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THE IDENTIFICATION OF BEHAVIOURAL KEY FEATURES AND THEIR INCORPORATION INTO A HOUSING DESIGN FOR PIGS

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Résumé

IDENTIFICATION DES CARACTÉRISTIQUES MAJEURES DU COMPORTEMENT ET LEUR PRISE EN COMPTE POUR LA CONCEPTION DU LOGEMENT DES PORCS. — Cette expérience éthologique essaie de définir le bien-être des porcs à partir de la satisfaction des motivations et des besoins comportementaux. Le bien-être psychologique peut être exprimé par un compromis entre diverses motivations. Les besoins comportementaux peuvent être définis par des caractéristiques essentielles de l'environnement et du comportement pour l'accomplissement des séquences comportementales. Les exigences éthologiques minimales ont été déterminées en observant des porcelets et des porcs adultes de race Large White élevés dans un grand enclos semi-naturel, dans un enclos plus restreint ou dans des conditions conventionnelles d'élevage. Les caractéristiques de l'environnement qui permettent aux porcs d'exécuter leurs fréquentes ou régulières séquences comportementales comme dans l'enclos témoin, sont les unités de construction pour une loge adaptée. Chaque installation d'étable est constituée de trois compartiments pour nicher, l'activité et la fouille, et d'un couloir à déjection. Quatre installations fusionnées constituent une unité familiale où sont logés 4 truies et leur descendance et parfois le verrat et les truies de remplacement, tous ensemble. Ces familles ont une structure sociale identique à celle des familles de l'enclos témoin. Les contacts sociaux dans ces groupes de famille stables favorisent l'apparition de l'œstrus pendant la lactation et permettent 2, 3 mises bas par an lorsque la nourriture est suffisante avant la saillie. Comme il n'y a pas de stress de sevrage les porcelets atteignent le poids commercial aux environs de 155 jours d'âge. Ce système de production montre combien la recherche éthologique peut améliorer les conditions de logement de façon à satisfaire les principales exigences comportementales d'un animal domestique.

In the laws and current attempts to lay down in regulations the requirements for the appropriate housing of domestic animals, the terms «welfare» and «behavioural need» are widely used (Swiss law for the protection of animals 1978, German law for the protection of animals 1972, Council of Europe Convention for the Protection of Animals kept for farming purposes 1979). However, they lack precise, delimiting definitions, so that researchers from different background have been using

them in quite differing, even contradicting ways (Duncan 1974, Hughes 1976, Teutsch 1979, Beilharz and Zeeb 1981, Tschanz 1982). In the following it is attempted to determine the ethological essence of these terms more clearly; the subsequent example of a pig family system in enriched pens shows, which kind of housing conditions may be obtained, if the design has been developed to satisfy these factors causal to welfare.

Welfare

Often the term welfare is used in a too restricted way including only physical or physiological well-being, which is measured by mortality, health or body functions. Obviously, the welfare of a pig is impaired, while it is dying from thirst or a sepsis; but these parameters are mainly summarizing certain long term effects on the animal and are generally too coarse to signal housing problems at an early stage. Also, they often fail to characterize in detail the primary causes leading to the observed physical consequences, as those may sometimes be functionally insignificant deficiencies in the physical or social environment of the pig. However, such information may be directly obtained from appropriately selected behavioural parameters, e.g. from the analysis of behavioural sequences. Usually they indicate minor deficiencies at earlier stages than the former physical variables. Examples for such sensitive indicators can be found in the redirection of social or nonsocial patterns on specific partners (Stolba and Wood-Gush 1981), or in the process of acquiring stereotypes (Stolba *et al.* in press).

Although the concepts of preventing injuries (Ekesbo 1981, Rist 1981) have a great value in the practical assessment of housing conditions on the farm, to be undamaged or to exhibit normal life-functions is quite secondary in determining welfare, as soon as one measures the much closer ethological correlates which indicate the proximate changes in the internal state of the animal. To *feel* well, as also is expressed by the German «Wohlbefinden», is the very central point of welfare, as feeling unwell, suffering or «Leiden» may be present previous to or even without physical consequences. This may be the reason why the absence of suffering has been included in the Swiss legislation in addition to the absence of injuries and pain (Schweiz. Tierschutzgesetz 1978). This is not to say, that behavioural variables attempt to measure subjective feelings of pigs, but they assess the objectively measurable correlates of the physiological state and the homeostatic processes which cause the changes and levels of internal motivational factors. Welfare may therefore be defined from an ethological point of view as a *state of general motivational balance*, whereby no specific motivation consistently remains unrelieved, because all direct or compensatory ways of satisfaction are suppressed. The identification of the kind and strength of the proximate causes for behaviour therefore is a crucial task for applied welfare advice.

Motivation and function:

To identify such causal factors influencing the motivational state of an animal has up to now been reserved to basic ethology, but it could be of

great help in the applied determination of behavioural needs. The relevant findings on the causation of behaviour are based on rich observational and experimental evidence from different species; reviews by Tinbergen (1950), Hinde (1966), Lorenz (1978), Franck (1979), Eibl-Eibesfeldt (1980) include birds and mammals, but hardly any domestic breeds. Barlow (1974), Immelmann (1979) and Hassenstein (1980) define *motivation* as the physiologically based variable, which integrates the compound effects of exogenous and endogeneous factors and causes the animal to act differently towards identical stimuli at different times. On the other hand, slight exogeneous stimuli may elicit the same behavioural reaction of same intensity as strong stimuli, if the level of endogeneous motivational factors is correspondingly higher. Motivation therefore controls the readiness to perform a certain behavioural action, which in general is shown as sequences of several elements of movement and orientation of similar motivational quality.

In the classical sequential structure by Craig (1918), appetitive elements of exploration are followed by appetitive elements of orientation and close interaction, until a consummatory act ends the action and significantly lowers the probability to continue the action. Whereas in the appetitive stages the patterning of behaviour is generally more variable, the subsequent consummatory elements often are fixed action patterns that clearly characterize the action. The corresponding motivational factors exert their effect on the entire behavioural sequence: the respective moods often can be read from the lasting elements of mimics and posture, which accompany the fast flow of instantaneous elements. In the example of an aggressive pig this may be the erect ears and neck.

This very general picture has been refined:

1. *Consummatory stimuli* have been identified. Hinde (1965) found, that the tactile stimuli of the nest cup on the brood patch of female canary advances the nest-building motivation to later stages of the sequence, and eventually lowers its frequency. However, although the nest cup stimuli have some consummatory effects, they only affect the behavioural frequencies and orientations within limits before the hormonal changes have altered the endogeneous factors of motivation.
2. The performance of consummatory acts is supplemented, but not made obsolete by sensory *feed-back*, in order for the animal to realize that the functional goal of the action has been fulfilled: Spitz (1957) and Ploog (1964) found, that human babies would not relax after being fed if they had suckled for considerably less than 20 min. They remained uneasy if suckling lasted for only 5 min, although they had obtained the same or an even

larger amount of milk. They even performed "vacuum suckling" and were only satisfied after suckling at the empty bottle for additional 10 to 15 min. In domestic animals, bucket-fed calves regularly develop stereotypic licking of hair. In experiments with dogs (Eibl-Eibesfeldt, 1980), three mechanisms to end drinking behaviour were identified: Osmoreception in the hypothalamus, mechanoreception in the stomach and the drinking movement itself; the performance of drinking never was fully suppressed by the former feedback stimuli alone.

3. Some *motivational factors* may be *specific to single behavioural elements*, as Leyhausen (1965) identified in the prey catching sequence of cats. As a possible consequence it might be expected that several elements, and not exclusively the end element of the sequence, influence the underlying motivation. Not all the elements that may be shown in variations of the same type of sequence are equally regularly seen: e.g. In the gathering sequence of the pig, pushing the torn-off grass with the snout before taking it up is not as regularly shown as carrying it for a few steps. In many actions sows seem to be able to change relatively freely between the elements of a cluster of sequentially related elements. This enables them to appropriately adapt their action to the environment. For instance in foraging, only a rough sequence of the first occurrences of a few obligatory elements can be consistently found, and the motivational satisfaction seems largely to depend on the performance of the reduced sequence of the few obligatory elements, of which the consummatory element of ingestion is but a very important example.

4. Sometimes, *sign stimuli* are essential for the behavioural sequence to proceed to a subsequent stage. For instance, in the herring gulls only speckled eggs elicit retrieving into the nest (Kruijt 1958). Another example is the mere sight of a male ring dove, possibly showing courtship, which induces the female dove to start nest building and then egg-laying (Erickson and Lehrmann 1964). Apart from the importance of specific stimuli of partner and nest to elicit brooding, Lehrman (1964) also showed that the performance of intermediate behaviour patterns is obligatory for reaching the subsequent behavioural phase: Pairs of unfamiliar male and female doves needed about 7 days of contact and also some time of nest-building to start incubating, even when provided with an already prepared nest with eggs. Were they kept for 7 days in the cage without nest materials and then provided with eggs in a prepared nest as well as with additional nest materials, they started intense building behaviour and were brooding within a day. However, they would accept the previously prepared nest if they could

perform nest-building on the preceding days. The internal motivational factors for nest-building were mediated by oestrogen: female ring doves that could merely see a courting male had an increased oestrogen production, and injection of oestrogen caused nest-building on the same day. The injection of progesterone, on the other hand, would cause immediate brooding on the prepared nest and eggs, taking the bird directly into this physiological state, which would never occur naturally.

5. There is evidence that some endogenous factors of *motivation* are *spontaneously produced*. Research by von Holst (1969) has shown, that completely deafferented spinal cords of fishes still perform spontaneous and coordinated impulses for swimming movements. The measurement of spontaneous neuronal activity, e.g. in the brain of cats (Eibl-Eibesfeldt 1980) gives supporting evidence for this. On higher levels of behavioural integration the spontaneous rise or decrease of action-specific motivation is known from corresponding changes in reaction thresholds (Lorenz, 1978). A consistent increase of certain motivations is likely to upset the motivational balance of the animal, if there is no satisfying behavioural outlet. The strong manipulative and explorative over-reaction by fatteners kept in partially slatted pens towards a familiar tyre, as opposed to the moderate reaction of similar pigs in less bare housing conditions, concurs with this view (Stolba and Wood-Gush, 1980).

Behavioural needs:

They thus consist of those obligatory features of behaviour and environment, that are essential for the satisfaction of motivations. Two types of needs may be distinguished: a) the *needs to perform the obligatory* (frequently and regularly shown) *elements* of a behaviour sequence, which are likely to exert a large consummatory effect on the specific motivation, and b) the *needs to perceive specific external key stimuli* or compound features, without which these obligatory elements cannot be released or oriented, enhanced or inhibited for a satisfying performance of the sequence.

According to this approach, the housing environment only needs to guarantee relatively few but selected key stimuli and main behaviour elements in order to prevent the impairment of welfare. Thus there is much scope for altering and simplifying the originally complex, natural environments, in which the ancestors of our domestic animals have evolved. For many behavioural actions it will not be necessary, that the housing conditions allow the functional goals to be reached through the original sequence; functional (i.e. physiological) and motivational requirements may be satisfied separately (cf. Abegglen, 1974).

An obvious example from my pig study is, to satisfy the exploratory and preparatory elements of foraging with dummy materials, and separately the nutrient requirements with a well balanced food mixture. If the physiological requirement is unsatisfied, the motivation for foraging will again rise in order to induce the animal to more extensive efforts which should increase nutrient intake. If only the functional consequences are fulfilled (in this case the desired level of nutrients), it is likely, that the behavioural needs might only temporarily vanish, even under proprioceptive feed-back. In the following section, examples will be given, showing how housing conditions can be designed as to satisfy the main behavioural needs of pigs.

Methods and Materials

In 1978 we started at the Edinburgh School of Agriculture research on domestic Large-White pigs with the aim of defining *ethologically minimal housing conditions*, in which the animals can satisfy their behavioural needs. The investigation covered the unrestricted behavioural system of this domestic breed and its range of behavioural adaptation in different environments. The pigs should be enabled to perform their main sequences of behaviour even in spatially restricted conditions. This attempts to satisfy the strongest motivations of behaviour, to minimize their build-up and to reduce the animal's problems associated with living in a relatively small, enclosed pen space. At the start the following questions were asked: 1. How does a decline in environmental and social complexity influence the different behaviour patterns and the range and structure of pig behaviour? 2. Which specific environmental features have to be present, for certain frequent behaviour patterns to be performed?

These key features were first identified by observing the pigs in a large outdoor enclosure that represents the semi-natural reference condition. Similar pigs were then observed in paddocks and a yard to examine, whether the physical features and partners, that were previously frequently contacted, were as important when the environment was smaller and simpler, but still outdoors. Finally, the features found to be consistently important are presented as abstract furnishing in an even smaller pen environment, together with the most frequently contacted classes of social partners. The range and structure of behaviour also was compared with observations from straw and strawless pen conditions. Thirteen groups including two to five adult sows, one to two adult boars, one to ten sub-adult «heavies» and growing offspring were observed in the two outside enclosures (in total 15 adults, 19 subadults and 80 juveniles). Twelve groups were observed in 8 paddocks and a yard (8 adults and sub-adults and 40 juveniles), four groups in the family pens (2 boars, 6 females, 156 juveniles) and ten groups of juveniles in the conventional fattening pens (68 juveniles in strawed and 60 in strawless pens). Table 1 summarises the treatment conditions.

In this process of reducing the environmental complexity, a number of specific *key features*, guiding the *regular and frequent behavioural actions* became apparent. Such key features were *consistently present* when certain actions were performed, such as high stan-

ding sedge tufts which elicit collecting the grass, or vertical tree or bush structures where the collected grass is subsequently deposited. Other clue features were characteristic to defaecation, rooting and nest sites and have been described by Stolba and Wood-Gush (1981). Arranging the most consistent features of the physical and social environment into relatively small, but well structured pen and group conditions, a novel housing system for pig families has been designed. While the reasons for the design are to ensure the fulfilment of many important behavioural needs in a practicable way, quite surprising results in productive traits have been obtained so far during the pilot trials.

Identification of key nest features

Enclosure nests

Pig families of various sizes with adult, sub-adult, juvenile and baby pigs were observed in turn for several months in the ecologically rich «forest» enclosure. On roughly 1.1 ha there are areas with gorse bushes, forest, open grass and bog. Several springs and 2 small streams provide access to water. In the forest and the adjacent gorse enclosure, which was of the same size but lacked trees, 99 nest sites have been mapped up to now. The following analysis shows, that these sites were not selected at random. The properties common to many nests are believed to represent the environmental features the pigs are looking for when they establish a nest site.

Table 2 shows, that more nests were located more than 120 m away from the artificial feeding site, than would have been expected from the respective area available in the enclosures. On the other hand, significantly fewer nests than expected were established within 30 m distance to the feeding site.

There was a marked tendency to select the forest and forest border habitats for establishing a nest, or the gorse border habitat in the enclosure without trees. In the open grass areas fewer nests than expected were built (table 3).

Most nests were established at somewhat sheltered sites: 40 % were at least partially covered by a roof of dense branches of trees or bushes, and 89 % were sheltered on at least one side. However, table 4 shows that fully enclosed and sheltered sites were only rarely selected, in spite of the presence of large densely bushed areas. Apparently, pigs look for shelter as well as for some open view out from their nests (table 4).

The hypothesis, that the pigs look for open view from their nests, is confirmed by their tendency to select nest sites at ridges where they can see up and downhill, and where they can easily hide from approaching intruders. Significantly, too many (18 to 99 nests) were located at such ridges, whereas

Table 1. — Summary of treatment conditions for assessing the consistency of key features

Environment	Group composition			Structural complexity	Area	
	ad.	sad.	juv.		total	m ² /an.
Enclosure	1♂, ♀♀ 2-6	1♂, 1♀	10-19	+++ (wood)	1.1 ha	~ 550
				++ (bushes)	...	...
Paddocks	...	...	10	++ (bushes)	1 000 m ²	100
	1♂, 1♀	1♂, 1♀	8-10	++/+ (bare)	300 m ²	30
Yard Enriched Pen	1♂, 1♀	...	8-10	-/+ (furniture)	27 m ²	2.5
	1♂, 4♀	1♂, 1♀ ²	36-40	++ (furniture)	4 × 27 m ²	2.35
Open front pen	...	...	13-14	+ (straw)	21 m ²	1.6
Part. slatted pen	...	...	10-14	-	12 m ²	1.0

Table 2. — Distance away from the artificial feeding site of the sites selected for nests. Fifty-four sites from the forest and 45 from the gorse enclosure are pooled. The plus or minus signs indicate a significant departure from the expected number of nests according to area available.

In both enclosures	Distance				
	0-29 m	30-59 m	60-89 m	90-119 m	120-149 m
% area available	11.5	23.9	31.2	23.2	10.2
No. of nests observed	- 4	23	24	29	+ 19

χ^2 , P; 4.81: P < 0.05; 7.82: P < 0.01

Table 3. — Habitats selected for nest sites. Significant deviations at the level of P < 0.01

Types of habitats	Gorse enclosure		Forest enclosure	
	% area available	No. nests observed	% area available	No. nests observed
Within gorse area	40	16	17	4
At gorse border	17	++ 24	11	7
Within forest area	... ^a	...	29	+ 27
At forest border	a	...	10	+ 12
Within and at swamp	5	0	9	2
Open grass area	38	- 5	24	- 2

a: not applicable

from the area available one would expect just 7.1 nests to be there ($\chi^2 = 16.6$; $P < 0.01$). A significant number of nests (30 out of 43) were sheltered against wind at the time of establishment, the expected number being 18.5 (χ^2 -test, $P < 0.01$); the expected number being based on a random siting of the exposed side. Shelter against south was not sought as frequently as shelter towards the other compass directions (24 times only, instead of the 41.5 times expected: $\chi^2 = 7.4$; $P < 0.01$). The nests, therefore, were open towards south in spite of the whole slope having a north-easterly exposure.

Paddock nests

Three paddocks measuring 21×14 m each were erected as an intermediate environment to bridge the large multifactorial gap between the semi-natural enclosure and the very small and simplified conventional pens. One paddock was barren, one had the back third of its area covered with gorse bushes, and the third paddock had bushes in its central third of the area. The nests established in the two latter paddocks reveal which characteristics of nest choice remain stable, when the available area is reduced about 40 times and when the features connected with bushes, i.e. those in, next to or between them, are the only ones left. The data so far collected give some idea of the most important factors of nest choice.

Fewer nests than expected were located in the third of the paddock with the feeding site, namely just one of a total of 18 nests. The mean distance from the nest to the feeding site was 8.2 ± 4.4 m. With just two habitat types being present in the paddocks, namely gorse-border and open areas, 15 of 16 nests were built in the former habitat. As in the findings in the enclosure, 43 % of the nests had some shelter above them, and again shelter on 2 sides was sought significantly more often than expected (7 times instead of 3.2 times expected; $\chi^2 = 4.5$; $P < 0.05$). Protection against wind was sought according to expectancy, and exposure towards south was dropped, however. With relatively few possibilities for selecting a nest site in the paddocks, this criterion apparently was dropped in favour of finding any site with shelter on two or more sides (15 of 16 nests). Half of the nest were actually located right next to and not between the bushes, which is significantly more than expected from the total length of this feature in the paddocks. (8 nests observed at bush borders, 1.7 expected; $\chi^2 = 23.3$; $P < 0.01$).

Conclusions for pen design

The main information on the location and structure of the pig's nest seems at present to be as follows:

- From the potential nest sites of a pen the pigs

should have an open view and see approaching persons from dozens of meters away.

- The nest sides should be sheltered against wind and possibly rain, and provide cover on two sides. The desired exposure of open-front buildings is towards the south.

- To imitate the preferred location at the border of forest or bush habitat, there should be a marked change of area between the part of the pen for nesting and the parts used for other activities.

- The potential nest sites should not coincide directly with the area used for feeding the pigs.

Identification of other environmental key features

With a similar procedure, the sites used for other frequent activities were analysed. However, only the conclusions for some features are presented here.

Rooting sites:

About 40 % of the foraging activity was recorded as rooting. Rooting on small roots, e.g. turning the grass mat, occurred everywhere in the enclosure. But rooting for big bush and tree roots was obviously confined to certain areas. Interestingly, the 170 rooting spots are unevenly distributed over the different types of habitat and do not strictly follow the potential distribution of roots. As with the nest sites, the habitat *borders* seem to carry important features for rooting sites; border features therefore have been incorporated by choosing an open-fronted building and by designing partitions between the nesting and rooting parts of the enriched pen.

Marking tree:

When trees are present the pigs quite often rub the body or head on them. In one distinctive variation of head rubbing — called «marking» — the pig gently strokes its cheek or ear along the tree trunk. This happens frequently in the late afternoon at trees between 3 and 25 m away from the nest before nesting for the night. Before occupying a paddock-nest, the pigs sometimes marked gorse branches stripped of leaves that were again some meters away from the nest. The best position for a marking and rubbing facility in a pen therefore would seem to be near, but not close to the nesting area.

Defaecation sites:

Faeces is regularly deposited at the morning defaecation site after leaving the nest. The pen size should allow the pigs to walk about 5 m away from the nest, as this distance appeared in both paddocks and enclosures.

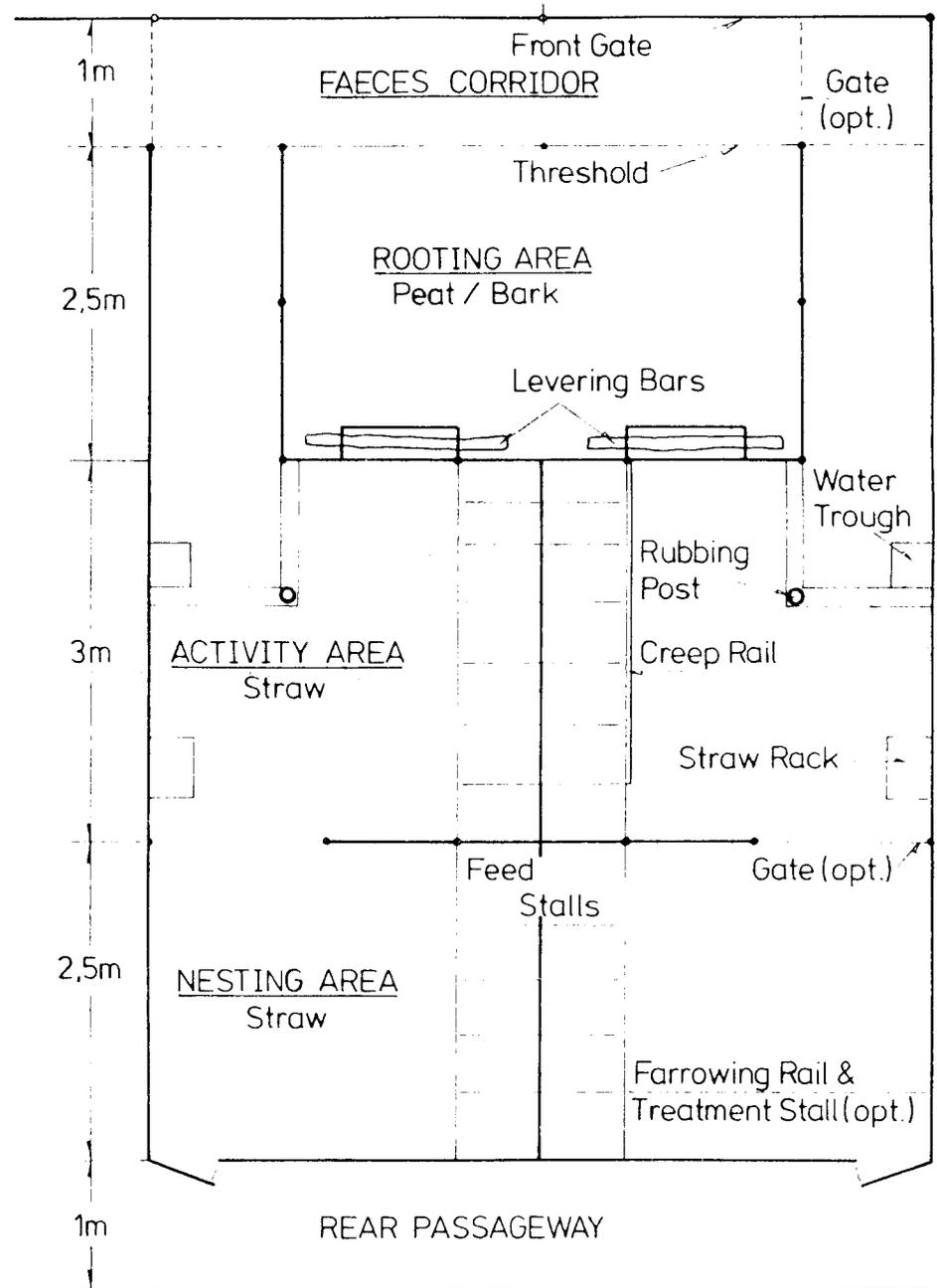


Fig. 1. — Groundplan and furniture of 2 enriched pens, 4 being allotted to a family unit of 4 sows with offspring.

While foraging during day the pigs defaecate here and there, but infrequently in open areas. To concentrate the deposition of faeces in certain parts of a pen, a corridor structure seems to be most appropriate, as it simulates the frequently used wide rides between bushes. This corridor should be situated towards an outdoor part of the pen, as the desired location is in border habitat.

Design of an enriched pen

To alleviate motivational problems in confined housing, a variety of structures have been included in so-called «enriched pens». They carry many of those features that were consistently found to be guiding the pig's behaviour in the outdoor reference environment, and therefore provide appropriate possibilities for the main behaviour sequences which most likely express important behavioural needs. Among others, the design incorporates the following features (fig. 1):

- A roofed and an open part of the pen to reproduce a forest border habitat.
- The main feeding area positioned away from the nest area.
- A sheltered nest site with open view out of the pen through the front side.
- The preferred nest position against two bushes, recreated by pen walls and permeable farrowing rails.
- Space for a nest of 2 to 3 m in diameter as found outside.
- A site for defaecating in the morning, 4.5 to 11 m away from the nest site, as found outside.
- A corridor for defaecation during day time resembling the wide rides between bushes preferred outside.
- Peat or bark and a levering bar in the rooting area as suitable materials for wallowing and digging.
- A rack for gathering straw sheaves and a post for comfort and marking behaviour in the central activity area.
- Head partitions between small feeding stalls to insure sufficient individual space while feeding.

— A possibility for escape behind removable partition walls to lower social tensions.

The following sequences observed during nest-building illustrate, how pigs can make use of this furniture: the pig approaches the rack, sniffs at it and makes few bites and tugs, then repeatedly collects straw, bundling it in the mouth. The load is carried with the head held high and deposited with exaggerated looking nodding movements. After several collection trips, the straw sheaves at the nest site are taken up, the head fervently shaken and the straw arranged in a half circle through slight pushing movements of the snout. Intermittently, the rubbing post is approached, sniffed at, gnawed and marked with gentle strokes of the antorbital head region. These sequences follow the patterns of nest-building seen in the outdoor reference environment, although the distances travelled there are longer, and often a wider variety of materials is used including tree trunks that are rolled to the nest to reinforce the walls.

Identification of social key features

In many conventional systems social problems arise from disrupted bonding and restricted possibilities for group formation. To avoid them in a system fitting the pig's social requirements, the basic features of social structure were closely investigated and accounted for in a similar way as for the key features of the physical environment. Our observations from the different enclosure and yard environments indicated, that pigs tend to form family groups, if conditions allow them to do so. By answering the following questions important features intrinsic to such family groups can be determined: which types of members are regularly included in the voluntarily formed outdoor groups, and which are the most intense and stable relationships between them? However, the spatial and social possibilities in the reference enclosures might not have allowed the pigs to fully express all preferred patterns of grouping. Still, there were quite clear tendencies in all groups observed to form and maintain closer relationships to certain partners than to others, that were

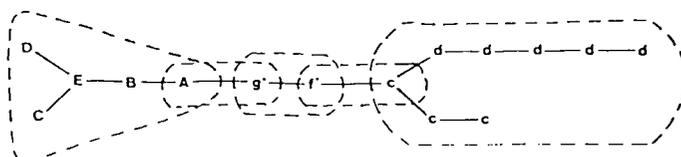


Fig. 2. — Sub-group formation in an outdoor reference group during phases of activity. Pictorial representation by B_j -Clusters (dotted circles) and maximum spanning tree (solid connections). A: boar; B: castrate; C, D, E: sows; f, g: sub-adult boar and gilt; c, d: piglets of C and D.

equally available. Therefore they serve as reference to characterize basic key features of the pig group structure. They are subsequently compared with the group structure in the pig family system. This need not necessarily be similar, although the family set-up attempts to allow their formation under pen conditions, as only a selection of the most consistently preferred partners are present for social interaction. Those however, may be encountered more frequently than in the reference enclosure.

In the outside enclosures, all pig groups studied showed a tendency to form *sub-groups*. Sub-group formation seemed stronger in large groups and was primarily based on the tendencies of the different animals to join the group's centre made up by well familiar adults and the boar. The sub-groups usually were identifiable by the spatial arrangement of the animals. Hutton (1979) and Stolba (unpubl. data) describe the sub-group structure of a large enclosure group for the periods of day-time activity: over a period of 90 days the spatial arrangement of the group was analysed using 365 maps, where the position of all group members was indicated throughout the day. Based on preliminary observations, a sub-group of

active animals was defined to include all pigs within 6 m of another member of the grouping. To visualise the frequencies with which the different pigs were seen in the same sub-group, two clustering techniques were used, the maximum spanning tree and the double-link-clusters (Morgan *et al.*, 1976). In figure 2 three distinctive sub-groups can be recognised: the first consisted of all adult pigs, whereby the sows and the castrate had been together for over a year. The second sub-group consisted of the two recently introduced half-grown pigs, which were not allowed to sleep in the communal nest for more than a month. The third sub-group united the seven-week-old juvenile pigs from two resident sows. While the sub-adult pigs tended to forage at the periphery of the adult sub-group during most of the day, the juveniles could easily join the adults but did so for only few hours in the late morning and early afternoon. The sub-adults became less peripheral with growing habituation, and after their third month of age the juveniles increasingly associated with them.

In this, as in other groups, strong sub-group tendencies resulted in the pigs sleeping in separate nests during the night. After a forced merger

Table 4. — Number of sheltered sides around the nest. If all listed possibilities are assumed to be equally frequent, 19.8 nests would be expected for all of them. Observations from the gorse and forest enclosure pooled

Number of sides sheltered	Number of nests observed	χ^2	Levels of significance
None	— 11	3.9	P < 0.05
One side	+ 35	11.7	P < 0.01
Two sides	+ 30	5.3	P < 0.05
Three sides	17	0.4	...
Four sides	— 6	9.6	P < 0.01

Table 5. — Number of times the members of a merged enclosure group shared same nest over 192 nights. Original relationships persist in two sub-groups: I) boar (A), sow (E) and daughter gilt (e); II) sow (C), daughter sow (c) and sow (F).

	Sub-group I			Sub-group II			Sleeps alone
	A	E	e	C	c	F	
A	...	150*	158*	25	12	23	18
E	187*	5	0	6	0
e	3	0	6	5(f)
C	129*	121*	44(f)
c	127*	41(f)
F	51(f)

*: sign. preference, (f): farrowed during obs. time.

of two other groups, the original bonds persisted and were spatially recognisable for over 190 days in the sharing of nests (table 5).

Differences in the kind and frequency of social interactions were also apparent between well familiar group members. The tendencies to interact in a more friendly way with certain partners than with others seem to be based on long-lasting bonds originating in the juvenile period. These were, for instance, apparent in the smaller distance between the sow and her own offspring as compared to another sow's juveniles, and this difference could still be recorded in the fifth month after farrowing (table 6). Although littermates were closer neighbours than mates from different litters, the juveniles from both litters still tended to stay in the same sub-group during the periods of activity (fig. 2).

The consequence: Keeping pigs in families

The family system has been tailored to these patterns of social structure: 1) in order to avoid mixing of sows, two older and two younger sows are kept together for several years, the culls to be preferably replaced from within the group; 2) the intense bonds between sow and piglets are not severed unless the juveniles are marketed as pork or bacon; 3) the family unit is limited to sub-group size, i.e. to only a few sows to minimise social tensions; 4) the breeding boar rotates between three to four familiar family units, staying each time for about 1.5 months; 5) he is not replaced before a new, fully grown boar has been accepted as group member by the resident sows.

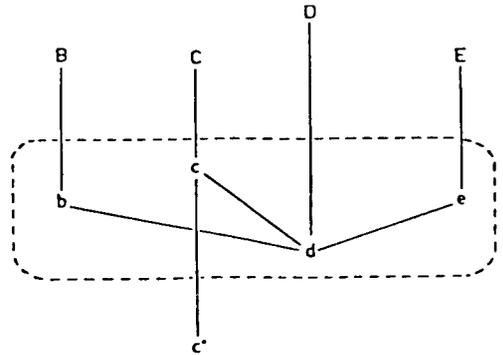


Fig. 4. — Nearest neighbourhood of group members during phases of activity in the family pens. Pictorial representation by B₂-Clusters (dotted circles) and maximum spanning tree (solid connections). B, C, D, E: sows; c*: replacement gilt; b, c, d, e: piglets of B, C, D, E.

Thus the pig family system in the enriched pens is based on 4 adult sows, always kept together in 4 pens freely connected through the defaecation corridor. They farrow in these pens and their offspring grow up there without artificial weaning and mixing. Three weeks *post-partum* a familiar boar is introduced to the group for 5 to 6 weeks before moving to another family group. He mates with the lactating sows and any replacements kept back from the previous litters. The procedures of feeding, cleaning and supplying straw have been outlined in Stolba (1981). If the potential of mating the sows around day 30 can consistently be reali-

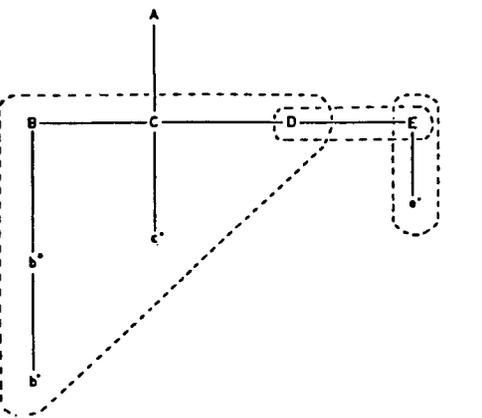


Fig. 3. — Sharing of nests in a family pen group. Pictorial representation by B₂-Clusters (dotted circles) and maximum spanning tree (solid connections). A: breeding boar; B, C, D, E: sows, b^a: fatterer boar; b*, c*, e*: replacement gilts.

Table 6. — Mean distances to nearest neighbours during phases of activity in reference-enclosure and family-pen groups. ♀: sow; ♀*: replacement gilt; o: piglet; symbols filled in: from same mother sow. ^: significant difference, t-test, P ≤ 0,05; (^): P ≤ 0,15.

Partners	Reference enclosure distance in m	Family pens distance in m
♀ - ♀	4,6 ± 5,9	1,0 ± 1,2
♀ - ♀*	3,1 ± 1,6	1,1 ± 0,7
♀* - ♀	5,6 ± 4,8	1,7 ± 1,6
♀ - ●	^ 1,2 ± 1,9	^ 0,3 ± 0,6
♀ - o	2,3 ± 1,8	^ 0,7 ± 1,1
● - ●	(^) 0,9 ± 0,9	^ 0,2 ± 0,3
● - o	1,4 ± 2,0	^ 0,6 ± 1,0

sed, a cycle would last 145 days and up to 2.5 litters per sow each year would be possible. Since the space requirements for the sows and the new litters are low during the early suckling period, up to 20 days of overlap with the slower growing pigs of the last litters are possible. Alternatively, an additional pen from a neighbouring family could temporarily be allotted to the slow growers. For the fattening and reproductive performance see Stolba (1981, 1982).

Such a management of families indeed enables the pigs to maintain their basic patterns of group structure in the pen environment, as the typical spatial associations could be found between the different partners. Figure 3 visualises observations on the sharing of nests in the family pens. Even at 170 to 200 days of age the replacement animals clearly tended to sleep together with their mothers. As in the enclosure, the juveniles tended to stay together during phases of activity, which is demonstrated by the nearest neighbourships in figure 4. However compared to the enclosure, the mothers more often stayed relatively close to their litters in the pens. Also there seemed to be insufficient space for spatially detached sub-groups to be formed. But, as in the enclosure, littermates tended to be closer neighbours than non-litter-mates, and the distance to their own mother was smaller than to another sow (table 6).

In summary, the preferences for certain neighbours and the relative distance between the different social partners could be maintained in the family pens, although not to the degree of forming detached sub-groups. Still, the system accounts for many basic social requirements, and the social problems due to various restrictions and confinement seem lessened.

Conclusions

The pig family system is an ethological attempt to give a practical answer to the question, what housing conditions pigs would require for their welfare needs to be satisfied. It should be noted, that the ecological function does not appear as a

proximate causal factor for behavioural actions, except indirectly through rewarding feed-back stimuli. Indeed, in order to achieve the action's functional goal, such as securing a deep-bedded nest for farrowing, the animals usually don't refer to the entire, very complex situation, but to selected components only. These may often be regular features of the natural situation and therefore suitable to either being learned or genetically fixed. In the above example, the sow may hardly gather nest material because of some understanding into possible selective benefits and parental care for the yet unborn piglets. More likely she collects grass, because high standing stalks elicit this behaviour and she deposits it, where the position of sheltering bushes gives orientating clues. Before farrowing the responsiveness to such stimuli, i.e. the internal motivation for such actions, is heightened by the hormonal changes. Welfare in the farrowing pens is thus not simply achieved by a functionally satisfying stall or straw environment. In addition to be satisfied are behavioural needs which require, that regular actions such as nest-building can be performed in a motivationally satisfying way. It is not impossible to achieve this in practicable housing, for it is usually unnecessary, that all elements of the action be performed, or that its natural functions be fulfilled. The design of the enriched pig pen illustrates, that many important motivations may be satisfied by providing selected stimuli for their main behavioural elements in a kind of «dummy nature».

Many sign stimuli still deserve more detailed research for identification, but it can be demonstrated, how simplified, but structured housing conditions may be derived from a rich reference environment. The practical importance of enabling the pigs to maintain also the basic features of their social group structure becomes apparent, in that also a wider range of reproductive traits can be expressed. Two effects seem to emerge that are of prime interest for pig production: lactation oestrus and synchrony of oestrus between sows (Stolba 1982).

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Summary

An ethological approach is presented which aims at meeting the welfare requirements of domestic pigs by satisfying their motivations and behavioural needs. Based on the causation of behaviour, welfare may be defined by motivational balance and behavioural needs by environmental and behavioural key features that are essential for the performance of behavioural sequences. Ethological minimum requirements were determined from observations of adult and juvenile large-white pigs in semi-natural enclosures, in increasingly restricted and in conventional conditions. Obligatory features in the environment which consistently enabled the pigs to perform their frequent or regular sequences of behaviour were the design factors

for the enriched pens. Each is composed of a nesting, an activity and a rooting area and includes a corridor connecting 4 neighbouring pens. Such an unit houses 4 familiar sows with their fattening offspring, a boar and replacements. Basic features of social structure of the outdoor reference groups were maintained in such pig families. The social contacts in stable family groups enhance the synchrony of heats and lactational oestrus. Thus 2.3 litters/year may be obtained if sows are well fed before mating. As there is no weaning check, the growers reach bacon weight for market around 155 days of age. The system shows, what basic ethological research may contribute to reach practical housing conditions which meet the main behavioural requirements of a species.

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Fourth Topic: *Chairman's Summary and Concluding Remarks*

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This session opened with a talk by Dr R. de Koning of the Research Institute for Animal Production, «Schoonoord», Zeist, entitled «An Environmental Model for sows: materializing physical and behavioural needs.» In this approach the author listed all the requirements for the vital functions of the sow under the following headings: respiration, osmoregulation, nutrition, excretion, thermoregulation maintenance of integrity of the animal and reproduction. From this list he indicated the basic physical and behavioural needs and the requirements for these needs to be met. For example, for maintenance of integrity of the animal its needs are social behaviour and comfort behaviour. For the former it needs conspecifics and for the latter its needs are rest, exercise, body and skin care. The requirements for adequate comfort behaviour can then be listed as adequate room, a suitable climate and facilities for the animal to scratch itself. Thus from a consideration of these needs and their requirements for fulfilment, a model environment can be constructed, and existing housing can be assessed. This approach is dependent on continued research for it to be fully effective. For example a space can be bare or it can have physical features in it that are of ethological importance to the animal. Conspecifics are necessary for social behaviour, but the questions arise as to how many conspecifics and what sort? Animals of the same age? Related animals of different or the same ages? Such questions obviously point to the need for detailed behavioural research. Indeed, the author was at

pains to emphasize the need for privacy during feeding which would entail individual feeding stalls and such a judgement is of course based on previous behavioural research. As a first approach to the minimal welfare requirements of a class of livestock such a model is extremely useful and, would, in the case of sows, prevent the use of crates too short for the animals or prevent the use of unsuitable floors for dairy cattle — two factors that had been mentioned in the discussion at a previous CEC meeting at Aberdeen (Housing and Welfare, Aberdeen 28-30 July 1982) as being commonly found in modern housing in the UK. Undoubtedly one of the most valuable results of such a model is to pinpoint the many gaps in our knowledge.

The general discussion which followed ranged over all the sessions and the discussions pertaining to them. In the discussions of the earlier sessions in which productivity had been discussed it was generally agreed that productivity alone could not be used as an index of welfare, e.g. in both Sweden and The Netherlands surveys are being conducted, nationwide, on the incidence of lesions and type of lesions in sows in relation to the type of housing employed. In these surveys the occurrence of lesions, lameness, and chronic sub-clinical diseases were all found to be compatible with good productivity.

The use of corticosteroid assays is often considered to be the most objective method of assessing welfare, and this was raised in the general

discussion. One paper had described the use of free corticosteroids concentrations for the assessment of stress, and is of particular interest because it is the first to attempt to investigate corticosteroid levels in pigs under conditions of chronic rather than acute stress. Young females housed in pairs appeared to be more stressed as judged by this criterion than individually housed, tethered females. However, the use of free cortisol in this respect was questioned for the amount of free cortisol might be a function of the number of binding sites: the relationship with stress might then be obscure. It was suggested that the use of hormone profiles as has been carried out in monkeys might be useful. In other studies it has been found that sows in the higher parities show greater incidences of "inappropriate" behaviour, suggesting that these endocrine studies should be repeated with older females which constitute the majority of the sow population. Finally, it was suggested that absolute reliance on hormonal levels might be faulty in that, through Natural Selection, behavioural responses might act as an

«early warning system» so that one need not necessarily find high levels of corticosteroids in animals showing behaviour commonly accepted as symptomatic of distress. The use of immune responses as another set of physiological criteria for the assessment of stress was advocated. One earlier paper had indicated that restriction of pigs by tethers or farrowing crates may decrease immune events and increase the sow's susceptibility to infectious and non-infectious diseases.

The need for a greater understanding of the motivation of the sow was stressed. By this term is meant not only the internal causal factors but the external factors that may initiate or release some types of behaviour together with the key stimuli that guide it to fulfilment. With this sort of knowledge the welfare needs of the sow could be realized. Meanwhile the model proposed by Dr De Koning and the modifications to existing systems mentioned in the earlier papers could do much to improve the sow's welfare in the shorter term.