

Chapter 7. Applied ethology – the basis for improved animal welfare in organic farming

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Introduction

Consumers associate organic animal husbandry with good animal welfare and ‘happy’ animals (Sies and Mahlau, 1997). Organic husbandry is seen in opposition to intensive, conventional agriculture with large groups, barren environments, and behavioural problems. In fact, the starting point of organic animal husbandry is to give both the animals and the humans concerned a higher quality of life by respecting their nature and requirements: the principles of organic animal husbandry postulate that housing systems are adapted to the species-specific needs of the animals and that the preservation and promotion of animal health result from optimizing the animals’ housing, feeding, breeding and care (Sundrum, 1993). These principles are also reflected in organic standards. Consequently, with respect to their behaviour the welfare of the animals in general is better than in conventional systems (e.g. Hörning, 1998).

At present the focus is often on health problems, because classical treatments of disease may not be compatible with the principles and standards of organic husbandry, but experience with alternative treatments still is limited (as discussed in Chapter 13). However, in a more holistic approach, behaviour is what constitutes the bridge between the animal and its environment, and many health problems are certainly related to deficits in husbandry, management and knowledge. Therefore, further improvements of organic husbandry systems also are needed concerning behavioural requirements. Furthermore, severe problems such as cross suckling in calves, tail biting in pigs and feather pecking in poultry need to be solved.

Ethology, the study of animal behaviour, has a critical role to play in the further development of organic husbandry that goes hand-in-hand with improved animal welfare. We will briefly discuss the meaning of animal welfare in science, the organic context, and public understanding. Natural behaviour plays a central role here, and we outline what natural behaviour means, its role for a life of quality in farm animals, and the implications for husbandry. We will then apply this for three main farm animal species – cattle, pigs and laying hens – and at the end summarize the significance of ethology and animal behaviour for organic animal husbandry now and in the future.

Natural behaviour – the key for a life of quality in animals

Definitions and expectations regarding animal welfare

Judgements concerning animal welfare have been made on various grounds. For example, Lorz (1973) suggested that good animal welfare involves the animal living in a state of

harmony with its environment, both physically and psychologically; that is, as van Putten (1973; 2000) suggested, the animal is able to adapt to or cope with its environment (Broom, 1986). The welfare of an animal can be assessed on a scale from very poor to very good as a result of its ability to cope. Welfare is poor when the individual has difficulty in coping with the conditions encountered (Broom, 1992). Difficulties in coping result in negative emotions, behavioural problems and physical health problems. Good welfare, involving high quality of life for the animal, does not mean only that the animal is able to cope with the environment, that suffering is avoided and biological functioning is enabled, which is what has been discussed the most in applied ethology so far. Rather, good welfare must go beyond this and ensure that the animal has positive emotions and experiences. Only recently has attention been addressed to this aspect of welfare, including how to assess it (Mench, 1998; Knierim, 1998; Désiré *et al.*, 2002).

Organic definitions of animal welfare emphasize the importance of naturalness, i.e. animals should be able to express their species-specific, natural behaviour by being provided with a natural environment or an environment with key features (Kiley-Worthington, 1989; Lund, 2000; Lund and Röcklingberg, 2001; see also Chapter 5). This is close to consumers' expectations: they believe that good animal welfare standards come as close as possible to nature (Ouédraogo, 2002), and they associate organic farming with pictures of animals in nature (Sies and Mahlau, 1997; Starzinger, 2001). As will be outlined in this chapter, the possibility of performing natural behaviour in fact is linked both to the animal's ability to cope with the environment and to positive experiences, and thus with the quality of life.

Evolution, domestication and natural behaviour

The wild ancestors of our domestic animals adapted to their environment during evolution in their body structures, their physiology and their behaviour (Darwin, 1859). Through the long-lasting evolutionary process, the appropriate body, mind and behaviour for survival and reproduction were selected for and imprinted genetically, building the basic genetic structure for the species-specific behaviour (the animals' 'nature'). But how, when, where and why a certain behaviour is performed – within the possible range of its nature – is the result of local conditions and the individual's experiences (its 'nurture'). It is this flexibility that allows for the great adaptability and variation of behaviour, shown in particular by domestic animals. For example, the exploration and food selection of the goat in any environment will depend on: 1) her internally controlled hunger; 2) the nutrients she requires; 3) her genetically imprinted preferences for browsing rather than grazing; 4) her ability to find the appropriate food as a result of what she has learned about the environment – also from others; and 5) her past experience of eating particular plants and how to do it, (e.g. avoid the prickles on gorse). Thus both internal and external stimuli affect the motivation to perform a behaviour, and how it is done. The results of the behaviour or the doing of it, in turn, feed back to the motivation: that is, to do more of it, or to do something else (Buchholtz, 1993; Jensen and Toates, 1993). In the natural environment, these motivational systems or behavioural control mechanisms are closely linked to the function, for example to ensure that the goat provides herself with sufficient nutrients in a difficult environment.

The differences in behaviour between farm animals and their wild counterparts primarily are quantitative rather than qualitative (Price, 1999). Chapter 6 gives some examples of changes in response thresholds and frequency of behaviour. The behavioural repertoire of the wild ancestors still exists in our domesticated animals, many of which can survive in their natural environment (for pigs, e.g. Stolba and Wood-Gush, 1984; Jensen, 1986; for cattle, Reinhardt, 1980a,b; Kiley-Worthington and de la Plain, 1983; for chickens, e.g. McBride *et al.*, 1969; Wood-Gush *et al.*, 1978). Even animals from intensive housing systems very quickly show all

behavioural elements when brought into an appropriate environment (for example in pigs, Stolba, 1984).

The set of behaviour and the underlying control mechanisms that have evolved in the species and are still possessed by our farm animals can be referred to as their species-specific or 'natural' behaviour. However, definitions of 'natural' behaviour are rare. The behavioural repertoire of a species in a (semi)-natural habitat is often referred to as 'normal' (Stauffacher, 1992) or 'natural' (Algers, 1992) or 'species-specific' behaviour. Lund and Röcklinsberg (2001) specifically consider 'natural behaviour' to be 'those sets of control systems developed by the evolutionary process to allow the animal to register and react to internal and external stimuli in order to optimize survival and reproduction'.

Significance of natural behaviour for animal welfare and husbandry

Conditions in husbandry often differ substantially from those in nature. If the evolved species-specific behavioural control systems are disregarded during rearing and husbandry so that the animal no longer can cope successfully with the environment, welfare problems arise (Wechsler, 1993; Fraser *et al.*, 1997). The animal's ability to cope depends on the adaptive capacity that it possesses both genetically as a member of its species and as an individual with its special development and lifetime experiences.

The inability to cope can have two main underlying causes (Fraser *et al.*, 1997). The first is a motivation to perform a behaviour without direct necessity. In domesticated animals kept under the control of humans, the functions of many behaviours have been taken over by the stockman or the housing. For example, providing food supersedes searching for food and sometimes even chewing it. Long walks to water are not necessary because water is provided. Artificial insemination and the absence of mixed groups of both sexes prevents searching for, courting and copulating with a mating partner. Lack of opportunities to perform behaviours can lead to behavioural problems, because the animals are motivated to perform the behaviours anyway – due to the lack of a negative feedback controlling the motivation (Buchholtz, 1993). For instance, if pigs are fed highly concentrated feed in a trough, the function of nutrition is fulfilled, but they still have a strong urge to root and explore (which in nature is necessary to search for food). Preventing them from doing so leads to behavioural problems such as tail biting. When prevented from performing a behaviour when they are highly motivated, animals may not only experience negative feeling or fail to experience positive ones, but they may also suffer physical health problems. Sows prevented from nest building show prolonged parturition that might result in higher stillbirth rate, less vital piglets and higher risk of MMA (mastitis, metritis, agalactia) (Weber and Troxler, 1988; Bertschinger *et al.*, 1994; Plonait, 1997).

The second source of inability to cope is that the environment presents challenges that the animals cannot meet, such as physical constraints that prevent them from performing certain behaviours. Behaviour is somewhat flexible and adaptable, but there are behavioural, physiological and anatomical limits. For instance, cattle naturally graze while walking. In this 'pasture pace', with one front leg in front of the other, the head is closer to the ground compared to standing upright with both forelegs parallel. When eating from a feeding rack while standing, their forelegs must be parallel; this makes it harder for them to reach the ground. If the feeding table is not raised sufficiently (20 cm is recommended in loose housing), the load on the shoulder and forelegs is greater and the animals may become lame and develop lesions at the shoulder (Metzner, 1976; Molz, 1989; Waiblinger *et al.*, 2001). Another possibility is that a behaviour did not evolve because in the natural habitat it was not necessary. Many pig breeds have hairless, unpigmented skin. They often get sunburned if offered access to an outside yard without shade and a wallowing site. They did not develop behaviour to protect themselves, because wild boars mainly live in forests.

In contrast, enabling natural behaviour will provide the animals with positive experiences and emotions and a life of quality. Even weakly motivated behaviour may be important to the animal because it is associated with positive feelings of comfort, satisfaction or pleasure or because it contributes to a sense of control, social support or engagement (Mench, 1998). In general, fulfilling the behavioural requirements nurtures health. Psychological well-being and reduction of stress are important for good immune function and health (e.g. Henry and Stephens, 1977; Kiley-Worthington, 1977). However, there appear to be contradictions. Health depends largely on the hygienic situation and pathogen pressure. A husbandry situation might be hygienically advantageous whilst disregarding behavioural requirements. On the other hand, a free range environment rich in diverse stimuli that allows the animal to perform its full behavioural repertoire may also present a high risk of parasitic infestation or predation. The farmer must overcome these risks by appropriate management. Good organic agricultural practice demonstrates that such problems can be overcome. For instance, cattle or sheep badly managed on pasture can develop parasitic gastroenteritis leading to production losses. However, good grazing management (such as rotational and multi-species grazing), combined with regular control, can reduce the parasitic infestation to a degree where no treatment is necessary and the animals are not harmed (e.g. Brelin, 1979; Githigia *et al.*, 2001; also Chapter 14).

Besides allowing animals to perform species-specific behaviour, some features of the environment are important for all species and will contribute to the quality of the animals' life. These include the chance to make choices and decisions and have some control over the environment (Dickinson, 1980; Toates, 1987). Animals have expectations and become frustrated if these are not fulfilled. For instance, pigs fed on an irregular, unpredictable schedule showed more aggressive interactions and a chronic stress response (Carlstead, 1986; Barnett and Taylor, 1997). The implication for husbandry is that one must give the animals choices and not decide what is 'better' for them (e.g. to give them permanent access to outside runs, even during bad weather). Furthermore, this means offering them a rich environment with diverse stimuli and letting them predict and control many aspects of their environment, such as by ensuring routines for feeding and milking and by reducing changes in the social structure.

Is there a substitute for nature?

'Natural behaviour' may be a misleading term for housing systems. The question arises: For good welfare must we offer an environment as close as possible to the natural habitat of the species, or can some elements be substituted?

Respecting the behavioural requirements of the animals does not inevitably mean turning them out into their natural environment or a copy of it, but rather ensuring they have appropriate environmental stimuli (Wechsler *et al.*, 1991). Of course, the more an environment resembles the natural habitat, the easier it is to enable the species-specific behaviour. But it is possible to reduce the natural environment to key features and stimuli, so that animals still can perform the species-specific behaviour and have a good quality of life. An example is the family pen for pigs (Stolba, 1984). First, the key behaviours and corresponding environmental features were identified by observing pigs in a semi-natural environment. Then, the environment was reduced step-by-step while retaining the relevant features, such as structuring the pen into different areas for rooting, nesting, and dunging (Stolba, 1984; Wechsler *et al.*, 1991). Further examples of these key features and of how a knowledge of them is necessary for good welfare will be given in the species-specific sections that follow.

But is offering key features in an ‘artificial’ environment enough for organic livestock? Does it comply with the values of organic farming and consumers expectations? For some features of nature there is no substitute in a (closed) housing system, for example natural light, sun, fresh air and wind, and natural ground. Therefore, organic standards usually require access to an open run or pasture. A difficult challenge is to ensure sufficient environmental diversity and complexity. The animal’s active interaction with the environment and dealing with environmental challenges seem to be central for animal welfare (Wemelsfelder and Birke, 1997). In this respect, too, a free range environment has far more to offer than indoor housing. In Table 1 we summarize the discussion so far. Organic farmers should provide the animals in their care with as high a quality of life as possible. In the following sections, we discuss necessary preconditions for three species as well as possible conflicts and their solutions.

Table 1. An outline of different levels of quality of life, how they are characterised with respect to behaviour and health aspects, what system would correspond to it (optimal management assumed) and where current organic husbandry standards fall.

Welfare level	Characteristics	Example in cattle	Standard
very good	natural behaviour possible, very few behavioural restrictions; health problems prevented	beef suckler herds outside on pasture, weaning at 9 months	beyond standards; greatest approach to natural life
good	parts of natural behaviour not possible, but behavioural restrictions not leading to problems; adaptation possible, no sign of distress, no health problems	beef bulls on deep litter with outside run, partially on pasture and feed with sufficient roughage	minimum organic standard; natural life only partially attained
poor	distinct behavioural restrictions in some functional systems; abnormal behaviour (tongue rolling)	beef bulls on deep litter, few space, insufficient roughage	improved conventional systems
very poor	high restrictions in several functional behavioural systems; health problems and abnormal behaviour (e.g. skin lesions, joint lesions, disturbed lying behaviour, tail tip lesions, tongue rolling)	beef bulls on fully slatted floors, high stocking density, insufficient roughage	accepted in many welfare laws, in conventional systems

Cattle

Species-specific behaviour

To know about the natural behaviour of any species, and thereby to be able to design environments to fulfil their needs, it is necessary for ethologists to study wild or feral groups. The ancestor of cattle, the aurochs, *Bos primigenius*, became extinct in 1627. But there are several wild close relatives, for example the bison in Europe and Northern America (Lott, 1991), the gaur in India and the Cape buffalo in Africa (Prins, 1997). There are few herds of feral cattle (e.g. Hall and Moore, 1986; Lazo, 1994), but cattle have been studied living with little interference from humans (e.g. for *Bos taurus*, Hafez *et al.*, 1963; Kiley-Worthington and de la Plain, 1983; for *Bos indicus*, Reinhardt, 1980a,b). Here we summarize what we know about the behaviour of cattle from these studies and then outline the needs of cattle.

Social structure

Cattle are extremely social, living in mixed herds of different ages and sexes, based on several cow-centred groups (adult cows and their female and subadult male offspring). The herd rarely has more than 50 animals, although occasionally many groups will join together temporarily for migrations or because of food resources. The herds may occupy specific home ranges. At two to four years of age, males leave their group to join a multi-male group or live solitary. During the rutting season they join a cow herd, but some males might stay in the herd during the whole year. The females and some of the bulls will remain with the same group for most of their lives. Consequently they have stable groups in which they know each other (Randle, 1994). They form long-lasting social bonds, especially between mother and offspring, but also between same-aged animals and between siblings (Reinhardt, 1980a; Reinhardt and Reinhardt, 1981, Kiley-Worthington and de la Plain, 1983).

The social organization of cattle is distinguished by a relatively stable dominance-subordinate relationships, but even more by affiliative behaviour, behaviour that strengthens the cohesion of the group by cooperation and tolerance, rather than competition (Randle, 1994). Individuals have roles within the group that may change, depending on circumstances. Their daily activities are performed synchronously.

Calving and cow-calf interaction

Cows may calve at any time of the year, although there is generally a peak in the spring. The cows separate from the herd to calve, but in some studies of domestic cows, only some really separated from the herd to calve (Kiley-Worthington and de la Plain, 1983; Lidfors and Jensen, 1988). The calf 'lies out' rather than follow the mother in the first week. After one to three weeks, the cow rejoins the herd with her calf (Reinhardt, 1980a). In the herd, a calf tends to stay in peer groups rather than follow its mother (Sato *et al.* 1987). However, the mother repeatedly comes back to the calf, who performs a lot of social behaviour with her, such as playing and social licking (Reinhardt, 1980a).

The cows suckle their calves around 8 times per day in the first week, later 3-5 times per day, with each bout taking around 10 min. They wean them at 8-12 months (Walker, 1962; Reinhardt, 1980a; Kiley-Worthington and de la Plain, 1983; Porzig and Sambras, 1991). Calves start to graze and ruminate for a remarkable amount of time at three weeks of age and regularly graze with the adults at 4-6 months (Arnold and Dudzinski, 1978; Reinhardt, 1980a).

Feeding, locomotion, resting and comfort

Cattle are specialized for living on the edge of forests, eating mainly grasses and ground level herbs and occasionally browsing trees. Consequently they have evolved to have varied diets. They primarily consume grass high in crude fibre, which needs to be chewed thoroughly before it can be digested. Rumination allows them to spend as little as 4-9 hours a day eating where they might be in view of predators, and thereafter withdraw to some quiet corner to rechew for another 4-9 hours, most of the time (60-80%) while lying. While grazing, they walk slowly, taking 50-80 bites of grass per minute; a dairy cow in total takes around 20,000 bites per day (Porzig and Sambras, 1991).

Cattle on pasture drink from one to four times daily (Hafez and Bouissou, 1975), at up to 20 l min⁻¹, by lowering their muzzles into the water at a 60° angle to keep their nostrils above the water (Metzner, 1976). Cattle mainly move while grazing. They travel an average of 5 km per day going to grazing sites or water (Hafez and Bouissou, 1975), but depending on the distribution of food and water the distance can increase to 30 km. Cattle rest around 8 hours, most of the time lying. When lying down and getting up, they use a head lunge to take weight from the hindleg. Cattle maintain their skin by self-grooming and reduce irritation by using their tails, scratching and rubbing themselves and shaking their heads.

Implications for organic cattle husbandry and some problems

Social environment and space

Living in groups is a basic characteristic of cattle, a social species, and can only be fulfilled by keep them loose housed. Tied cattle are very restricted in their behaviour, which has negative consequences on health (Bendixen *et al.*, 1988a,b). Regular access to exercise, such as pasturing the animals during summer or regularly offering an outside run, has only a limited beneficial effect (Wiederkehr *et al.*, 2001; Spycher *et al.*, 2002). Consequently, tying systems are not in line with organic principles and should be avoided. Except in beef suckler herds, the social environment differs from groups in nature with respect to composition (single sex and similar age) and stability (frequent regrouping or new members). Integration of heifers into a milking herd and regrouping can lead to stress responses with reduced lying times, an increase in cortisol, and a decrease in milk yield (Hasegawa *et al.*, 1997; Knierim, 1999a,b). Dairy cattle are regrouped frequently to meet the nutritional requirements for their stage of lactation or milk yield.

One way of overcoming the conflict between their social and nutritional requirements is to keep cows in one group with access to separate feeding areas. To date, only a few farms are organized in this way. If regrouping is unavoidable, measures to reduce stress should be taken, such as regrouping on pasture, where there is plenty of space and where the natural ground reduces the risk of claw lesions. In horned cows it seems advantageous to introduce heifers individually to reduce aggression (Menke *et al.*, 2000). Nevertheless, Knierim (1999a,b) found some hints of social support among heifers introduced as a group. This is an area where further ethological research is needed.

The most successful approach is to maximize the herd's stability to allow long-lasting social bonds and social support (Sachser *et al.*, 1998) and to reduce social stress by decreasing the number of regroupings and enhancing the predictability and controllability of the social environment. Competition can be reduced by a wider distribution and sufficient number of resources such as drinkers, brushes, and concentrate feeders. Space allowance also is related

to lameness (Leonard *et al.*, 1996) and agonistic interactions (Menke *et al.*, 1999); adequate space helps to avoid long standing periods, which are detrimental to claw health (Galindo and Broom, 1994).

To enable synchronous herd behaviour, at least one feeding and lying place (cubicle) per animal is necessary; otherwise agonistic behaviour increases and daily rhythms change (Wierenga, 1983a,b; Stumpf *et al.*, 2000). The duration of lying during the usual resting times increases when more cubicles are available than cows (Wierenga *et al.*, 1985). Food should be available in a consistent quality all the time to avoid competition. If limited food is offered, animals must be fixed in the feeding rack to ensure that low ranking animals can eat enough, without disturbances.

Cow-calf interactions

In contrast to beef suckler cattle, a natural social structure rarely exists with dairy cows, so that two major behavioural restrictions are almost universal. First, dairy cows now rarely run with bulls, or in mixed sex and age groups. Second, their calves are taken away shortly after birth, with both mother and calf showing stress reactions: increased vocalization, movement, and aggression (Kiley-Worthington, 1995). Though the reaction to separation is stronger after 4 to 14 days of suckling, later separation has advantages for health and performance advantages (Krohn *et al.*, 1990; Weary and Chua, 2000; Flower and Weary, 2001; for a review see Krohn, 2001).

Non-nutritive sucking (calves sucking at the pen or bucket), cross sucking (calves sucking at various body parts of other calves) and intersucking (weaned subadult or adult cows sucking at the udder of a group-member) are common behavioural problems in artificially reared animals that might cause skin irritations and infections of the navel, the scrotum or the udder (Plath, 1999; Keil, 2000). Different factors contribute to this abnormal behaviour, but the main cause seems to be unfulfilled sucking motivation (Sambraus, 1985), perhaps because the internal signal to stop the sucking motivation (possibly satiety) comes too late compared with the short duration of milk intake in artificial rearing systems (Egle *et al.* 1999; de Passillé, 2001).

Several measures may reduce cross-sucking, for example:

- restricting the calves for 10 minutes after drinking milk (Graf *et al.*, 1989)
- using a gated automatic milk feeder, where calves are protected from displacement from the teat (Weber, 1999; Weber and Wechsler, 2001)
- using teat buckets instead of open buckets
- providing calves with the teat bucket after milk intake
- especially, reducing milk flow rate to prolong nutritive suckling (de Passillé, 2001; Jung and Lidfors, 2001; Loberg and Lidfors, 2001a).

However, these measures do not completely prevent cross-sucking, which may continue after weaning. It might be prevented by feeding fulfilling their energetic and behavioural requirements (constant availability of food, long feeding times) after weaning (Keil *et al.*, 2000; Keil and Langhans, 2001). Such problems rarely arise when cows are kept with their calves in an appropriate environment. Therefore, systems where calves can run with their

dairy cows should be promoted in organic agriculture. Pilot studies (see Box 1) and limited practical experience are encouraging, but also show the need for additional research.

Box 1. Single suckling

Pilot studies have been done on organic farms to study the problems and economics of leaving calves with their mothers in a dairy herd running with a bull (Kiley-Worthington, in preparation). The milking cows and their calves were kept together as a herd during the day. At night the calves were separated. In the morning, the cows were milked and let out with their calves. The disadvantages of this system were that some of the cows withheld their milk at milking, and milk yields were lower. The advantages of the system were substantial:

- lower labour costs (once a day milking and very little labour looking after the calves)
- very little sickness in the calves, no mastitis in the cows
- better grown calves that sold at higher prices
- running with a bull, the cows were back in oestrus within two months of calving, and 90% were pregnant on their first return
- better overall economic performance and longer productive life of cows.

The system can be adapted to the producer and the herd. If the cows are very high yielding, they may be milked twice a day, with the calves running with them all the time.

The positive effects on production and the health of the calves and cows are supported by other studies (Boden and Leaver, 1994; Flower and Weary, 2001; Margerison *et al.*, 2003; for a review see Krohn, 2001). The experience of one conventional farmer documented in the farming press (Hovi, 1998) suggests that such a system can also be used without major problems with large, loose housed herds.

More common on organic dairy farms is to use foster cows for multiple suckling, i.e. one cow suckles two to four calves (e.g. Hudson, 1977; Loberg and Lidfors, 2001b). The calves live in groups, have some contact with adult cows, and can perform natural sucking behaviour. However, they may not all be properly mothered. In the study of Loberg and Lidfors (2001b), foster cows licked the calves very rarely; in beef cows, a high proportion (60%) of calves were only tolerated (that is suckled but not licked), but not adopted by the cow in double suckling systems in Saler cattle. Consequently, those calves gained less weight than the mother's own calf (Le Neindre, 1982). Although in a multiple suckler system the calves might only partly be able to perform and experience natural cow-calf interactions, they are less restricted than with artificial rearing.

The same limitations may apply to multiple suckling in beef herds. Economic constraints might force small organic farms to make more money from each cow. Here extra calves can be bought in, usually from dairy herds. The tendency of the beef cow to discriminate against calves other than her own (Le Neindre, 1982) can be reduced by some measures tested experimentally (Kiley, 1976; Le Neindre and Garel, 1979): introducing the calf as soon as possible after birth, and if possible covering it with amniotic fluid. Also, to ensure that her own calf is not disadvantaged by a stronger and more active introduced calf, her own calf

should be made to suck as soon as possible. One way of ensuring that both calves do well is to have them suckle in synchrony for the first few days. The economic performance of cattle managed in this way on organic farms is above that of normal single suckler beef cows (Kiley-Worthington and Randle, 1997).

Comfort

Self-grooming of all naturally reached body parts is possible only on a non-skid floor. Otherwise animals avoid licking areas that are difficult to reach, and slip during self-grooming, resulting in claw lesions (Sommer and Troxler, 1986). Automatic brushes are popularly used by cows.

Access to an outside run for loose housed cattle outside the pasturing season is not compulsory in all organic standards. However, a permanent accessible outside run, sufficiently sunny during winter and unroofed, is necessary for cattle to perform some of their natural behaviour, such as sun bathing. In Switzerland, cows have been observed to use an outside run especially often on sunny days in autumn, standing at right angles to the sun to get the most radiation (Arnold and Dudzinski, 1978; Krötzl and Hauser, 1997). Cattle also choose to go out in the rain (Krötzl and Hauser, 1997). The yard has positive effects on locomotion and social behaviour by increasing space and by structuring the housing (Menke *et al.*, 2000). It can be fitted with brushes, drinkers, and additional hay feeders (Van Caenegem and Krötzl Messerli, 1997).

If cattle are kept on pasture, shelter should be available to protect them from sun during hot periods and from rain and wind during cold. Trees can serve to give shade and protection in summer. During the winter in temperate and cold areas, free-range cattle need at least a dry lying area with protection against wind (Wallbaum *et al.*, 1997); in wet areas this can only be offered by a roofed area. Cattle on pasture use a shelter after two hours of rain (Vandenheede *et al.*, 1994).

Lying and feeding

The head lunge that cattle use to get up takes up to 1.5 m, measured from the carpus to the tip of the muzzle (Boxberger, 1983). The carpal joints serve as a pivot and thereby must carry a high load during lying down and getting up (Boxberger, 1983). Thus, a comfortable lying area for cattle consists of a soft and non-skid surface big enough for them to get up and down and lie unrestricted. A free lying area with deep litter or straw flow pen is the best way of ensuring this. Sufficiently large cubicles with high quality straw bedding (a straw mattress, which is a compact mattress composed of straw and cow dung) and flexible separations can also provide sufficient comfort (Hörning and Tost, 2001, Hörning, 2002).

Unfortunately, many farms still use cubicles that do not fulfil the cows' requirements, as shown by their lower daily duration of lying, fewer but longer bouts of lying, less comfortable lying positions, abnormal horse-like raising (Buchwalder *et al.*, 2000; Chaplin *et al.*, 2000; Hörning *et al.*, 2001), and more lameness than with deep litter (Somers *et al.*, 2001). Soft lying mats are equivalent to straw-mattresses regarding cow behaviour in temperate conditions, but cows develop hock lesions with them (Wechsler *et al.*, 2000) and prefer straw bedding in (cold) winter (Manninen *et al.*, 2002). Sand is often recommended in cubicles to avoid mastitis, but cows prefer straw and soft lying mats (Manninen *et al.*, 2002).

To avoid skin and claw lesions from a heavy load and to allow a relaxed feeding posture, the feeding area should have these three features: a raised feeding table or crib (20-25 cm in loose housing); an inclined feeding rack; and food always within reach (Boxberger, 1983; Konggaard, 1983; Hansen *et al.*, 1998; Waiblinger *et al.*, 2001). Drinkers should not be too high – at most 80 cm for adults – so that the cattle can use their normal drinking posture (Metzner, 1976). Water flow must be high enough; lactating cows must have access to a large amount of water at least twice a day. Water troughs are best.

Handling

Another cause of behavioural problems and inconveniences in cattle is bad handling. Research has developed some general rules and knowledge about how to reduce the animals' fear of humans and improve the ease of handling (Grandin, 1989; 1993a,b; Boivin *et al.*, 1992).

All cattle can be taught to be easy to handle and not to be frightened or attack defensively. For example, it is important to provide bulls with an appropriate social environment, to handle them with confidence, and to teach them acceptable behaviour as calves. Individually reared bulls were found to threaten and attack humans more than group-reared ones (Price and Wallach, 1990). Positively handled animals are easier to handle, whilst lack of habituation and negative interactions such as shouting and hitting lead to a higher level of fear of humans and more animals attacking humans (Boivin *et al.*, 1992; Grandin, 1993a,b; Hemsworth *et al.*, 2000; Lensink *et al.*, 2001; Waiblinger *et al.*, 2002; for reviews see Hemsworth and Coleman, 1998; Rushen *et al.*, 1999). Further examples of the importance of how the animals are handled and the human-animal relationship are given in Chapter 10.

Assessing husbandry systems

The restrictions on the different functional behavioural systems (e.g. maternal, social, lying behaviour) in different environments can be assessed, with this assessment used as a guide for improving the quality of cattle's lives. The least behavioural restriction for cattle is with outdoor suckled cattle, as described in Box 2. Here, the physical and social environments and the level of stimulation and active interaction with the environment resemble those of natural conditions.

Box 2. An example of husbandry close to nature - a beef suckler herd

Provided that feeding and care are appropriate, the behavioural and physical requirements are best fulfilled in outdoor suckled cattle allowed to live in stable herds with at least one bull. They can mate and raise their own young, which remain with the herd until finished and sent for beef. In temperate areas, it is necessary to maintain grass for the next year, avoid poaching, and ensure some shelter for the animals. This can be achieved with open-front barns with deep litter straw bedding that they can enter when they wish during bad weather, including a separate creep area for calves. Fodder (hay or silage) is always available, with extra feed as appropriate. The animals choose to go out or in. However, the cycling heifers must be separated from the maternal group to avoid becoming pregnant too young.

Pigs

Species-specific behaviour

Our knowledge of the natural behaviour of pigs is derived from studies on wild boars (Gundlach, 1968; Frädriich, 1974; Meynhardt, 1978; Mauget, 1981; Graves, 1984), feral pigs, and domestic pigs kept in semi-natural environments (Jensen and Wood-Gush, 1984; Stolba and Wood-Gush, 1984; 1989; Petersen *et al.*, 1989; Wechsler *et al.*, 1991).

Social structure

Pigs are gregarious animals. Their basic social unit consists of two to six related sows, their most recent litters, and juvenile offspring of previous litters (Graves, 1984). The number of sows depends upon the available resources. Within sow and offspring groups, sows form a stable linear hierarchy, based on age and size (Beilharz, 1967; Ewbank, 1976). The hierarchy is maintained by subordinates avoiding dominants, rather than by dominants attacking subordinates (Jensen, 1980; 1982). Individuals recognize each other largely by smell, whereas sight is relatively unimportant once a social order is established (Ewbank *et al.*, 1974). Non-member sows are rarely allowed into a group (Stolba and Wood-Gush, 1989). Juvenile males leave the group at 7-8 months of age and form groups of two or three. Mature males are solitary and nomadic, which permits promiscuous mating (Mauget, 1981).

Pigs live in home ranges of 100-2500 ha, but they are not territorial. The size and use of the home range depends on the available resources and is related to the social organization (Mauget, 1981). Within the home range, maternal groups build communal nests for sleeping, preferably at the border of forest or bush habitats. Pigs leave the nest site to defaecate (Stolba and Wood-Gush, 1984). Most suidae species are diurnal (Frädriich, 1965; Gundlach, 1968; van Putten, 1978a; Mauget, 1981).

Their time budget is controlled mainly by the search for food. Domestic pigs in a semi-natural enclosure were most active for some hours in the morning and the late afternoon to early evening, resting in the middle of the day and during the night (Wood-Gush *et al.*, 1990). During nursing, the rhythm becomes polyphasic. Pigs in a group prefer to eat, suckle and rest in synchrony (Hsia and Wood-Gush, 1984).

Pigs have many vocalizations, varying in frequency, tone and magnitude. They communicate by means of grunts, squeals, snarls and snorts. The function of only a few of these is known, such as contact grunts, warning calls, sow lactation grunts, begging calls of piglets (described in detail in Chapter 6), and mating songs (Grauvogl, 1958; Klingholz *et al.*, 1979; Weary and Fraser, 1995). Smells from faeces, urine and secretions of the metacarpal, lachrymal, salivary and preputial glands are thought to be important for familiarity, dominance and reproduction.

Reproduction, nursing and weaning

Wild boar and feral pigs have pronounced seasonal reproductive periods, one or two matings per year in most studies (Mauget, 1981), whereas domestic pigs breed more or less year round. Reproduction is synchronized within a sow group. A new boar joins the maternal group for each mating season and courts the sows in heat. During oestrus sows actively search for boars and stay close.

A few days before farrowing a pregnant sow leaves the maternal group to search for a suitable nest site. Farrowing nests will be built on the periphery of the group's home range. Nest

building begins about 16-20 hours before farrowing. The initial phase of nest building, the excavation of a hollow, is thought to be mainly internally controlled, whereas the second phase, the arrangement of nesting material, depends on environmental stimuli (Jensen, 1993). Nest building is mostly finished 2-4 hours before farrowing (Gundlach 1968; Jensen, 1993).

During farrowing the sow mostly lies still. The new-born piglets usually find the teats within less than 30 minutes, and for several hours they sample different teats and ingest colostrum (Fraser *et al.*, 1995). During the first few hours the typical cyclical pattern of nursing develops, with nursing intervals of 40-60 minutes (Castren *et al.*, 1993). The newborn piglets frequently fight to get control of highly productive teats, and a stable teat order develops within the first week. Thereafter the pigs tend to suckle at the same teat for the rest of the lactation (Fraser, 1975; Martys, 1982). After farrowing, the sow and litter stay in or near the nest for about ten days. This allows them to form a strong bond. The sow and her piglets recognize each other by smells and vocal cues (Jensen and Redbo, 1987).

After this isolation period, the sow and litter rejoin the primary maternal group (Stangel and Jensen, 1991). Reintegration involves much social activity but little overt fighting, and the social activity stabilizes about 8 weeks post-partum (Petersen *et al.*, 1989). Piglets from several litters are reared together. Social bonds among litter mates remain stronger than other bonds in the group (Newberry and Wood-Gush, 1986).

Piglets also develop dominance relationships among themselves that do not correlate with the teat order (Martys, 1991). Play amongst piglets begins within the first few days after birth and peaks between weeks 2 and 6 (Newberry and Wood-Gush, 1986; Blackshaw *et al.*, 1997). Under free-range conditions, some piglets tend to suckle from mothers other than their own (Jensen and Stangel, 1992). Whereas some piglets suckle opportunistically on several mothers, others get completely adopted and integrated into another litter (Newberry and Wood-Gush, 1986; Goetz and Troxler, 1993). Weaning in free ranging domestic pigs is a gradual process that begins 2-3 weeks after birth but is not finished until the pigs are on average 13-17 weeks, a weaning age similar to that of wild boars (Gundlach, 1968, Newberry and Wood-Gush, 1985; Jensen, 1995). It is characterized by a gradual decrease of suckling frequency and more sucklings with the sow standing (Jensen and Recén, 1989; Jensen and Stangel, 1992).

Feeding and temperature regulation

Pigs are omnivorous. The diet of wild boars and feral pigs is based on plants (grass, roots, fruit, berries, seeds), but animals such as worms, frogs and rodents may also be important (Hansen *et al.*, 1959). Foraging behaviour is closely linked to exploratory behaviour, for which the pig has a highly sensitive and well-adapted snout. Domestic pigs in a semi-natural enclosure have been noted to spend 6-8 hours per day searching for food by rooting, grazing and browsing (Wood-Gush *et al.*, 1990).

Since pigs – wild and domestic alike – have very limited sweating and panting abilities; they rely on wallowing and skin wetting for cooling in hot weather (Baldwin and Ingram, 1967). Pigs outside their thermoneutral zone adjust their lying posture to dissipate excessive heat or to limit its loss. Pigs huddle in cold weather, while a resting group will spread out when it's hot.

In summary, pigs have a highly complex behavioural repertoire. They live in stable social groups within a home range, their activities show a variable diurnal biphasic rhythm, and their exploratory behaviour is strongly developed. These facts must be considered in designing and managing housing systems for pigs.

Implications for the husbandry of pigs

Grouping

Apart from adult boars and sows around farrowing, pigs are social animals and therefore should be kept in groups. Their natural groupings are small and stable (Gundlach, 1968; Frädrieh, 1974). In commercial production, they are usually kept in larger groups and repeatedly mixed with unfamiliar individuals. It is common to group piglets from different litters after weaning and to regroup unfamiliar pigs by weight or sex during the growing and finishing phases. Problems arise from disrupted social bonds and the repeated need to rebuild a hierarchy under restricted conditions.

Thus, mixing of pigs should be avoided whenever possible. The frequency and intensity of fighting after mixing can be reduced by enriching the pen (Schaefer *et al.*, 1990; Peterson *et al.*, 1995), by providing food *ad libitum*, and by grouping after dark (Barnett *et al.*, 1996). Regrouping young piglets results in less aggression than with older ones (Jensen, 1994). Newly weaned piglets have more problems coping with unfamiliar housing than coping with unfamiliar piglets (Puppe *et al.*, 1997). Playing music or other sound provides no improvement in conditions for piglets during weaning (Cloutier *et al.*, 2000).

According to the Council Regulation (EC) No 1804/1999, sows in organic farms must be kept in groups, except in the last stage of pregnancy and during suckling. There are many group housing systems for dry sows that differ regarding grouping system, group size, feeding system, flooring and bedding. As a consequence it is not possible to make a general statement about welfare in group housing (Edwards, 2000). A 'static' (stable) grouping system minimizes disturbances of the group by limiting changes in its composition. Once a group is formed after weaning or at the beginning of pregnancy, no other sows are added and the group disbands only at farrowing. The 'dynamic' system, in contrast, regularly adds recently bred animals and removes those approaching farrowing.

'Dynamic' groups regularly result in post-regrouping aggression, but allow farms to operate with only a few larger groups. Problems with social behaviour can occur if the group has more than 100 animals. With small groups, on the other hand, space may be very limited, impairing locomotion and not allowing the animals to avoid each other (IGN-Working Group 'Group Housing of Dry Sows', 2000). Dynamic groupings can benefit by providing well-defined areas within the pen that new groups can claim as their own when being integrated into the main group (van Putten and van de Burgwal, 1990). Fighting at grouping can be reduced by regrouping sows that have already been kept in the same group before. A 'grouping arena', with adequate flooring surface and enough space, where sows can establish a hierarchy, minimizes the risk of injuries (Deininger, 1998; Deininger *et al.*, 2002). Edwards *et al.* (1993) used a central suspended barrier in a mixing pen and found that it reduced fighting. The impact of large groups on social organization and aggression is poorly understood. Whilst retaining the ability to discriminate between pen mates and foreign pigs, sows from large groups display a marked reduction in aggressive tendency towards foreign individuals (Turner *et al.*, 2001).

Since much less space is available in commercial pig production than in nature, great attention must be paid to giving each animal enough space for its behavioural requirements. Pigs prefer to separate their dunging/activity area from the lying area, choosing to lie in the most thermally comfortable and undisturbed areas and excreting in areas that are cold, wet or draughty. They need space for social interactions or to withdraw from or be out of sight of pen mates (McGlone and Curtis, 1985). Insufficient space increases agonistic interactions and the incidence of body lesions (Weng *et al.*, 1998), and reduces resting time (Ewbank and Bryant, 1969), mating rate (Hemsworth *et al.*, 1986) and weight gain and feed conversion efficiency (Brumm, 1996).

Feeding

Pigs should be allowed to eat simultaneously. If their feed is restricted, each pig should have sufficient space at the trough. *Ad libitum* feeding of weaning, growing and finishing pigs has become increasingly common because it enables the housing of large groups, which saves costs. Over the last few years several types of feeders have been developed, making it difficult to give a general recommendation about the number of pigs per trough and the number of spaces provided per group. For a tube feeder there should be no more than ten pigs per trough (Kircher, 2001). Nielsen *et al.* (1995a) found that groups of 5, 10, 15 or 20 pigs fed with single-space feeders showed no differences in the number of attempts to displace other pigs from the feeder or in production variables. Pigs in groups of 20 made fewer but longer visits to the feeder and ate more and faster than pigs in smaller groups. Pigs in groups of 10 given access to a four-space trough visited the feeder much more frequently and for shorter duration than pigs with access to a single-space feeder, but there were no differences in production variables (Nielsen *et al.*, 1995b). If pigs are fed restrictively on a ration basis, the feeding space should allow all animals to feed simultaneously to limit competition.

Dry sows typically are fed simultaneously in individual feeding stalls, or they are fed sequentially from a single or a few stalls, as in electronic feeding stations. When feed is restricted and competition for feed is not well controlled, dominant sows become fat and subordinates become thin. This causes reproductive problems and low levels of milk production. Precise rationing of each sow without aggression can only be guaranteed by individually confining the animals at feeding. When sows are fed in electronic feeding stations, aggression and feeder occupation following the start of the feeding cycle are lower with one feeding cycle per day than with two (Weber *et al.*, 1993).

Providing straw as bedding material and starting the cycle in the evening for overnight feeding may reduce aggression and feeder occupation following the start of the cycle (Jensen *et al.*, 2000). Another strategy to control competition is to feed sows *ad libitum* with a high fibre diet, which prevents them from getting fat. Sugarbeet pulp without molasses may be used to feed sows *ad libitum* during gestation without reducing productivity. However, food intake may be too high to make *ad libitum* feeding of pregnant sows an attractive option (Whittaker *et al.*, 2000). In organic farming fresh or dry fodder or silage must be added to pigs' daily rations (Council Regulation (EC) No 1804/1999). Grower pigs with access to roughage showed less aggression (Olsen *et al.*, 2002).

Flooring

To prevent injury floors must not be slippery. The roughness of the surface is important for regulating hoof growth. Smooth surfaces and deep litter systems can cause excessive hoof

growth, leading to lameness (Geyer, 1979). The floor in the lying area has to be clean, dry and comfortable. The thermal characteristics of flooring materials must be related to the thermal requirements of the pigs and the ambient temperature. In hot conditions, being cooled by the floor may be more important to the pigs than physical comfort or insulation. If pigs are kept on perforated or slatted floors, the size of the slots, the surface roughness and the edge design must be taken into account. To reduce the risk of claw injuries, bar width and slot space between bars of perforated floors need to be adjusted to the size of the pigs' claws (Geyer, 1979; Mulitze, 1989). Early weaned piglets prefer an insulated floor to a barren expanded metal or wire floor. Floors with a high ratio of solid to slotted area are preferred (Marx and Schuster, 1986).

Bedded flooring not only improves comfort, but also allows manipulatory and investigatory activities. Also, in the case of straw, it may provide dietary fibre and allow pigs to express feeding behaviour. Pigs provided with bedding (mainly straw) are reported to be more active and to exhibit increased rooting and exploratory behaviour than pigs housed on bare flooring without bedding (Fraser *et al.*, 1991; Arey and Franklin, 1995; Beattie *et al.*, 1995; Guy *et al.*, 2002). Straw bedding also reduces destructive behaviour directed at pen mates, such as tail biting, ear biting and belly nosing (Troxler, 1981; Fraser *et al.*, 1991; Beattie *et al.*, 1995; Day *et al.*, 2002). Straw or other destructible materials for investigation and manipulation should be provided whenever possible; it can be bedding material, but need not be.

The interest of pigs in manipulating artificial objects decreases with familiarity (Heizmann *et al.*, 1988). Rooting appears to be a need that is performed regardless of feeding level or nutritional feedback. This suggests that a suitable rooting substrate should be provided even for pigs that are fed *ad libitum* (Beattie and O'Connell, 2002). In preference to straw, growing pigs favour substrates that are similar in texture to soil, such as peat, mushroom compost and sawdust (Beattie *et al.*, 1997). Commercial pigs kept outdoors are often given nose rings to inhibit rooting and minimize pasture damage (see Chapter 8).

Temperature regulation

The thermoneutral zone of a pig varies with its age, size and nutritional status (Mount, 1960; 1968). Draughts, ambient temperature, floor type, bedding, and the design of the lying area all affect the pig's thermoregulation. Straw on the floor helps to maintain the temperature close to the thermoneutral zone. For finishing pigs the ambient temperature in a lying area with straw bedding should not drop below 9°C, whereas without bedding the minimum is 17°C (Mayer, 1999). At a temperature above thermoneutrality, pigs cannot dissipate heat fast enough to regulate their body temperature, and respond with reduced activity, modified lying behaviour and wallowing. As a result, the lying area may become much dirtier, especially on a concrete floor (McKinnon *et al.*, 1989). Therefore, above 18°C pigs should be provided with showers and outdoor runs (Mayer, 1999).

A wallow is another effective way for pigs to cool down. Wallowing also plays a role in skin and hair care of pigs (van Putten, 1978a). Olsen *et al.* (2001) reported that pigs used a wallow for lying and oral behaviour within the whole temperature range (-4 to +24°C), but this behaviour lasted longer above 15°C. Providing a wallow can cause problems with internal parasites if it is not cleaned regularly (Simantke, 2000). If pigs are exposed to sunshine for too long in summer, they often burn their skin. For pigs kept outside in areas without natural shade, a shelter must be provided.

Farrowing and nursing

Special emphasis should be given to the housing of farrowing and lactating sows. Under commercial conditions sows are usually moved to the farrowing accommodation 3-7 days before the expected farrowing and are penned individually. To enable them to turn around, to perform nest building behaviour and to separate their dunging area from their lying area, sows must not be confined in farrowing crates. The minimum space to allow undisturbed behaviour at the nest and to prevent piglets from being crushed is 7.5 m² (Schmid, 1992; 1993). These findings correspond with the Council Regulation (EC) No 1804/1999, according to which the minimum indoor surface area for farrowing sows in organic farming is 7.5 m².

A loose housing farrowing pen must have a lying/nest area with bedding and an activity/defaecating area. Cronin *et al.* (1998) concluded that the width of the nest area affects sow and piglet behaviour that may be relevant to piglet survival. Anti-crushing rails around the walls or inward-slipping bars to limit the area where the sow can lie can help reduce crushing of piglets. Providing straw as nest building material presumably favours piglet survival by affecting the timing and quality of nest building, reducing the duration of the first part of farrowing, and reducing nest building and postural changes during farrowing (Thodberg *et al.*, 1999).

Another important factor in the design of a farrowing pen is the type of floor, which affects the choice of the nest site and nest building behaviour. Newborn piglets often develop abrasions on their front legs from contact with the floor during suckling activity (Furniss *et al.*, 1986).

The sow and piglets are separated much earlier under commercial conditions than in nature. Several studies have shown that weaning may be a source of distress, causing an increase in vocalizations, aggression, plasmacortisol concentration and digestive disorders. Weaning piglets at seven weeks of age, as required by the Council Regulation (EC) No 1804/1999, is better than weaning earlier, but is still thought to be a problem for the piglets.

The temperature requirements of lactating sows and piglets are very different. The thermoneutral zone is likely to be around 34°C for newborn piglets and 25-30°C for 4-6 kg piglets, whereas for sows it is about 15°C (Mount, 1968). This makes it necessary to match the ambient temperature to the sows' requirements and provide a well-designed nest with straw bedding for the piglets, which can be heated with either infrared or underground heaters. Over the last few years several 'get-away pens' have been developed, such as the Schmid pen (Schmid, 1992; 1993), the FAT pen (Weber, 1996; 2000) and the Werribee pen (Cronin *et al.*, 1996; 1998). These systems usually do not have access to an outdoor run, which must be provided to all animals in organic farming according to Council Regulation (EC) No 1804/1999. However, little research has been done about the effects of an outdoor run on the behaviour and health of lactating sows and suckling piglets.

Group housing

An interesting alternative to keeping sows and piglets in farrowing pens for the whole lactation is to move them to a group pen 10-14 days after farrowing, where 3-15 sows and their litters are kept together until weaning (Algers, 1991). This system, often referred to as 'multi-suckling units', is reported to reduce aggression among sows and piglets and allow a

better design of the pen than an individual farrowing pen, especially if an outdoor run must be provided.

However, cross suckling (presence of alien piglets at the udder during milk ejection) may be a problem. Cross suckling results in more fighting amongst piglets (Pedersen *et al.*, 1998), missed nursings, and nursings without milk ejection (Arey and Sancha, 1996), and reduced milk intake and weight gain (Puppe and Tuchscherer, 1995). Cross suckling declines with decreasing group size (Fraser and Broom, 1990) and with decreasing variation in the age and size of the litters (Brodmann *et al.*, 1995).

In group farrowing systems the sows are already grouped before farrowing and give birth in small compartments within the group pen; therefore they are never moved during the lactation (van Putten and van de Burgwal, 1989; Goetz and Troxler, 1995a,b; Aray and Sancha, 1996). The mortality of piglets may be higher in these systems.

An ethological approach that aims to satisfy the motivations and behavioural requirements of domestic pigs is the 'family pen system' (Stolba and Wood-Gush, 1989; Wechsler *et al.*, 1991). It is a combined breeding, rearing and fattening system. The sows are kept in stable groups throughout production. The piglets are weaned naturally by their mother and are not removed from the family group until they have reached market weight. By this time the sows, which are served during lactation, are ready to farrow again, and the cycle is complete. Arey and Sancha (1996) reported that piglet mortality was not significantly different from farrowing crates. The pen is an adaptation of the features that released normal behaviour in a semi-natural enclosure. It contains nest areas, activity areas and rooting areas. Wechsler (1996) reported that lactational oestrus occurred in 54% of the sows before the piglets were seven weeks old; it is a problem if not all sows of a group can be mated.

Poultry (Laying hens)

Domesticated species of poultry currently kept in organic agriculture are mainly terrestrial birds of the order galliformes, the most important being chickens and turkeys. Others, such as guinea fowl and quail, play a minor role. Also important are aquatic species of the order anseriformes, such as ducks, muscovy ducks and geese. Here we concentrate on chickens, especially laying hens.

Species-specific behaviour

The ancestor of the domestic chicken, the red jungle fowl, *Gallus gallus* (with several subspecies) lives from India to Malaysia at the edges of densely covered forest areas (Fumihito *et al.*, 1996). Because it is difficult to study in its natural habitat, we also draw on studies of unconfined flocks of red jungle fowl in zoos (e.g. Collias *et al.*, 1966; Dawkins, 1989) or in pens (Fölsch, 1981b; Kruijt, 1964). We also present information on feral domestic chickens studied on two islands off Australia (McBride *et al.*, 1969) and in Scotland (Duncan *et al.*, 1978); these showed behavioural traits qualitatively consistent with those of the red jungle fowl.

Social structure

Chickens are highly social. They form comparatively stable groups (flocks of 6-30 at San Diego Zoo according to Collias *et al.*, 1966) that center their lives around a roosting site (tree) in a territory or home range of few hectares with watering places and less densely covered or

open feeding sites (Collias and Collias, 1967; Wood-Gush *et al.*, 1978). However, McBride *et al.* (1969) report that feral fowl have fixed, defended territories only during the breeding season, with overlapping home ranges around the roosting place the rest of the year.

Within the flock a dominance hierarchy is established. Breeding flocks are usually composed of 4-6 females and a dominant male, sometimes with a few subordinate males (Collias and Collias, 1967; McBride *et al.*, 1969). Females form an independent dominance hierarchy (Collias and Collias, 1996) and are rather tolerant of females from other flocks (McBride *et al.*, 1969). In domesticated chickens, status is affected by age, breed, comb size and colour, and body weight (Mench and Keeling, 2001). All behaviours (e.g. walking, preening, feeding, resting) are highly synchronized (Savory *et al.*, 1978; Mench and Keeling, 2001).

Reproduction

Red jungle fowl breed seasonally, from March to May (Collias and Collias, 1967). Before laying, hens separate from the group and start inspecting possible nesting sites (Fölsch, 1981b). By giving a nesting call the hen attracts a male who will accompany her and show her possible nests (Fölsch, 1981b; McBride *et al.*, 1969). Nests are located on the ground, covered by bushes or other structures (Collias and Collias, 1967; Duncan *et al.*, 1978). When a nest is finally chosen, the hen will scratch and turn to create a suitable shallow depression. The nest also will have a few leaves and feathers. Whilst sitting on the nest the hen throws loose material on her back or places it along her body (McBride *et al.*, 1969; Fölsch, 1981a).

Eggs are usually laid in the morning. After laying the egg, the hen quietly moves away from the nest and gives a cackle, which attracts a male to accompany her back to the flock (Fölsch, 1981a). During this occasion mating occurs (McBride *et al.*, 1969). Red jungle fowl usually have a clutch of 5-10 eggs (Collias and Collias, 1967). After the whole clutch is laid, the hen starts brooding, briefly leaving the nest only once a day (Duncan *et al.*, 1978; Fölsch, 1981b).

The chicks of a clutch hatch at nearly the same time. Chicks are nidifugous and are led out of the nest by the hen within 36 hours after the first chick is hatched (Fölsch, 1981b). Except for social and reproductive behaviour, most of the behavioural repertoire of red jungle fowl chicks (e.g. locomotion, feeding, drinking and comfort behaviour) is completely developed within the first two weeks (Kruijt, 1964). Domestic chickens already dust bathe by the third day. They fly as early as 4-5 weeks (Collias and Collias, 1967), and Wood-Gush *et al.* (1978) observed a brood at age 7 weeks roosting in a tree 7 m above the ground. Broods are left by the hen at 5-8 weeks (Wood-Gush *et al.*, 1978; Collias and Collias, 1996). Wood-Gush *et al.* (1978) observed broods of feral domestic chickens staying together in a group and integrating into the flock at age 4-5 months.

Feeding, movement and body care

Chickens are omnivorous. Red jungle fowl eat a great variety of items, including seeds, insects (caterpillars, termites, etc.), spiders, snails, leaves, grasses, and fruits (Collias and Collias, 1967). McBride *et al.* (1969) observed their population of feral domestic chickens also eating carrion. Laying hens even can be observed hunting small animals, such as mice and frogs. Chicks seem to depend mainly on animal sources of protein, such as invertebrates (Collias and Collias, 1967; Savory *et al.*, 1978). Red jungle fowl and feral domestic chickens spend half to two-thirds of the day in feeding and foraging behaviour, such as walking,

scratching and pecking (Collias and Collias, 1967; Savory *et al.*, 1978; Dawkins, 1989). Red jungle fowl usually get water from waterholes (Collias and Collias, 1967).

Chickens are very active. Locomotion is closely related to foraging, and red jungle fowl might spend more than 60% of the daytime walking even when fed *ad libitum* (Dawkins, 1989). Nevertheless, they generally move within a small area, about 140 m in diameter (Collias and Collias, 1967). Similarly McBride *et al.* (1969) report average distances of 60-150 m between roosting trees of dominant males. Red jungle fowl and feral chickens fly very little, mostly to access or leave the roosting tree or to escape. Both red jungle fowl and feral chickens roost on branches of high trees during both night and day (Collias and Collias, 1967; Wood-Gush *et al.*, 1978).

Comfort behaviour such as preening and dust bathing are important for maintaining the plumage in good conditions. Dawkins (1989) found red jungle fowl spending more than 10% of the daytime preening. Besides egg laying, dust bathing is the chicken's most complex behaviour, but so far it has been studied mainly under experimental conditions (Vestergaard *et al.*, 1997).

To summarize, chickens have a highly complex behavioural repertoire. Their behaviour is arranged in a distinctive daily pattern with peaks of activity in the morning and afternoon. Typically, they start preening before daylight, leave their night roost, go to search for food, (lay an egg in domestic hens), rest at midday, search for food again and start roosting again before sunset. Both their behaviour and daily activity pattern must be taken into account in designing and managing a hen house.

Implications for the husbandry of laying hens

Grouping

In today's organic agriculture, hens are usually kept in groups of several hundred to a thousand. Compared to the social environment usually experienced by their ancestors, this presents a considerable challenge. As described earlier, in red jungle fowl a flock usually is much smaller, allowing individual recognition and the formation of a dominance hierarchy (Pagel and Dawkins, 1997). Whether the critical group size for individual recognition is actually 100, as reported by Guhl (1953), is open to debate (Mench and Keeling, 2001).

Although there have been reports of sub-groups forming in laying hens (Bölter, 1987) or individual recognition of at least some birds (Odén *et al.*, 2000), hens probably do not form a dominance hierarchy in larger flocks (Mench and Keeling, 2001). In these flocks, hens may classify other hens by features such as comb or body size (Pagel and Dawkins, 1997) and give way to those perceived as higher in status. Hens in large flocks show little aggression, even when mixed with unfamiliar flocks (Hughes *et al.*, 1997), although in single flocks agonistic behaviour can be a problem (Gunnarsson *et al.*, 1995). Cocks seem to reduce agonistic interactions between females (Odén *et al.*, 1999). Even though commercial flocks are bigger than 'natural' red jungle fowl groups, hens seem to cope well with the larger size. Furthermore, it is very difficult to design and manage alternative systems for groups of fewer than 100 birds that take into account most of the behavioural requirements of laying hens. This does not mean, however, that group size is unimportant; for example, groups of more than 500 birds seem to use outside runs less (Hirt *et al.*, 2000; Niebuhr *et al.*, 2001)

Feeding

Feeders should be evenly distributed and easily accessible, and linear feeders should be equipped with perches over the feeding space to prevent hens from roosting in the trough. Attention should be paid to avoid having linear feeders act as barriers for the birds. This can be overcome by raising the feeding equipment in combination with raised perches or walks. Nevertheless, the birds must be carefully observed, especially at the start of laying, as birds not used to raised areas or perches may have trouble getting to the feeding trough. As many feeding systems do not truly feed *ad libitum*, because of the diurnal rhythm of food intake in laying hens feed should be plentiful, especially in late daytime hours.

Even when fed mash, laying hens spend less time feeding than red jungle fowl or feral hens spend foraging and feeding. Therefore a scratching area with adequate litter is important for the welfare of laying hens, including to prevent feather pecking and cannibalism (Appleby *et al.*, 1992; see also Chapter 8). From practical evidence, long straw seems to be the most suitable material for foraging, scratching and pecking. It remains attractive longer when given in intervals as bales, and can be manipulated and torn into smaller pieces, of which at least a part is also swallowed. Also, giving hay, silage and other materials (e.g. pecking stones), as well as scattering grain, allows foraging and keeps the hens busy.

The outdoor run also provides excellent foraging possibilities, as long as it is open for the hens during daytime, covered with vegetation, and easy to access. However, it cannot replace an indoor scratching area lit 16 hours a day. In outdoor runs hens can take in a lot of fresh plant material; Hughes and Dun (1983) found a daily intake as high as 30 g dry matter per hen. Free range areas, which now are compulsory for laying hens in organic farming, generally should have a maximum distance of 100 to 150 m from the hen house, since more distant areas are hardly used (Niebuhr *et al.*, 2001). This maximum distance corresponds closely to the distances covered by red jungle fowl in their natural habitat.

The run also should be equipped with cover, such as trees and bushes. Apart from hiding places, cover provides shade and thus roosting places at midday. To prevent excessive vegetation use and nutrient loading, a rotation system must be used (at least two runs of 4 m² each), thereby also reducing the risk of parasitic infection. Especially during bad weather and in winter, a covered run ('bad weather run', 'winter garden') is an excellent addition to deep litter or aviary systems with access to a free range area. It provides an extra area for scratching and pecking all year round and thus reduces stocking density in the hen house. Furthermore, it allows sun bathing and can be equipped with boxes of sand for dust bathing, thereby decreasing the amount of dust produced in the hen house.

As feeding and drinking are closely associated (Fölsch, 1981a), drinkers should be close to the feeders. Given a choice, hens generally prefer open water surfaces, as in bell or cup drinkers, rather than nipple drinkers. Drinking from nipples is not a natural behaviour and must be learned, but switching from nipple to bell drinkers also may cause problems (Appleby *et al.*, 1992). Rearing facilities should therefore be equipped with drinkers of various types, or at least the type that the hens will later find in the hen house.

Body care, nesting and sleeping

Apart from physical space, comfort behaviour mainly requires two facilities within a hen house: raised areas or perches for preening, and litter for dust bathing. Although free range hens can dust bathe in the run, a separate large box with sand should be present in the hen

house or the ‘winter garden’. Sand seems to be preferred to wood shavings or straw (Sanotra *et al.*, 1995), but remains attractive only if the boxes are refilled regularly.

Perches are not only a preferred site for laying hens to preen, but also the most important facility for roosting and sleeping, especially at night (Blokhuys, 1984). Higher perches are generally preferred (e.g. Olsson and Keeling, 2000). Series of perches should not be positioned steeper than 45°, as the birds may have problems in descending (Lambe *et al.*, 1997). In adult laying hens, raised perches reduce the number of birds on the floor and lead to less agonistic interaction (Cordiner and Savory, 2001). Perches higher than 70 cm also could reduce feather damage (Wechsler and Huber-Eicher, 1998). Raised perches are especially important during early rearing, as rearing without perches leads to poorer spatial ability later in life (Fröhlich, 1991; Gunnarsson *et al.*, 2000). It also increases the probability of feather pecking (Huber-Eicher and Audigé, 1999), cannibalism (Fröhlich, 1991; Gunnarsson *et al.*, 1999) and floor eggs in adult hens (Appleby *et al.*, 1988a; Gunnarsson *et al.*, 1999).

Floor eggs are an important problem in alternative systems, as they are often dirty or broken, which further encourages egg eating (Appleby *et al.*, 1992). To prevent floor laying, nests should be easy accessible but separated from the areas of activity. Nests with litter are preferred over rollaway nests (Appleby *et al.*, 1988b). Apart from rearing factors, nest site selection and floor laying are influenced by age, genotype, social structure, layout of the hen house and nests, number of nests (or area) per hen, and management (Bauer, 1995). Dark and enclosed sites in the littered area should be avoided (Appleby *et al.*, 1992). Raised nests should have at least two perches or a slatted area in front to let the hens inspect them.

As with other species, facilities for laying hens should be structured into functional areas corresponding to functional behavioural systems such as feeding, egg laying, drinking, roosting and foraging. Use of each area should be limited to a certain behavioural system, e.g. areas intended for roosting should not be equipped with feeders, and scratching areas should be sufficiently lighted to prevent egg laying in the litter and allow explorative behaviour.

Conclusions for organic animal husbandry – current knowledge, current systems and future requirements

Although ethology, the study of animal behaviour, has made considerable progress towards understanding what animal welfare is and how animals must be kept to have a high quality of life, in many systems major elements of natural behaviour cannot be performed, leading to welfare problems. But how far we should go in offering the animals a ‘natural’ environment is still a matter for debate. Whilst a tree that is used for rubbing is easily replaced by a brush, there are no artificial replacements for calves or piglets. Thus, is it acceptable to separate the calf from the cow or the piglet from the sow much earlier than would happen in nature? Is it acceptable to frequently separate individual animals that have bonded together, exposing them to stress and reducing the possibilities of social support? Of course, we always will have to interfere with ‘natural behaviour’, but we have the responsibility of balancing our own interests with those of the animals. We need to think much more about where the boundaries are to be drawn so that both the animals and the humans have lives of quality and can mutually enrich each other’s.

A step towards enabling all natural behaviour was made many years ago in pigs, with the Stolba family pen system (described earlier), where the pigs are provided not only with all relevant features of the physical environment, but also a social structure similar to nature’s.

However, although the first version was developed two decades ago, little research has been done on this system. In dairy cows, only recently have efforts been undertaken to avoid early separation of calves and cows, which is accepted by most organic standards. Pilot work in this area and some practical experience are promising. However, to make it acceptable economically, contact between cow and calf is allowed only part of the time or only for the first three weeks of life. Some farmers have already gone further, integrating calves and young stock into the dairy herd, thereby approaching a natural social structure.

There are many other areas where further research is needed to solve existing problems or to move toward a higher quality of life, e.g. keeping ducks, geese and hens as egg layers in free range systems, raising sows and fattening pigs outdoors, using males rather than artificial insemination, keeping males with the herds, and not castrating males.

Taking seriously the values of naturalness and the holistic view of the organic movement means that it is not enough that the animals can fulfil their needs in a minimal fashion. A major challenge for organic husbandry is not only to optimize current systems by using existing ethological knowledge, but also to develop more innovative systems in which all aspects of natural behaviour are taken into account. Beyond avoiding suffering, such systems make positive experiences an important part of the animal's life. It is not important to 'prove' that a sow needs to root or a hen needs to dust bathe, because these are natural behaviours belonging to the animal's species-specific nature. Rather, researchers and farmers should concentrate on answering more detailed questions to help use our understanding of animals' nature (e.g. Kiley-Worthington, 1993). This will make respect for and knowledge of animal behaviour the basis for a sustainable organic agriculture.

References

- Algers, B. (1991) Group housing of farrowing sows - health aspects of a new system. In: *Proceedings VII International Congress on Animal Hygiene, Leipzig*, p. 851.
- Algers, B. (1992) Natürliches Verhalten - ein natürlicher Begriff? *Berliner Münchner Tierärztliche Wochenschrift* 105, 372-374.
- Appleby, M.C., Duncan, I.J.H. and McRae, H.E. (1988a) Perching and floor laying by domestic hens: Experimental results and their commercial application. *British Poultry Science* 29, 351-357.
- Appleby, M.C., Hogart, G.S. and Hughes, B.O. (1988b) Nest box design and nesting material in a deep litter house for laying hens. *British Poultry Science* 29, 215-222.
- Appleby, M.C., Hughes, B.O. and Elson, H.A. (1992) *Poultry Production Systems. Behaviour, Management and Welfare*. CAB International, Wallingford, UK, 238pp.
- Arey, D.S. and Franklin, M.F. (1995) Effects of straw and unfamiliarity on fighting between newly mixed growing pigs. *Applied Animal Behaviour Science* 45, 23-30.
- Arey, D.S. and Sancha, E.S. (1996) Behaviour and productivity of sows and piglets in a family system and in crates. *Applied Animal Behaviour Science* 50, 135-145.
- Arnold, G.W. and Dudzinski, M.L. (1978) *Ethology of Free-Ranging Domestic Animals*.

Elsevier, Amsterdam.

Baldwin, B.A. and Ingram, D.L. (1967) Behavioural thermoregulation in pigs. *Physiology and Behaviour* 2, 15-21.

Barnett, J.L. and Taylor, I.A. (1997) Sequential versus concurrent feeding on acute and chronic stress responses in pigs. In: *Fifth International Livestock Environment Symposium*. American Society of Agricultural Engineers, St. Joseph, Michigan, USA, pp. 607-612.

Barnett, J.L., Cronin, G.M., McCallum, T.H., Newman, E.A. and Hennessy, D.P. (1996) Effects of grouping unfamiliar adult pigs after dark, after treatment with Amperozide and by using pens with stalls, on aggression, skin lesions and plasma cortisol concentrations. *Applied Animal Behaviour Science* 50, 121-133.

Bauer, T. (1995) Ergebnisse von Untersuchungen zum Nestwahlverhalten von Legehennen in alternativen Haltungssystemen. Thesis, Humboldt Universität, Berlin, Germany.

Beattie, V.E. and O'Connell, N.E. (2002) Relationship between rooting behaviour and foraging in growing pigs. *Animal Welfare* 11, 295-303.

Beattie, V.E., Walker, N. and Sneddon, I.A. (1995) Effects of environmental enrichment on behaviour and productivity of growing pigs. *Animal Welfare* 4, 207-220.

Beattie, V.E., Walker, N. and Sneddon, I.A. (1997) Preference testing of substrates by growing pigs. *Animal Welfare* 7, 27-34.

Beilharz, R.G. and Cox, D.F. (1967) Social dominance in swine. *Animal Behaviour* 15, 117-22.

Bendixen, P.H., Vilson, B., Ekesbo, I. and Åstrand, D.B. (1988a) Disease frequency in dairy cows in Sweden V. Mastitis. *Preventive Veterinary Medicine* 5, 263-274.

Bendixen, P.H., Vilson, B., Ekesbo, I. and Åstrand, D.B. (1988b) Disease frequency in dairy cows in Sweden VI. Tramped teat. *Preventive Veterinary Medicine* 6, 25.

Bertschinger, H.U., Drossaert van Dusseldorp, P. and Troxler, J. (1994) Incidence of intramammary infection and of mastitis in sows kept in four different farrowing systems. In: *Proceedings of the 8th International Congress on Animal Hygiene, 12-16 September 1994*. International Society for Animal Hygiene, St. Paul, Minnesota, USA, pp. 93-96.

Blackshaw, J.K., Swain, A.J., Thomas, F.J.M. and Gillies, K.J. (1997) The development of playful behaviour in piglets from birth to weaning in three farrowing environments. *Applied Animal Behaviour Science* 55, 37-49.

Blokhuys, H.J. (1984) Rest in poultry. *Applied Animal Behaviour Science* 12, 289-303.

Boden, R.F. and Leaver, J.D. (1994) A dual purpose cattle system combining milk and beef production. *Animal Production* 58, 463-464.

Boivin, X., LeNeindre, P., Chupin, J.M., Garel, J.P. and Trillat, C. (1992) Influence of breed and early management on ease of handling and open-field behaviour of cattle. *Applied Animal Behaviour Science* 32, 313-323

Bölter, U. (1987) Felduntersuchungen zum Sozialverhalten von Hühnern in der Auslauf- und Volierenhaltung. Thesis, Justus-Liebig-Universität Giessen, Germany.

Boxberger, J. (1983) *Wichtige Verhaltensparameter von Kühen als Grundlage zur Verbesserung der Stalleinrichtung*. Forschungsbericht Agrartechnik der MEG, Weihenstephan.

Brelvi, B. (1979) Mixed grazing with sheep and cattle compared with single grazing. *Swedish Journal of Agricultural Research* 9, 112-120.

Briedermann, L. (1971) Ermittlung zur Aktivitätsperiodik des mitteleuropäischen Wildschweines (*Sus s. scrofa* L.). *Zool. Garten N.F., Leipzig* 40, 302-327.

Brodmann, N., Wechsler, B. and Rist, M. (1995) Strategien von fremdsaugenden Ferkeln bei der Gruppenhaltung von ferkelführenden Sauen. In: *Aktuelle Arbeiten zur artgemäßen Tierhaltung 1994. KTBL-Schrift* 370, 237-246.

Broom, D.M. (1986) Indicators of poor welfare. *British Veterinary Journal* 142, 524-526.

Broom, D.M. (1992) Animal welfare: its scientific measurement and current relevance to animal husbandry in Europe. In: Phillips, C. and Piggins, D. (eds) *Farm Animals and the Environment*. CAB International, pp. 245-254.

Brumm, M.C. (1996) Effect of space allowance on barrow performance to 136 kilograms body weight. *Journal of Animal Science* 74, 745-749.

Buchholz, C. (1993) Das Handlungsbereitschaftsmodell - ein Konzept zur Beurteilung und Bewertung von Verhaltensstörungen. In: Martin, G. (ed.) *Leiden und Verhaltensstörungen bei Tieren. Tierhaltung* 23, Birkhäuser Verlag, Basel, pp. 93-109

Buchwalder, T., Wechsler, B., Hauser, R., Schaub, J. and Friedli, K. (2000) Liegeplatzqualität für Kühe im Boxenlaufstall im Test. *Agrarforschung* 7, 292-296.

Carlstead, K. (1986) Predictability of feeding: its effect in agonistic behaviour and growth in grower pigs. *Applied Animal Behaviour Science* 16, 25-38.

Castren, H., Algers, B., de Passillé, A.M., Rushen, J. and Uvnäs-Moberg, K. (1993) Early milk ejection, prolonged parturition and periparturient oxytocin release in the pig. *Animal Production* 57, 465-471.

Chaplin, S.J., Tierney, G., Stockwell, C., Logue, D.N. and Kelly, M. (2000) An evaluation of mattresses and mats in two dairy units. *Applied Animal Behaviour Science* 66, 263-272.

Cloutier, S., Weary, D.M. and Fraser, D. (2000) Can ambient sound reduce distress in piglets during weaning and restraint? *Journal of applied Animal Welfare Science* 3, Vol. 2:107-116.

Collias, N.E. and Collias, E.C. (1967) A field study of the Red Jungle Fowl in north-central India. *The Condor* 69, 360-386.

Collias, N.E. and Collias, E.C. (1996) Social organization of a red junglefowl, *Gallus gallus*, population related to evolution theory. *Animal Behaviour* 51, 1137-1354.

Collias, N.E., Collias, E.C., Hunsaker, D. and Minning, L. (1966) Locality fixation, mobility and social organization within an unconfined population of Red Jungle Fowl. *Animal Behaviour* 14, 550-559.

Cordiner, L.S. and Savory, C.J. (2001) Use of perches and nestboxes by laying hens in relation to social status, based on examination of consistency of ranking orders and frequency of interaction. *Applied Animal Behaviour Science* 71, 305-317.

Cronin, G.M., Simpson, G.J. and Hemsworth, P.H. (1996) The effects of the gestation and farrowing environments on sow and piglet behaviour and piglet survival and growth in early lactation. *Applied Animal Behaviour Science* 46, 175-192.

Cronin, G.M., Dunsmore, B. and Leeson E. (1998) The effects of farrowing nest size and width on sow and piglet behaviour and piglet survival. *Applied Animal Behaviour Science* 60, 331-345

Darwin, C. (1859) *The Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle of Life*. John Murray, London, 502pp.

Dawkins, M.S. (1989) Time budgets in red junglefowl as a baseline for the assessment of welfare in domestic fowl. *Applied Animal Behaviour Science* 24, 77-80.

Day, J.E.L., Burfoot, A., Docking, C.M., Whittaker, X., Spoolder, H.A.M. and Edwards, S.A. (2002) The effects of prior experience of straw and the level of straw provision on the behaviour of growing pigs. *Applied Animal Behaviour Science* 76, 189-202.

Deininger, E. (1998) Beeinflussung der aggressiven Auseinandersetzungen beim Gruppieren von abgesetzten Sauen. *FAT-Schrift* 49, Tänikon, Switzerland.

Deininger, E., Friedli, K. and Troxler, J. (2002) Gruppieren von Sauen nach dem Absetzen. *Tierärztliche Umschau* 57, 234-238.

de Passillé, A.M. (2001) Sucking motivation and related problems in calves. *Applied Animal Behaviour Science* 72, 175-187.

Désiré, L., Boissy, A. and Veissier, I. (2002) Emotions in farm animals: a new approach to animal welfare in applied ethology. *Behaviour Proceedings* 60, 165-180.

Dickinson A. (1980) *Contemporary Animal Learning Theory*. Cambridge University Press, Cambridge, 120pp.

Duncan, I.J.H., Savory, C.J. and Wood-Gush, D.G.M. (1978) Observations on the reproductive behaviour of domestic fowl in the wild. *Applied Animal Ethology* 4, 29-42.

EC Council Regulation (1999) Council Regulation (EC) No 1804/1999 of 19 July 1999 supplementing Regulation (EEC) No 2092/91 on organic production of agricultural products and indications referring thereto on agricultural products and foodstuffs to include livestock production (OJ L 222 of 24.8.1999) *Official Journal L* 083, 04/04/2000 P. 0035 - 0035 EN.

Edwards, S. (2000) Alternative housing for sows: System studies or component analyses? In: Blokhuis, H.J., Ekel, E.D. and Wechsler, B. (eds) *Improving Health and Welfare in Animal*

Production. EAAP Publication No. 102. Wageningen, pp. 99-107.

Edwards, S.A., Mauchline, S. and Stewart, A.H. (1993) Designing pens to minimise the aggression when sows are mixed. *Farm Building Progress* 113, 20-23.

Egle, B., Meier, K., Richter, T. and Von Borell, E.H. (1999) Gegenseitiges Besaugen von Kälbern unter dem Einfluss von Glucosezufütterung. In: *Aktuelle Arbeiten zur artgemäßen Tierhaltung 1998. KTBL-Schrift* 382, 137-145.

Ewbank, R. (1976) Social hierarchy in suckling and fattening pigs: a review. *Livestock Production Science* 3, 363-372.

Ewbank, R. and Bryant, M.J. (1969) The effects of population density upon the behaviour and economic performance of fattening pigs. *Farm Building Progress* 18, 14-15.

Ewbank, R., Meese, G.B. and Cox, J.E. (1974) Individual recognition and the dominance hierarchy in the domestic pig. The role of sight. *Animal Behaviour* 22, 473-480.

Flower, F.C. and Weary, D.M. (2001) Effects of early separation on the dairy cow and calf: 2. Separation at 1 day and 2 weeks after birth. *Applied Animal Behaviour Science* 70, 275-284.

Fölsch, D.W. (1981a) Das Verhalten von Legehennen in unterschiedlichen Haltungssystemen unter Berücksichtigung der Aufzuchtmethoden. In: Fölsch, D.W. and Vestergaard, K. (eds) *The Behaviour of Fowl. The Normal Behaviour and the Effect of Different Housing Systems and Rearing Methods*. Tierhaltung 12, Birkhäuser Verlag, Basel, pp. 9-114.

Fölsch, D.W. (1981b) Die Veranlagung zum Brutverhalten und zur Aufzucht von Leghorn-Hybriden und Bankiva-Hühnern. In: Fölsch, D.W. and Vestergaard, K. (eds) *The Behaviour of Fowl. The Normal Behaviour and the Effect of Different Housing Systems and Rearing Methods*. Tierhaltung 12, Birkhäuser Verlag, Basel, pp. 133-143.

Frädrich, H. (1965) Zur Biologie und Ethologie des Warzenschweines (*Phacochoerus aethiopicus*) unter Berücksichtigung des Verhaltens anderer Suiden. *Zeitschrift für Tierpsychologie* 22, 328-393.

Frädrich, H. (1974) A comparison of behaviour in the suidae. In: *The Behaviour of Ungulates and Its Relation to Management*. IUCN Pub. 24:133-143, Morgues.

Fraser, D. (1975) The 'teat order' of suckling pigs. II. Fighting during suckling and the effects of clipping the eye teeth. *Journal of Agricultural Science, Camb.* 84, 393-399.

Fraser, A.F. and Broom, D.M. (1990) Feeding. In: *Farm Animal Behaviour and Welfare*, 3rd ed. CAB International, Wallingford, UK, pp. 79-98.

Fraser, D., Phillips, P.A., Thompson, B.K. and Tennessen, T. (1991) Effect of straw on the behaviour of growing pigs. *Applied Animal Behaviour Science* 30, 307-318.

Fraser, D., Phillips, P.A., Thompson, B.K., Pajor, E.A., Weary, D.M. and Braithwaite, L.A. (1995) Behavioural aspects of piglet survival and growth. In: Varley, M.A. (ed.) *The Neonatal Pig - Development and Survival*. CAB International, Wallingford, UK, pp. 287-312.

Fraser, D., Weary, D.M., Pajor, E.A. and Milligan, B.N. (1997) A scientific conception of

animal welfare that reflects ethical concerns. *Animal Welfare* 6, 187-205.

Fröhlich, E.K.F. (1991) Zur Bedeutung erhöhter Sitzstangen und räumlicher Enge während der Aufzucht von Legehennen. In: *Aktuelle Arbeiten zur artgemäßen Tierhaltung 1990*. *KTBL-Schrift* 344, 36-46.

Fumihito, A., Miyake, T., Takada, M., Shingu, R., Endo, T., Gojobori, T., Kondo, N. and Ohno, S. (1996) Monophyletic origin and unique dispersal patterns of domestic fowls. *Proceedings of the National Academy of Sciences, USA*, 93, 6792-6795.

Furniss, S.J., Edwards, S.A., Lightfoot, A.L. and Spechter, H.H. (1986) The effect of floor type in farrowing pens on pig injury. I. Leg and teat damage of suckling piglets. *British Veterinary Journal* 142, 434-440.

Galindo, F. and Broom, D.M. (1994) How does social behaviour of dairy cows affect the occurrence of lameness? *Applied Animal Behaviour Science* 41, 272-272.

Geyer, H. (1979) Morphologie und Wachstum der Schweineklaue. Grundlagen für Stallbodengestaltung und Klauenpathologie. *Schweizer Archiv für Tierheilkunde* 121, 275-293.

Githigia, S.M., Thamsborg, S.M. and Larsen, M. (2001) Effectiveness of grazing management in controlling gastrointestinal nematodes in weaner lambs on pasture in Denmark. *Veterinary Parasitology* 99, 15-27.

Goetz, M. and Troxler, J. (1993) Farrowing and nursing in the group. In: Collins, E. and Boon, C. (eds) *Livestock Environment IV*. American Society of Agricultural Engineers, St. Joseph, Michigan, USA, p. 159.

Goetz, M. and Troxler, J. (1995a) Sauen in Gruppen während der Geburt und Säugezeit. *FAT-Schrift* 50, Tänikon, Switzerland.

Goetz, M. and Troxler, J. (1995b) Group housing of sows during farrowing and lactation. *Transaction of the ASAE* 38, 1495-1500.

Graf, B., Verhagen, N. and Sambras, H.H. (1989) Reduzierung des Ersatzsaugens bei künstlich aufgezogenen Kälbern durch Fixierung nach dem Tränken oder Verlängerung der Saugezeit. *Züchtungskunde* 61, 384-400.

Grandin, T. (1989) Behavioural principles of livestock handling. *The Professional Animal Scientist* 5, 1-11.

Grandin, T. (1993a) Behavioural principles of cattle handling under extensive conditions. In: Grandin, T. (ed.) *Livestock Handling and Transport*. CAB International, Wallingford, UK, pp. 43-58.

Grandin, T. (1993b) Handling facilities and restraint of range cattle. In: Grandin, T. (ed.) *Livestock Handling and Transport*. CAB International, Wallingford, UK.

Grauvogl, A. (1958) Über das Verhalten der Hausschweine mit besonderer Berücksichtigung des Fortpflanzungsverhaltens. Thesis, Freie Universität Berlin.

Graves, H.B. (1984) Behaviour and ecology of wild and feral swine (*Sus scrofa*). *Journal of Animal Science* 58, 482-492.

Guhl, A.M. (1953) Social behaviour of the domestic fowl. *Kansas Agricultural Experimental Station Technical Bulletin* 73, 1-48.

Gundlach, H. (1968) Brutfürsorge, Brutpflege, Verhaltensontogenese und Tagesperiodik beim Europäischen Wildschwein (*Sus scrofa* L.). *Zeitschrift für Tierpsychologie* 25, 955 - 995.

Gunnarsson, S., Odén, K., Algers, B., Svedberg, J. and Keeling, L. (1995) *Poultry Health and Behaviour in a Tiered System for Loose Housed Layers*. Report 35, Department of Animal Hygiene, Swedish University of Agricultural Sciences, Skara.

Gunnarsson, S., Keeling, L.J. and Svedberg, J. (1999) Effect of rearing factors on the prevalence of floor eggs, cloacal cannibalism and feather pecking in commercial flocks of loose housed laying hens. *British Poultry Science* 40, 12-18.

Gunnarsson, S., Yngvesson, J., Keeling, L.J. and Forkman, B. (2000) Rearing without early access to perches impairs the spatial skills of laying hens. *Applied Animal Behaviour Science* 67, 217-228.

Guy, J.H., Rowlinson, P., Chadwick, J.P. and Ellis, M. (2002) Behaviour of two genotypes of growing-finishing pig in three different housing systems. *Applied Animal Behaviour Science* 75, 193-206.

Hafez, E.S.E. and Bouissou, M.F. (1975) The behaviour of cattle. In: Hafez, E.S.E. (ed.) *The Behaviour of Domestic Animals*. Balliere Tindall, London, pp. 203-245.

Hafez, E.S.E., Schein, M.W. and Ewbank, R. (1963) The behaviour of cattle. In: Hafez, E.S.E. (ed.) *The Behaviour of Domestic Animals*. Balliere Tindall, London, pp. 247-296.

Hall, S.J.G. and Moore, G.F. (1986) Feral cattle of Swona, Orkney Islands. *Mammal Review* 16, 89-96.

Hansen, R.P. and Karstad, L. (1959) Feral swine in the south-eastern United States. *Journal of Wildlife Management* 23, 64-74.

Hansen, K., Pallesen, C.N. and Chastain, J.P. (1998) Dairy cow pressure on self-locking feed barriers. *Proceedings of the 4th International Dairy Housing Conference*. St. Louis, Missouri, USA, pp. 312-319.

Hasegawa, N., Nishiwaki, A., Sugawara, K. and Ito, I. (1997) The effects of social exchange between two groups of lactating primiparous heifers on milk production, dominance order, behavior and adrenocortical response. *Applied Animal Behaviour Science* 51, 15-27.

Heizmann, V., Hauser, C. and Mann, M. (1988) Zum Erkundungs- und Spielverhalten juveniler Hausschweine in der Stallhaltung. In: *Aktuelle Arbeiten zur artgemäßen Tierhaltung 1987*. KTBL-Schrift 323, 243-265.

Hemsworth, P.H. and Coleman, G.J. (1998) *Human-Livestock Interactions: The Stockperson and the Productivity and Welfare of Intensively Farmed Animals*. CAB International,

Wallingford, UK.

Hemsworth, P.H., Barnett, J.L., Hansen, C. and Winfield, C.G. (1986) Effects of social environment on welfare status and sexual behaviour of female pigs. II. Effects of space allowance. *Applied Animal Behaviour Science* 16, 259-267.

Hemsworth, P.H., Coleman, G.J., Barnett, J.L. and Borg, S. (2000) Relationships between human-animal interactions and productivity of commercial dairy cows. *Journal of Animal Science* 78, 2821-2831.

Henry, J.P. and Stephens, P.M. (1977) *Stress, Health, and the Social Environment*. Springer, London.

Hirt, H., Hördegen, P. and Zeltner, E. (2000) Laying hen husbandry: group size and use of hen-runs. In: Alföldi, T., Lockeretz, W. and Niggli, U. (eds) *IFOAM 2000 – The World Grows Organic. Proceedings of the 13th International IFOAM Scientific Conference*, Basel, 28-31 August 2000. VDF, Zürich, p. 363.

Hörning, B. (1998) Tiergerechtigkeit und Tiergesundheit in ökologisch wirtschaftenden Betrieben. *Deutsche Tierärztliche Wochenschrift* 105, 313-321.

Hörning, B. (2002) Vergleich von Milchviehlaufstallsystemen unter nutztierethologischen und wirtschaftlichen Gesichtspunkten. Habilitation, Universität Gesamthochschule Kassel, Witzenhausen, Germany.

Hörning, B. and Tost, J. (2001) Lying behaviour of dairy cows in different loose housing system. In: *Proceedings of the International Symposium, Animal Welfare Considerations in Livestock Housing Systems*. 2nd Technical Section of the International Commission of Agricultural Engineering (C.I.G.R.), Zielona Góra, Poland, pp.229-238.

Hörning, B., Zeitlmann, C. and Tost, J. (2001) Unterschiede im Verhalten von Milchkühen im Liegebereich verschiedener Laufstallsysteme. In: *Aktuelle Arbeiten zur artgemäßen Tierhaltung 2000. KTBL-Schrift* 403, 153-162.

Hovi, M. (1998) A new approach to calf rearing. *Organic Farming* 60, 18-19.

Hsia, L.C. and Wood-Gush, D.G.M. (1984) The relationship between social facilitation and feeding behaviour in pigs. *Applied Animal Ethology* 8, 410.

Huber-Eicher, B. and Audigè, L. (1999) Analysis of risk factors for the occurrence of feather pecking in laying hen growers. *British Poultry Science* 40, 599-604.

Hudson, S.J. (1977) Multi-fostering of calves onto nurse cows at birth. *Applied Animal Ethology* 3, 57-63.

Hughes, B.O. and Dun, P. (1983) Production and behaviour of laying domestic fowls in outside pens. *Applied Animal Ethology* 11, 201.

Hughes, B.O., Carmichael, N.L., Walker, A.W. and Grigor, P.N. (1997) Low incidence of aggression in large flocks of laying hens. *Applied Animal Behaviour Science* 54, 215-234.

IGN-Working Group 'Group Housing of Dry Sows' (2000) *Report on the IGN-Workshop*

Group Housing of Dry Sows, 9-11 September 1998. Bundesanstalt für Alpenländische Landwirtschaft.

Jensen, P. (1980) An ethogram of social interaction pattern in group-housed dry sows. *Applied Animal Ethology* 6, 341-350.

Jensen, P. (1982) An analysis of agonistic interaction patterns in group-housed dry sows: aggression regulation through an 'avoidance order'. *Applied Animal Ethology* 9, 47-61.

Jensen, P. (1986) Observations on the maternal behaviour of free-ranging domestic pigs. *Applied Animal Behaviour Science* 16, 131-142.

Jensen, P. (1993) Nest building in domestic sows: the role of external stimuli. *Animal Behaviour* 45, 351-358.

Jensen, P. (1994) Fighting between unacquainted pigs. Effects of age and of individual reaction pattern. *Applied Animal Behaviour Science* 41, 37-52.

Jensen, P. (1995) The weaning process of free-ranging domestic pigs: within-and between-litter variations. *Ethology* 100, 14-25.

Jensen, P. and Recén, B. (1989) When to wean - observations from free-ranging domestic pigs. *Applied Animal Behaviour Science* 23, 49-60.

Jensen, P. and Redbo, I. (1987) Behaviour during nest leaving in free-ranging domestic pig. *Applied Animal Behaviour Science* 18, 355-362.

Jensen, P. and Stangel, G. (1992) Behaviour of piglets during weaning in a semi-natural enclosure. *Applied Animal Behaviour Science* 33, 227-238.

Jensen, P. and Toates, F.M. (1993) Who needs 'behavioural needs'? Motivational aspects of the needs of animals. *Applied Animal Behaviour Science* 37, 161-181.

Jensen, P. and Wood-Gush, D.G.M. (1984) Social interactions in a group of free-ranging sows. *Applied Animal Behaviour Science* 12, 327-337.

Jensen, K.H., Sørensen, L.S., Bertelsen, D., Pedersen, A.R., Jørgensen, E., Nielsen, N.P. and Vestergaard, K.S. (2000) Management factors affecting activity and aggression in dynamic group housing systems with electronic sow feeding: a field trial. *Animal Science* 71, 535-545.

Jones, G. F. (1998) Genetic aspects of domestication, common breeds and their origin. In: Ruvinsky, A. and Rothschild, M. F. (eds) *The Genetics of the Pig*. CAB International, Oxon, UK, pp. 17-50.

Jung, J. and Lidfors, L. (2001) Effects of milk, milk flow and access to a rubber teat on cross-sucking and non-nutritive sucking in dairy calves. *Applied Animal Behaviour Science* 72, 201-213.

Keil, N.M. (2000) Development of intersucking in dairy heifers and cows. Dissertation, Swiss Federal Institute of Technology, Zürich.

Keil, N.M. and Langhans, W. 2001. The development of intersucking in dairy calves around

weaning. *Applied Animal Behaviour Science* 72, 295-308.

Keil, N.M., Audigé, L. and Langhans, W. (2000) Factors associated with intersucking in Swiss dairy heifers. *Preventive Veterinary Medicine* 45, 305-323.

Kiley, M. (1976) Fostering and adoption in beef cattle. *British Cattle Breeders Digest* 31, 42-55.

Kiley-Worthington, M. (1977) *Behavioural Problems of Agricultural Animals*. Oriel Press, Stocksfield, UK. 103pp.

Kiley-Worthington, M. (1989) Ecological, ethological and ethically sound environments for animals: Toward symbiosis. *Journal of Agricultural Ethics* 2, 232-247.

Kiley-Worthington, M. (1993) *Eco-Agriculture, Food First Farming*. Souvenir Press, London, 274pp.

Kiley-Worthington (1995) The future of the dairy industry. Can we overcome the environmental, ethological and ethical problems? If so how? In: *3rd International Dairy Housing Conference, Orlando, Florida*, pp. 524-532.

Kiley-Worthington, M. and de la Plain, S. (1983) *The Behaviour of Beef Suckler Cattle*. Birkhäuser Verlag, Basel.

Kiley-Worthington, M. and Randle, H. D. (1997) The practicalities and economics of ethologically and ecologically raised double suckled beef. *Biological Agriculture and Horticulture* 16, 381-393.

Kircher, A. (2001) Untersuchung zum Tier-Fressplatzverhältnis bei der Fütterung von Aufzuchtferkeln und Mastschweinen an Rohrbreiautomaten unter dem Aspekt der Tiergerechtheit. *FAT-Schrift* 53, Tänikon, Switzerland.

Klingholz, F., Siegert, C. and Meynhardt, H. (1979) Die akustische Kommunikation des Europäischen Wildschweines (*Sus scrofa* L.). *Der Zoologische Garten* 49, 277-303)

Knierim, U. (1998) Wissenschaftliche Untersuchungsmethoden zur Beurteilung der Tiergerechtheit. In: *Beurteilung der Tiergerechtheit von Haltungssystemen. KTBL-Schrift* 377, 40-48.

Knierim, U. (1999a) Das Verhalten von Färsen bei der Einzel- oder Gruppeneinführung in die Milchviehherde. In: *Aktuelle Arbeiten zur artgerechten Tierhaltung 1998. KTBL-Schrift* 382, 115-120.

Knierem (1999b) Social and resting behaviour of heifers after single or group introduction to the dairy herd. In: Veissier, I. and Boissy, A. (eds) *Proceedings of the 32nd International Congress of the ISAE, Clermont-Ferrand*, p. 153.

Konggaard, S.P. (1983) Feeding conditions in relation to welfare for cows in loose- housing systems. In: Baxter, S.H., Baxter, M.R. and MacCormack, J.A.D. (eds) *Farm Animal Housing and Welfare*. Martin Nijhoff Publishers, Boston, USA, pp. 272-282.

Krohn, C.C. (2001) Effects of different suckling systems on milk production, udder health,

reproduction, calf growth and some behavioural aspects in high producing dairy cows – a review. *Applied Animal Behaviour Science* 72, 271-280.

Krohn, C.C., Jonassen, B. and Munksgaard, L. (1990) Cow-calf relations III. The effect of 6-8 weeks suckling on behaviour of the cow, milk production and udder health and reproduction. Report from the National Institute of Animal Science, Fredriksberg, Denmark.

Krötzl H. und Hauser R. (1997) Ethologische Grundlagen zum Platzbedarf, zur Gestaltung und zum Betrieb von Laufhöfen bei Kühen im Laufstall. *Agrartechnische Forschung* 3, 141.

Kruijt, J.P. (1964) Ontogeny of social behaviour in burmese red junglefowl. *Behaviour*, Supplement XII. Brill, Leiden, The Netherlands.

Lambe, N.R., Scott, G.B. and Hitchcock, D. (1997) Behaviour of laying hens negotiating perches at different heights. *Animal Welfare* 6, 29-41.

Lazo, A. (1994) Social segregation and the maintenance of social stability in a feral cattle population. *Animal Behaviour* 48, 1133-1141.

Le Neindre, P. (1982) Cow-calf relationships: The effect of management systems. In: Signoret, P. (ed.) *Welfare and Husbandry of Calves*. Martin Nijhoff Publishers, Boston, USA, pp. 24-35.

Le Neindre, P. and Garel, J.-P. (1979) Adoption of foster calves by Salers cows several days after calving. *Annales de Zootechnie* 28, 231-234.

Lensink, J., Fernandez, X., Cozzi, G., Florand, L. and Veissier, I. (2001) The influence of farmers' behavior on calves' reactions to transport and quality of veal meat. *Journal of Animal Science* 79, 642-652.

Leonard, F.C., O'Connell, J.M. and O'Farrell, K.J. (1996) Effect of overcrowding on claw health in first-calved Friesian heifers. *British Veterinary Journal* 152, 459-472.

Lidfors, L. and Jensen, P. (1988) Behaviour of free-ranging beef cows and calves. *Applied Animal Behaviour Science* 20, 237-247.

Loberg, J. and Lidfors, L. (2001a) Effect of milkflow rate and presence of a floating nipple on abnormal sucking between dairy calves. *Applied Animal Behaviour Science* 72, 189-199.

Loberg, J. and Lidfors, L. (2001b) Effect of stage of lactation and breed on dairy cows' acceptance of foster calves. *Applied Animal Behaviour Science* 74, 97-108.

Lorz, A. (1973) *Tierschutzgesetz. Kommentar*. Beck, Munich.

Lott, D.F. (1991) American bison sociobiology. *Applied Animal Behaviour Science* 29, 135-145.

Lund, V. (2000) Is there such a thing as 'organic' animal welfare? In: Hovi, M. and Trujillo, R.G. (eds) *Diversity of Livestock Systems and Definition of Animal Welfare. Proceedings of the Second NAHWOA Workshop, Córdoba, 8-11 January 2000*. University of Reading, UK, pp. 151-160.

Lund, V. and Röcklinsberg, H. (2001) Outlining a conception of animal welfare for organic farming systems. *Journal of Agricultural and Environmental Ethics* 14, 391-424.

Manninen, E., de Passillé, A.M., Rushen, J., Norring, M. and Saloniemi, H. (2002) Preferences of dairy cows kept in unheated buildings for different kind of cubicle flooring. *Applied Animal Behaviour Science* 75, 281-292.

Margerison, J.K., Phillips, C.J.C. and Preston, T.R. (2003) Effect of restricted suckling in dairy cows on milk production, reproduction and calf production. *Journal of Animal Science* (in press).

Martys, M. (1982) Gehegebeobachtungen zur Geburts- und Reproduktionsbiologie des Europäischen Wildschweines (*Sus scrofa* L.). *Zeitschrift für Säugetierkunde* 47, 100-113.

Martys, M. F. (1991) Ontogenie und Funktion der Saugordnung und Rangordnung beim Europäischen Wildschwein, *Sus scrofa* L. *Sitzung der Tagung über Wildschweine und Pekariss im Zoo Berlin vom 12. bis 15. Juli 1990*. Frädrich-Jubiläumsband, Bongo, Berlin, 18, 219 - 232.

Marx, D. and Schuster, H. (1986) Ethologische Wahlversuche mit frühabgesetzten Ferkeln während der Flatdeckhaltung. *Deutsche tierärztliche Wochenschrift* 93, 65-104.

Mauget, R. (1981) Behavioural and reproductive strategies in wild forms of *Sus scrofa* (European wild boar and feral pigs). In: Sybesma, W. (ed.) *The Welfare of Pigs*. Martinus Nijhoff, The Hague.

Mayer, C. (1999) Stallklima, ethologische und klimatische Untersuchungen zur Tiergerechtigkeit unterschiedlicher Haltungssysteme in der Schweinemast. *FAT-Schrift* 50.

McBride, G., Parer, I.P. and Foenander, F. (1969) The social organization and behaviour of the feral domestic fowl. *Animal Behaviour Monographs* 2, 126-181.

McGlone, J.J. and Curtis, S.E. (1985) Behaviour and performance of weanling pigs in pens equipped with hide areas. *Journal of Animal Science* 60, 20-24.

McKinnon, A.J., Edwards, S.A., Stephens, D.B. and Walters, D.E. (1989) Behaviour of groups of weaner pigs in three different housing systems. *British Veterinary Journal* 145, 367-372.

Mench, J.A. (1998) Thirty years after Brambell: Whither animal welfare science? *Journal of Applied Animal Welfare Science* 1, 91-102.

Mench, J.A. and Keeling, L.J. (2001) The social behaviour of domestic birds. In: Keeling, L.J. and Gonyou, H.W. (eds) *Social Behaviour in Farm Animals*. CAB International, Wallingford, UK, pp. 177-209.

Menke, C., Waiblinger, S., Fölsch, D.W. and Wiepkema, P.R. (1999) Social behaviour and injuries of horned cows in loose housing systems. *Animal Welfare* 8, 243-258.

Menke, C., Waiblinger, S. and Fölsch, D.W. (2000) Die Bedeutung von Managementmaßnahmen im Laufstall für das Sozialverhalten von Milchkühen. *Deutsche*

tierärztliche Wochenschrift 107, 262-268.

Metzner, R. (1976) Kennwerte tiergerechter Versorgungseinrichtungen des Kurzstandes für Fleckviehkühe. Dissertation, TU München, Germany.

Meynhardt, H. (1978) *Schwarzwild-Report*. Neumann-Neudamm. Melsungen.

Molz, C. (1989) Beziehung zwischen haltungstechnischen Faktoren und Schäden beim Milchvieh in Boxenlaufställen. Dissertation, LMU München, Germany.

Mount, L.E. (1960) The influence of huddling and body size on the metabolic rate of the young pig. *Journal of Agriculture Science* 55, 101-105.

Mount, L.E. (1968) *The Climatic Physiology of the Pig*. E. Arnold, London.

Mulitze, P. (1989) Die Bestimmung der Trittsicherheit perforierter Stallfußböden für die Schweinehaltung. Dissertation, Fachbereich Agrarwissenschaften, Justus-Liebig-Universität Gießen, Germany.

Newberry, R.C. and Wood-Gush, D.G.M. (1985) The suckling behaviour of domestic pigs in a semi-natural environment. *Behaviour* 95, 11-25.

Newberry, R.C. and Wood-Gush, D.G.M. (1986) Social relationship of piglets in a semi-natural environment. *Animal Behaviour* 34, 1311-1318.

Newberry, R.C. and Wood-Gush, D.G.M. (1988) Development of some behaviour patterns in piglets under semi-natural conditions. *Animal Production* 46, 103-09.

Niebuhr, K., Harlander-Matauschek, A. and Troxler, J. (2001) *Untersuchungen zum Einfluß der Gruppengröße und der Größe der Auslauföffnungen auf die Auslaufnutzung bei Legehennen in Freilandhaltung*. Endbericht zu Händen des Ministeriums für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft. Institut für Tierhaltung und Tierschutz, Veterinärmedizinische Universität Wien, Vienna.

Nielsen, B.L., Lawrence, A.B. and Whittemore, C.T. (1995a) Effect of group size on feeding behaviour, social behaviour, and performance of growing pigs using single-space feeders. *Livestock Production Science* 44, 73-85.

Nielsen, B.L., Lawrence, A.B. and Whittemore, C.T. (1995b) Feeding behaviour of growing pigs using single or multi-space feeders. *Applied Animal Behaviour Science* 47, 235-246.

Odén, K., Vestergaard, K.S. and Algers, B. (1999) Agonistic behaviour and feather pecking in single-sexed and mixed flocks of laying hens. *Applied Animal Behaviour Science* 62, 219-231.

Odén, K., Vestergaard, K.S. and Algers, B. (2000) Space use and agonistic behaviour in relation to sex composition in large flocks of laying hens. *Applied Animal Behaviour Science* 67, 307-320.

Olsen, A.W., Dybkjær, L. and Simonsen, H.B. (2001) Behaviour of growing pigs kept in pens with outdoor runs: II. Temperature regulatory behaviour, comfort behaviour and dunging preferences. *Livestock Production Science* 69, 265-278.

Olsen, A.W., Simonsen, H.B. and Dybkjaer, L. (2002) Effect of access to roughage and shelter on selected behavioural indicators of welfare in pigs housed in a complex environment. *Animal Welfare* 11, 75-87.

Olsson, I.A.S. and Keeling, L.J. (2000) Night time roosting in laying hens and the effect of thwarting access to perches. *Applied Animal Behaviour Science* 68, 243-256.

Ouédraogo, A.P. (2002) Consumers' concern about animal welfare and the impact on food choice: social and ethical conflicts. INPL-Nancy, 84-86.

Pagel, M. and Dawkins, M.S. (1997) Peck orders and group size in laying hens: 'future contracts' for non-aggression. *Behavioural Processes* 40, 13-25.

Pedersen, L.J., Studnitz, M., Jensen, K.H. and Giersing, A.M. (1998) Suckling behaviour of piglets in relation to accessibility to the sow and the presence of foreign litters. *Applied Animal Behaviour Science* 58, 267-279.

Petersen, H.V., Vetergaard, K. and Jensen, P. (1989) Integration of piglets into social groups of free-ranging domestic pigs. *Applied Animal Behaviour Science* 23, 223-236.

Petersen, V., Simonsen, H.B. and Lawson, L.G. (1995) The effect of environmental stimulation on the development of behaviour of pigs. *Applied Animal Behaviour Science* 45, 215-224.

Plath, U. (1999) Beurteilung verschiedener Tränketechniken und Betreuungsmaßnahmen hinsichtlich ihrer Auswirkungen auf die oralen Aktivitäten, den Gesundheitszustand und die Mastleistung über zwei bis acht Wochen alter Mastkälber in Gruppenhaltung. Dissertation, Tierärztliche Hochschule, Hannover, Germany.

Plonait, H. (1997) Perinatale Sterblichkeit. In: Plonait, H. and Birckhardt, K. (eds) *Lehrbuch der Schweinekrankheiten*. Parey, Berlin, pp. 503-507.

Porzig, E. and Sambras, H.H. (1991) *Nahrungsaufnahmeverhalten landwirtschaftlicher Nutztiere*. Deutscher Landwirtschaftsverlag Berlin GmbH, Berlin.

Price, E.O. (1999) Behavioral development in animals undergoing domestication. *Applied Animal Behaviour Science* 65, 245-271.

Price, E.O. and Wallach, S.J.R. (1990) Physical isolation of hand-reared Hereford bulls increases their aggressiveness toward humans. *Applied Animal Behaviour Science* 27, 263-267.

Prins, H.H.T. (1997) *Ecology and Behaviour of the African Buffalo*. Chapman and Hall, London.

Puppe, B. and Tuchscherer, M. (1995) Zum Saugverhalten und zur Entwicklung biochemischer Parameter bei Ferkeln unter den Bedingungen einer Gruppenhaltung säugender Sauen: Erste Ergebnisse. *Berliner und Münchner Tierärztliche Wochenschrift* 108, 161-166.

Puppe, B., Tuchscherer, M. and Tuchscherer, A. (1997) The effect of housing conditions and

the social environment immediately after weaning on the agonistic behaviour, neutrophil/lymphocyte ratio, and plasma glucose level in pigs. *Livestock Production Science* 48, 157-164.

Randle, H. (1994) Adoption and personality in cattle. Ph.D. thesis, University of Exeter, UK.

Reinhardt, V. (1980a) *Untersuchungen zum Sozialverhalten des Rindes*. Tierhaltung 10, Birkhäuser Verlag, Basel.

Reinhardt, V. (1980b) Social behaviour of *Bos indicus*. In: Wodzicka-Tomaszewska, M., Edey, T.M. and Lynch, J.J. (eds) *Reviews in Rural Science IV. Behaviour in Relation to Reproduction, Management and Welfare of Farm Animals*. University of New England, pp. 153-156.

Reinhardt, V. and Reinhardt, A. (1981) Cohesive relationships in a cattle herd (*Bos indicus*). *Behaviour* 77, 121-151.

Rushen, J., Taylor, A. and de Passillé, A. (1999) Domestic animals' fear of humans and its effect on their welfare. *Applied Animal Behaviour Science* 65, 285-303.

Sachser, N., Dürschlag, M. and Hirzel, D. (1998) Social relationships and the management of stress. *Psychoneuroendocrinology* 23, 891-904.

Sambraus, H.H. (1985) Cross suckling of bucket reared calves that were tied for varying times after feeding. *Applied Animal Behaviour Science* 13, 179.

Sanotra, G.S., Vestergaard, K.S., Agger, J.F. and Lawson, L.G. (1995) The relative preference for feathers, straw, wood-shavings and sand for dustbathing, pecking and scratching in domestic chicks. *Applied Animal Behaviour Science* 43, 263-277.

Sato, S., Wood-Gush, D.G.M. and Wetherill, G. (1987) Observations of creche behaviour in suckler calves. *Behaviour Proceedings* 15, 126-142.

Savory, C.J., Wood-Gush, D.G.M. and Duncan, I.J.H. (1978) Feeding behaviour in a population of domestic fowl in the wild. *Applied Animal Ethology* 4, 13-27.

Schaefer, A.L., Salomons, M.O., Tong, A.K.W., Sather, A.P. and Lepage, P. (1990) The effect of environmental enrichment on aggression in newly weaned pigs. *Applied Animal Behaviour Science* 27, 41-52.

Schmid, H. (1992) Arttypische Strukturierung der Abferkelbucht. In: *Aktuelle Arbeiten zur artgemäßen Tierhaltung 1991*. KTBL-Schrift 351, 27-36.

Schmid, H. (1993) Ethological design of a practicable farrowing pen. In: Nichelmann, M., Wierenga, H.K. and Braun, S. (eds) *Proceedings of the International Congress on Applied Ethology*. KTBL Darmstadt, Berlin, pp. 238-241.

Sies, S. and Mahlau, G. (1997) *Das Image der Landwirtschaft - Ergebnisse von Assoziationstests*. Lehrstuhl für Agrarmarketing, Institut für Agrarökonomie der Universität Kiel, Germany.

Simantke, C. (2000) *Ökologische Schweinehaltung: Haltungssysteme und Baulösungen*.

Bioland, Mainz, Germany, 139 pp.

Somers, J.G.C.J., Noordhuizen-Stassen, E.N., Frankena, K. and Metz, J.H.M. (2001) Epidemiological study on claw disorders in dairy cattle: impact of floor systems. In: *Proceedings of the 12th International Symposium on Lameness in Ruminants, 9th-13th January 2002, Orlando, Florida, USA*, pp. 350-354.

Sommer, T. and Troxler, J. (1986) Ethologische und veterinärmedizinische Beurteilungskriterien in Bezug auf die Tiergerechtheit von Loch- und Spaltenböden für Milchvieh. In: *Aktuelle Arbeiten zur artgemäßen Tierhaltung 1985. KTBL-Schrift* 311, 73-85.

Spycher, B., Regula, G., Wechsler, B. and Danuser, J. (2002) Gesundheit und Wohlergehen von Milchkühen in verschiedenen Haltungssystemen. *Schweizer Archiv für Tierheilkunde* 144, 519-530.

Stangel, G. and Jensen, P. (1991) Behaviour of semi-naturally kept sows and piglets (except suckling) during 10 days postpartum. *Applied Animal Behaviour Science* 31, 211-227.

Starzinger, B. (2001) 'Bio'-Blicke - Von der Stadt auf's Land. *Freiland-Journal* 4(1), 14-15.

Stauffacher, M. (1992) Ethologische Grundlagen zur Beurteilung der Tiergerechtheit von Haltungssystemen für landwirtschaftliche Nutztiere und Labortiere. *Schweizerisches Archiv für Tierheilkunde* 134, 115-125.

Stolba, A. (1984) Verhaltensmuster von Hausschweinen in einem Freigehege: Bemerkungen zum Film. In: *Aktuelle Arbeiten zur artgemässen Tierhaltung 1983. KTBL-Schrift* 299, 106-115.

Stolba, A. and Wood-Gush, D.G.M. (1984) The identification of behavioural key features and their incorporation into a housing design for pigs. *Annales de Recherches Vétérinaires* 15, 287-298.

Stolba, A. and Wood-Gush, D.G.M. (1989) The behaviour of pigs in a semi-natural environment. *Animal Production* 48, 419-425.

Stumpf, S., Nydegger, F., Wechsler, B. and Beyer, S. (2000) Untersuchungen zum Tier-Fressplatzverhältnis und zur Fressplatzgestaltung bei der Selbstfütterung von Milchkühen am Fahrsilo. In: *Aktuelle Arbeiten zur artgemäßen Tierhaltung 1999. KTBL-Schrift* 391, 103-110.

Sundrum, A. (1993) Tierschutznormen in der ökologischen Nutztierhaltung und Möglichkeiten zu ihrer Kontrolle. *Deutsche tierärztliche Wochenschrift* 100, 41-88.

Thodberg, K., Jensen, K.H., Herskin, M.S. and Jørgensen, E. (1999) Influence of environmental stimuli on nest building and farrowing behaviour in domestic sows. *Applied Animal Behaviour Science* 63, 131-144.

Toates, F. (1987) The relevance of models of motivation and learning to animal welfare. In: Wiepkema, P. R. and Adrichem van, P.W.M. (eds) *Biology of Stress in Farm Animals: An Integrative Approach*. Martin Nijhoff Publishers, Dordrecht, The Netherlands, pp. 153-186.

Troxler, J. (1981) Beurteilung zweier Haltungssysteme für Absetzferkel. In: *Aktuelle Arbeiten*

zur artgemäßen Tierhaltung 1980. *KTBL-Schrift* 264, 151-164.

Turner, S.P., Horgan, G.W. and Edwards, S.A. (2001) Effect of social group size on aggressive behaviour between unacquainted domestic pigs. *Applied Animal Behaviour Science* 74, 203-215.

Van Caenegem, L. and Krötzl Messerli, H. (1997) Der Laufhof für den Milchvieh-Laufstall. *FAT-Bericht* 493, Tänikon, Switzerland.

van Putten, G. (1973) Enkele aspecten van het gedrag van varkens. *Proceedings Varkensstudiedag*, 10.5., Gent, Belgium. Wessanen, Wormerveer, The Netherlands, pp. 43-46.

van Putten, G. (1978a) Schwein. In: Sambraus, H.-H. (ed.) *Nutztierethologie*, Ulmer Verlag, Stuttgart, Germany, pp. 168-213.

van Putten, G. (1978b) Comfort behaviour in pigs: informative for their well-being. In: *Proceedings of the 28th Annual Meeting, European Association for Animal Production, Brussels, Belgium, August, 1977*, pp. 70-76.

van Putten, G. (2000) An ethological definition of animal welfare with special emphasis on pig behaviour. In: Hovi, M. and Trujillo, R.G. (eds) *Diversity of Livestock Systems and Definition of Animal Welfare. Proceedings of the Second NAHWOA Workshop, Córdoba, 8-11 January 2000*. University of Reading, UK, pp. 120-134.

van Putten, G. and van de Burgwal, J.A. (1989) Tiergerechte Gruppenhaltung im Abferkelstall. In: *Aktuelle Arbeiten zur artgemäßen Tierhaltung 1988. KTBL-Schrift* 336, 93-108.

van Putten, G. and van de Burgwal, J.A. (1990) Vulva biting in group-housed sows: preliminary report. *Applied Animal Behaviour Science* 26, 181-186.

Vandenheede, M., Shehi, R., Nicks, B., Canart, B., Dufrasne, I., Biston, R. and Lecomte, P. (1994) Influence de la pluie sur l'utilisation d'un abri par des taurillons au pâturage. *Annales de Medecine Veterinaire* 138, 91-94.

Vestergaard, K.S., Skadhauge, E. and Lawson, L.G. (1997) The stress of not being able to perform dustbathing in laying hens. *Physiology and Behavior* 62, 413-419.

Waiblinger, S., V. Reichmann, J. Troxler, H. Dreiseitel, J. Haller und G. Windischbauer (2001) Einfluß eines Vorrückfressgitters auf Druckbelastungen und Schäden an den Schultern von Milchkühen. In: *Bau, Technik und Umwelt in der landwirtschaftlichen Nutztierhaltung*. Institut für Agrartechnik der Universität Hohenheim, pp. 462-465.

Waiblinger, S., Menke, C. and Coleman, G. (2002) The relationship between attitudes, personal characteristics and behaviour of stockpeople and subsequent behaviour and production of dairy cows. *Applied Animal Behaviour Science* 79, 195-219.

Walker, B.E. (1962) Suckling and grazing behaviour of beef heifers and calves. *New Zealand Journal of Agricultural Research* 5, 331-338.

Wallbaum, F., Wassmuth, R. and Langholz, H.-J. (1997) Outdoor wintering of suckler cows

in low mountain range. In: Arendonk, J.A.M. (ed.) *Outdoor Wintering of Suckler Cows in Low Mountain Range*. Book of abstracts of the 48th annual meeting of the European Association for Animal Production, Vienna, 25.-28.8.97, pp. 226-226.

Weary, D.M. and Chua, B. (2000) Effects of early separation on the dairy cow and calf 1. separation at 6 h, 1 day and 4 days after birth. *Applied Animal Behaviour Science* 69, 177-188.

Weary, D.M. and Fraser, D. (1995) Signalling need: costly signals and animal welfare assessment. *Applied Animal Behaviour Science* 44, 149-158.

Weber, R. (1996) Neue Abferkelbuchten ohne Fixation der Muttersau. Wenig höhere Investitionen, praxisüblicher Zeitbedarf. *FAT-Bericht* 481, Tänikon, Switzerland.

Weber, R. (1999) Reduzierung des Besaugens von Artgenossen bei Kälbern durch Verwendung eines verschliessbaren Tränkestandes. In: *Aktuelle Arbeiten zur artgemäßen Tierhaltung 1998*. *KTBL-Schrift* 382, 146-152.

Weber, R. (2000) Alternative housing systems for farrowing and lactating sows. In: Blokhuis, H.J., Ekkel, E.D. and Wechsler, B. (eds) *Improving Health and Welfare in Animal Production*. EAAP Publication No. 102. Wageningen, pp. 109-115.

Weber, R. and Troxler, J. (1988) Die Bedeutung der Zeitdauer der Geburt in verschiedenen Abferkelbuchten zur Beurteilung auf Tiergerechtigkeit. In: *Aktuelle Arbeiten zur artgemäßen Tierhaltung 1987*. *KTBL-Schrift* 323, 172-184.

Weber, R. and Wechsler, B. (2001) Reduction in cross-sucking in calves by the use of a modified automatic teat feeder. *Applied Animal Behaviour Science* 72, 215-223.

Weber, R., Friedli, K. and Winterling, C. (1993) Einfluß der Abruffütterung auf Aggressionen zwischen Sauen. In: *Aktuelle Arbeiten zur artgemäßen Tierhaltung 1992*. *KTBL-Schrift* 356, 155-166.

Wechsler, B. (1993) Verhaltensstörungen und Wohlbefinden - ethologische Überlegungen. In: Martin, G. (ed.) *Leiden und Verhaltensstörungen bei Tieren*. *Tierhaltung* 23, Birkhäuser Verlag, Basel, pp. 50-64.

Wechsler, B. (1996) Rearing pigs in species-specific family groups. *Animal Welfare* 5, 25-35.

Wechsler, B. and Huber-Eicher, B. (1998) The effect of foraging material and perch height on feather pecking and feather damage in laying hens. *Applied Animal Behaviour Science* 58, 131-141.

Wechsler, B., Schmid, H. and Moser, H. (1991) *Der Stolba-Familienstall für Hausschweine. Ein tiergerechtes Haltungssystem für Zucht- und Mastschweine*. *Tierhaltung* 22, Birkhäuser Verlag, Basel.

Wechsler, B., Schaub, J., Friedli, K. and Hauser, R. (2000) Behaviour and leg injuries in dairy cows kept in cubicle systems with straw bedding or soft lying mats. *Applied Animal Behaviour Science* 69, 189-197.

Wemelsfelder, F. and Birke, L. (1997) Environmental challenge. In: Appleby, M.C. and Hughes, B.O. (eds) *Animal Welfare*. CAB International, pp. 35-47.

Weng, R.C., Edwards, S.A. and English, P.R. (1998) Behaviour, social interactions and lesion score of group-housed sows in relation to floor space allowance. *Applied Animal Behaviour Science* 59, 307-316.

Whittaker, X., Edwards, S.A., Spooler, H.A.M., Corning, S. and Lawrence, A.B. (2000) The performance of group-housed sows offered a high fibre diet ad libitum. *Animal Science* 70, 85-93.

Wiederkehr, T., Friedli, K. and Wechsler, B. (2001) Einfluss von regelmäßigem Auslauf auf das Vorkommen und den Schweregrad von Sprunggelenksschäden bei Milchvieh im Anbindestall. In: *Aktuelle Arbeiten zur artgemäßen Tierhaltung 2000. KTBL-Schrift* 403, 163-170.

Wierenga, H.K. (1983a) Auswirkungen einer Beschränkung der Liegeplätze im Laufstall auf das Verhalten von Milchkühen. *Tierzüchter* 11, 473-475.

Wierenga, H.K. (1983b) The influence of the space for walking and lying in a cubicle system on the behaviour of dairy cattle. In: Baxter, S.H., Baxter, M.R. and MacCormack, J.A.D. (eds) *Farm Animal Housing and Welfare*. Martin Nijhoff Publishers, Boston, USA, pp. 171-179.

Wierenga, H.K., Metz, J.H.M. and Hopster, H. (1985) The effect of extra space on the behaviour of dairy cows kept in a cubicle house. In: Zayan, R (ed.) *Social Space for Domestic Animals*. pp. 160-169.

Wood-Gush, D.G.M., Duncan, I.J.H. and Savory, C.J. (1978) Observations on the social behaviour of domestic fowl in the wild. *Biology of Behaviour* 3, 193-205.

Wood-Gush, D.M.G., Jensen, P. and Algers, B. (1990) Behaviour of pigs in a novel semi-natural environment. *Biology of Behaviour* 15, 62-73.