prep.). One interpretation is that it is only when such behaviour is flexible does it closely mirror motivation and hence frustration; if more habit-like the behaviour is "de-coupled" from the causes of reduced well-being. Thus, lower levels of stereotypy (i.e. fewer instances, or behaviour that is less rigid) do not necessarily indicate better well-being. Rules about levels of stereotypy that are "acceptable" for welfare will not reduce animal suffering unless this is taken into account.

Mink stereotypies and early experience

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The amount and type of stereotypy performed by a 6 month-old mink is predicted by its date of birth within the 3-week breeding season. Animals born later develop more stereotypy, and females tend to develop patterns that involve use of their nestbox. As these animals will have been younger when first removed from their mothers and re-caged, these results are interpreted in terms of an age-dependent sensitivity. Early experience with the mother also seems to predict stereotypy. Multiparous, but not primiparous, females restrict the milk supply to their young after a time, causing the litter to stop growing for a few days. This growth plateau starts earlier the heavier the kits. In the kits of multiparous, but not primiparous, mothers, kit weight predicts the proportion of their later stereotypy that consists of head movements. It is possible that this early frustration results in stereotypies that resemble nipple-searching movements.

Impact of the pollution problem on strategies to improve animal welfare

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Intensive livestock units are a major source of atmospheric ammonia and acidification. Solutions for this problem must partly be sought at the level of the housing system. Current research is focusing on factors such as overall design, space, floor construction, bedding material, hygienic conditions and climatic factors. The handling, storage and disposal of urine and manure are a major issue. Most of the solutions being considered for reducing ammonia emission from animal houses have an impact on the animals' welfare. Some options currently being studied, such as the use of deep litter or bio-bed systems for pigs, may benefit the animals, but others introduce potential risks, such as when floor systems are made smoother and cleaner, and, therefore, become more slippery and inconvenient for the animals. In turn, new housing systems and management techniques introduced to improve animal welfare may have drawbacks in terms of environmental pollution. In many cases group housing is likely to increase the ammonia-emitting area compared with individual housing. In the same way, social density may be a relevant factor when considering the ammonia emission. It has also been shown that litter systems for laying hens have levels of ammonia emission far in excess of those from battery cages, where the manure is frequently removed and dried. It is probable that some sort of litter management will be obligatory in alternative housing systems, if these

systems are to be acceptable in terms of pollution. An integrated approach must be used to find proper answers for both the welfare and pollution problems in animal husbandry, otherwise welfare legislation or recommendations may conflict with the burgeoning regulations on environmental pollution.

The performance of dustbathing behaviour in an alternative housing system for laying hens: the Tiered Wire Floor system

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A laying hen performs dustbathing behaviour in almost any housing system. However, depending on the conditions (available space, presence of litter etc.) this behaviour pattern is complete, or more or less disturbed (incomplete). This behaviour may give an indication of the state of well-being of the birds in a specific housing system. Dustbathing was observed in the Tiered Wire Floor (TWF) aviary on a semi-practical scale (unit with 6000 birds). The frequency and duration of the dustbathing components in individual dustbathings were scored during six photoperiods (17 hr light) at six different locations in the system. An estimate was made of the number of dustbathings/bird/day and the daily pattern of dustbathing in the whole flock. Comparable observations were also carried out of hens housed in battery cages. The results showed clear differences in dustbathing behaviour between the TWF system and battery cages. In the cages the birds performed more but shorter dustbathings in which some components were very often missing (incomplete). Dustbathing in cages was seen from five hours after light-onset until the end of the photoperiod. In the TWF system the dustbaths were longer, more complete and concentrated between 6 hr and 12 hr after light-onset.

The use of a model chicken to estimate heat and cold stress experienced by poultry during transportation

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A model chicken, of similar size to an adult hen, has been developed to measure sensible heat loss. This can be placed among live birds during transportation to measure the thermal demands of their microenvironments. The influences on heat loss of position on lorry, type of road, wind speed and air temperature are

demonstrated. Conditions of thermal stress detrimental to the welfare of poultry in transit are quantified.

Coping styles in tethered sows

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The behaviour of 20 non-pregnant, primiparous sows was observed from the moment of first tethering until 2 hr after, and after being tethered for one and two months. After two months of tethering the sows could be divided into two distinct groups; 1) high stereotypers (n=10, spending on average 47% of the observation time stereotyping) and 2) low stereotypers (n=10, spending on average 16% of the observation time stereotyping). Sows that resisted most at first tethering showed the lowest level of stereotyping after one and two months of tethering ($r=0.60$; $P<0.01$, $N=18$). High resisting sows may experience the uncontrollability of first tethering most drastically and develop a state of helplessness. Low resisting sows may accept tethering more easily and adapt by developing stereotypies. Low stereotyping sows were more alert after one and two months of tethering than high stereotyping ones (13.5% versus 25.5%; $t=2.18$; $P<0.05$; $n1=n2=10$). Heart rate measurements showed that high stereotyping sows had lower mean heart-rates after feeding (when stereotyping is most pronounced) than low stereotyping ones. This difference was already present before tethering, when the sows were loose-housed. The results show differences in styles of coping in sows. These differences do not result from tethering, but become more visible during tethering.

The preference of hens for pecking simple objects of different colours

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Providing hens with inanimate pecking objects could reduce feather pecking and its concomitant welfare and economic problems. It is likely that various characteristics of objects would heighten or reduce their attractiveness for hens to peck; one such characteristic is colour. This investigation sought to determine which, if any, colour(s) might attract more pecking. Ultimately, pecking objects might be more efficacious in reducing feather pecking if they were of this colour. Simple pecking objects were painted in one of the following six colours: red, orange, yellow, green, blue or white. Preferences were tested by hanging three objects (each a different colour) in the cages and recording the number of pecks directed at each object during a 90 min observation period later that day. This was

conducted on a total of 52 occasions using 18 cages each containing a pair of laying hens. 1371 pecks were recorded and rapid habituation to the objects was evident. The rate of pecking was highly variable from one day to the next. An LSD test showed that the mean rate of pecking at the green-coloured objects was significantly greater than at the other coloured objects. This preference might be explained in terms of adaptive value in food selection by the adult fowl.

Head shaking as an indicator of the awareness state of broilers after fasting and transport

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It is believed that head shaking in chickens is exhibited when a bird is paying increased attention to its environment. It should be possible, then, to use head shaking as a measure of the state of awareness of chickens after transport. This in turn might be an indicator of welfare status. Broiler chickens were trained to associate hearing a recording of a piano scale (13 sec duration) with an aversive treatment, i.e. being squirted with a spray of water. The birds were then subjected to one of four treatments: 10 hr fasting + 6 hr transport, 0 hr fasting + 6 hr transport, 10 hr fasting + 0 hr transport, or 0 hr fasting + 0 hr transport (control). After the treatment the birds were played the recording of the piano scale and the latency to head-shake was determined. Tukey's Test showed that the mean latency of the group which had undergone 6 hr transport + 10 hr fasting was significantly greater than that of the control group (8.94 sec versus 2.21 sec; $P<0.05$) or the other two treatments. These preliminary results indicate that broilers fasted and transported under simulated commercial conditions may have been less aware of their environment subsequent to the journey. The precise function of head shaking and its motivations are not fully understood, but state of awareness might be related to other mental states such as fearfulness or to fatigue. Further experiments are planned to elucidate these relationships and to assess the suitability of head shaking as an indicator of chicken welfare.

The effect of slaughter handling system and pig behaviour on welfare and meat quality

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Pigs were selected on a farm basis as 'easy to handle' (EH, two farms) and 'difficult to handle' (DH, two farms). Pigs from these farms were slaughtered at two abattoirs with two different slaughter handling systems at each abattoir. The four slaughter handling systems were:

Abattoir 1 - race-restrainer, electric stun (RR)
- floor pen, electric stun (FP)

Abattoir 2 - sow pen, electric stun (FP)
- semicircular crush pen, CO_2 stun (CO_2)

Pigs from all farms went through each stun system and were balanced for deck of transporter requiring 16 replicates. Each replicate consisted of 100 pigs per abattoir giving a total of 3,200 pigs in the experiment.

Slaughter handling systems: At abattoir 1 carcases from the RR had higher early rigor levels ($P<0.001$) and more skin blemish ($P<0.001$) than those from other systems. The RR also produced meat with lower pH ($P<0.001$) which was paler in colour ($P<0.01$). At abattoir 2 the FP produced carcases with higher early rigor levels ($P<0.001$) and more skin blemish ($P<0.001$). There was no difference in pH or colour.

Behavioural type: There were no trends evident for early rigor, skin blemish, initial pH or initial colour measurements. For ultimate measurements at both abattoirs, the DH pigs produced darker meat with a higher pH.

Physiological measures: Blood samples were also taken and results will be presented on levels of cortisol, creatine phosphokinase, lactate dehydrogenase (LDH) and LDH isoenzymes.

Conclusions: The results of the experiment indicate that both slaughter handling system and pig behavioural type had significant effects on pig welfare.

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