The development and causation of feather pecking in the domestic fowl

Promotor: dr. P. R. Wiepkema,
hoogleraar in de ethologie

STELLINGEN

1. Verenpikken is een vorm van omgericht bodempikken.

   Dit proefschrift.

2. De kwaliteit van strooiselmateriaal wordt als regel teveel afgemeten aan (zoö)technische parameters zonder rekening te houden met de specifieke eisen van de kip.

   Ehlhardt, D.A., 1986. COVP uitgave 009, 15-34.

3. Gemeenschappelijke causale faktoren van bodempikken en verenpikken vormen een verklaring voor de toename van verenpikken in de namiddag.

   Preston, A.P., 1987. Br. Poult. Sci., 28, 653-658.

   Dit proefschrift.

4. De toepassing van "fuzzy set decision analysis" ten behoeve van de evaluatie van bezettingsdichtheid van leghennen in kooien geeft geen informatie over het niveau van het welzijn van de hennen.

   Roush, W.B., R.G. Bock and M.A. Marszalek, 1989. Appl. Anim. Behav. Sci., 155- 163.

5. Selektie tegen stereotypieën bij landbouwhuisdieren dient pas overwogen te worden nadat meer bekend is over de funktionele betekenis van dergelijk gedrag.

6. Een economisch-technisch gerichte ziektecontrole bij pluimvee, zoals voorgesteld door Van der Stroom-Kruyswijk, gaat ten onrechte geheel voorbij aan de eigenwaarde van het dier.

   Van der Stroom-Kruyswijk, J., 1989. Pluimveehouderij, 10, 8-9.

7. De term "alternatief" in relatie tot nieuwe huisvestingsvormen voor leghennen zegt tot op heden meer over de achtergronden van het onderzoek dan over de feitelijke uitkomst.

   Kuit, A.R., D.A. Ehlhardt and H.J. Blokhuis (eds.), 1989. CEC Report EUR 11711 EN.

8. **Het gebruik van de term kippig doet geen recht aan de visuele capaciteiten van de kip.**

9. **Gedragsobservaties worden onderschat als bron van inspiratie.**

H.J. Blokhuis
The development and causation of feather pecking in the domestic fowl
Wageningen, 28 november 1989

H. J. Blokhuis

The development and causation of feather pecking in the domestic fowl

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mijn ouders

aan Martina en Hedy

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De huisvesting zoals gebruikt voor de experimenten moest als regel speciaal geschroefd, gespijkerd of verbouwd worden. Door de mensen van Proevendienst en Technische Dienst werd dit altijd weer gerealiseerd. Mijn dank daarvoor.

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Harry Blokhuis

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CHAPTER 1

GENERAL INTRODUCTION

Feather pecking is considered as one of the serious problems of keeping poultry in confinement. The problem was already described by Jáque in 1861, who gave two possibilities to solve the problem: "la liberté ou le couteau". Feather pecking has been of major concern to poultry farmers ever since. The behaviour consists of pecking directed at the feathers of other birds, sometimes pulling out and eating these feathers. It may result in severe damage of the integument of the birds, including wounds of the skin (photo's 1 and 2). Finally, wounded birds may be pecked to death. The latter is called "cannibalism" and may be considered as a serious final phase of feather pecking. Cannibalism can also occur as a consequence of "vent pecking". This type of cannibalism however is considered to be independent of feather pecking (Allen and Perry, 1975).

About 30 years ago, when most poultry was kept in traditional floor systems, feather pecking and subsequent cannibalism was an important cause of mortalility (e.g. Kull, 1948; Richter, 1954; Schaible *et al*, 1947). Nowadays, the mortality due to cannibalism seems to have been decreased. The so called "beaktrimming" may be one of the reasons of the decrease (Eskeland, 1981; Hughes and Michie, 1982). Beaktrimming is the partial amputation of the beak: about one third of the upper and lower beaks are cut and cauterized with a heated blade. This treatment is commonly performed in laying and breeding chicks or pullets in The Netherlands. Beak trimmed birds are obviously less capable of inflicting injuries upon other birds.
Another factor which might have reduced the mortality is the change in housing conditions which has taken place over the last decades. Formerly hens were housed in large groups in houses with deep litter or half litter/half slatted (or wire) floors. Nowadays, in The Netherlands, about 92% of the laying hens are housed in small groups (four to six hens) on battery cages. However, the latter type of housing did

Photo 1. Seriously damaged bird (at the feeder) is pecked by another hen.

Photo 2. Hen with feather damage and small wound at the back.

not result in less feather pecking. Several authors showed that in fact the frequency of feather pecking in cages is higher then in floor pens (Bessei *et al.*, 1984; Koelkebeck *et al.*, 1987). Nevertheless it is possible that the final phase of feather pecking, that is cannibalism, is less likely to occur in cages than in pens.
A factor in relation to modern housing compared to the older situations, is artificial light control. From the farms with battery cages in The Netherlands, 44.7% use artificial light conditions (CBS, 1987). Artificial lighting, in contrast to natural lighting, makes it possible to realise a constant low level of illumination in the house. It was shown that feather pecking damage is less when low light intensities are used (Hughes and Duncan, 1972).

Although beak trimming and changes in housing conditions might have reduced the mortality due to cannibalism, substantial feather damage still occurs in modern poultry farming (Norgaard-Nielsen, 1986; Simonsen *et al.*, 1980; Tauson, 1984; Wathes *et al.*, 1985). Especially in cages part of this feather damage is likely to be caused by abrasion against the cage. Although it is difficult to establish what contribution to the total damage is made by abrasion, several reports suggest that it is relativily unimportant compared to the contribution made by feather pecking (Bessei, 1984; Hughes, 1978; Hughes, 1980; Hughes and Michie, 1982).
Defeathering has a pronounced increasing effect on heat production (Richards, 1977), leading to increased energetic needs (e.g. Emmans and Charles, 1977; Tauson and Svensson, 1980). Herremans and Decuypere (1988) recently presented a formula to calculate the energetic needs in grams of food per day, in dependence on the % of defeathering. They stated that with the average feather condition as can be found in battery cages, energetic needs (at 20^{o} C) are on average increased by 5 % over the whole production year. Less optimal management may easily result in needs increased up to 20 %. In terms of grams of food this represents about 5 and 20 g per hen per day respectively.

The above illustrates the importance of research concerning feather pecking. First of all there is of course the suffering of the birds involved, both as a result of beak trimming and when heavily pecked. Secondly there are major economic considerations as well. A third factor, underlining the relevance of such research, is the development of alternative housing systems for laying hens. These often incorporate certain characteristics of traditional floor systems and "traditional" problems like feather pecking and cannibalism would be expected to occur. Severe feather pecking was indeed observed in some of these systems (Wegner, 1983; Hill, 1984), but not in others (Fölsch *et al.*, 1983; Wegner, 1983; Ehlhardt *et al.*, 1984).

In the past many factors have been studied in relation to feather pecking and cannibalism. Hughes (1982) reviews the different studies under the headings "dietary composition", "environment", "hormonal influence" and "psychic factors". Some studies have shown very definite results, ascribing feather pecking to one or a few factors, while others failed to show any consistent influence of such factors. This discrepancy is precisely what one would expect when the subject under study is influenced by a large number of (unknown) factors, as was recognised by Hughes and Duncan (1972). Unknown or uncontrolled factors will vary from one experiment to another and may be the cause of whether or not extensive feather pecking occurs.
Against this background a research project on feather pecking was started at the Spelderholt Centre. In this project it was deemed essential to try to elucidate the basic motivation behind feather pecking. It was recognised that very different factors such as genetic components, light intensity, groupsize etc., may predispose birds to peck at feathers and in that way the cause of the behaviour may be classified as multi-factorial (Hughes and Duncan, 1972). The starting point of the project however, was that all these factors influence one and the same basic process leading to feather pecking. The idea was that when the basic process is understood, it should be possible to predict more precisely the effect of different factors on the occurrence of feather pecking and thus direct future research. Moreover, when the process leading to feather pecking is studied, parameters other than feather pecking frequency or feather pecking damage may emerge, which are indicative of the risk that feather pecking may oc-

cur. This would make it possible to analyze the effect of different factors on feather pecking without actual feather pecking having to originate.

The results of the Spelderholt project on feather pecking are described in this thesis. Chapter two presents the results of the first preliminary observations. Feather pecking is analyzed in some more detail and the effect of litter versus slatted floors is indicated. The hypothesis is proposed which suggests that feather pecking is a form of redirected behaviour. Evidence to support this hypothesis is presented in chapters three and four. The results are discussed in terms of incentive motivation theory.

The experiments in chapters five and six focus on variables which are expected to be important in relation to feather pecking and which are practically manageable. Moreover, it was studied if rearing conditions may affect feather pecking in later live.

In the last chapter, a regulatory model of pecking is presented and the motivation of pecking is discussed. Moreover the risk of some husbandry factors in relation to the occurrence of feather pecking is discussed and some measures to prevent feather pecking are suggested.

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CHAPTER 2

THE DEVELOPMENT AND CAUSATION OF FEATHER PECKING IN THE DOMESTIC FOWL

SOME OBSERVATIONS ON THE DEVELOPMENT OF FEATHER PECKING IN POULTRY

H.J. Blokhuis[1] and J.G. Arkes[2]

[1] Spelderholt Centre for Poultry Research and Extension, Spelderholt 9, 7361 DA Beekbergen, The Netherlands.

[2] Present address: Ministry of Agriculture and Fisheries, Department for Animal Husbandry and Dairying, P.O. Box 20401, 2500 EK 's-Gravenhage, The Netherlands.

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SOME OBSERVATIONS ON THE DEVELOPMENT OF FEATHER PECKING IN POULTRY

ABSTRACT

In 2 experiments, observations were made on the development of feather pecking in poultry.

In the first experiment, 4 groups of 8 pullets each were observed from hatching until 17 weeks of age. Two groups were housed on litter (L-groups), two groups on slatted floors (NL-groups). Pecking at conspecifics increased in NL-groups with time, whereas it tended to decrease in L-groups. Moreover, in the latter, about 20% of the pecks was directed to particles on the plumage of other birds and about 25% to feathers. In the NL-groups, these percentages were about 1 and 55, respectively.

In Experiment 2, half of the animals from each floor-type was transferred to the other type of flooring material. Most striking was that in the group of animals reared on litter and changed to slats, feather pecking increased significantly with the duration of the experiment.

In both experiments, ground pecking was high in groups with a low frequency of pecking at conspecifics and vice versa.

It is concluded that the results strongly support the view that feather pecking evolves as "misdirected" food pecking.

INTRODUCTION

Feather pecking has always been, and still is, a major problem in intensively housed poultry. In short, it consists of pecking the feathers of other birds; sometimes pulling out and eating these feathers. According to Wennrich (1975b), this behaviour can mostly be interpreted as misdirected food pecking. It may lead to severe damage of the plumage of the birds and wounding. Wounds are apparently very attractive objects, and wounded birds are easily pecked to death. The latter is called "cannibalism" and has to be considered as a serious final phase of feather pecking (Schaible *et al.*, 1947), although cannibalism can also occur as a consequence of "vent pecking" (Hughes and Duncan, 1972; Allen and Perry, 1975). Although it is recognized that the cause of feather pecking is multi-factorial (Hughes and Duncan, 1972; Hughes, 1982), it is not clear how these factors may act together and why this may result in feather pecking.

Our starting point was that various factors all influence one and the same process, leading to feather pecking. The aim of the present experiments was to elucidate this process.

In the first experiment, we followed the development (0-15 weeks of age) of feather pecking in 2 situations differing in one factor (litter or no-litter) known to be of influence on feather pecking (Hughes and Duncan, 1972; Simonsen *et al.*, 1980). We relate differences in feather pecking to other behavioural characteristics of the animals involved, and this suggests a picture of the basic process leading to feather pecking. In a second experiment, we investigated how feather pecking was influenced by moving the animals from litter to no-litter and vice versa at the age of 17 weeks. To imitate a practical situation, all animals were also assigned to new groups. This experiment was planned to give some insight into the rigidity of feather pecking when developed, and into the effects of introducing a no-litter situation, after a rearing period with litter, on feather pecking.

EXPERIMENT 1

MATERIAL

Thirty-two newly hatched chickens (female, not beak-trimmed) of a brown commercial laying strain (Hubbard) were randomly assigned to 1 of 4 groups, housed in 4 seperate pens. Two groups (L1 and L2) were housed on litter (wood-shavings), the other 2 (NL1 and NL2) on slatted floors, which were covered with a plastic perforated mat until the animals were seven weeks of age. The 4 pens had a surface of 3 m^2 each. Continuous light was provided for the first 24 h, thereafter a 14-h photoperiod was maintained until 11 weeks of age and a 9-h photoperiod until the end of the experiment.

The photoperiod was reduced to delay egg production in order to avoid any influence of endocrinological status during Experiment 1. Food and water were *ad libitum*. Animals were individualised with coloured markers on head and legs.

METHOD

Individual observations were carried out during the first 15 weeks of the animals' lives. Each animal was observed 4 times every week (except for Week 6, in which they were observed 3 times) during periods of 4 min each. All animals of a group were observed in a random order before observation of the next group was started. Two groups were observed between 8.30 h and 10.00 h, the other 2 between 13.00 h and 14.30 h. In one week, each group was observed once first, once second, once third and once last.

The observer (J.G.A.), sitting in front of the pen, recorded occurrences of behaviour patterns on tape. For convenience, related patterns were grouped.

Occurrences of the following behaviours were recorded:

Pecking at conspecifics. Non-aggressive pecking at other birds. Several parts of the pecked bird were distinguished: head/beak, comb/wattle, back, wing, chest, vent, tail, leg.

Aggressive pecking. A vigorous movement, usually directed to the head of the other bird.

Pecking at food. Pecking directly to food-particles in the feed-trough.

Pecking at the ground. Pecking directed to the ground while standing or walking.

Other pecking. Pecking at water, the wall, etc.

Comfort behaviour. Consisting of stretching, shaking and preening as described by Kruyt (1964). When an interruption in preening exceeded 3 s, a new occurrence was recorded.

Ground scratching. The body bending forward, the bird makes a backward stroke with one leg. Usually 1-4 strokes with one leg are followed by 1-4 strokes with the other. Every stroke was registered as one occurrence.

During normal observation procedures as described above, some additional information was gathered.

(a) On 12 observation days, distributed over the whole experimental period, except for the first 2 weeks, the behaviour of pecked conspecifics was also classified into one of 5 classes.

(1) Eating	- Pecking at food.
(2) Ground scratching and/or -pecking	- The bird makes ground scratches (see above) and/or makes groundpecks (see above).
(3) Resting	- The bird doesn't move.
(4) Dustbathing	- The bird is in a sitting position, feathers are fluffed and it shows behaviour elements as described by Kruyt (1964).
(5) Other	- The bird is not involved in one of the fore-going patterns (e.g. drinking, moving, preening, etc.).

(b) On 15 observation days, distributed over the last 9 weeks of the experiment, pecking at conspecifics was also classified into one of 4 classes according to the aim of the pecks.

(1) Litter particles on the other bird.

(2) The beak of the other bird.

(3) The feathers of the other bird, including pulling and plucking of feathers.

(4) Other.

RESULTS

Pecking at conspecifics

The pecking frequency, averaged over birds, differed between L- and NL-groups. These differences are clearly shown in the graphs of Figure 1. Pecking at conspecifics tended to increase in the NL-groups (Spearman rank-correlation: r_s=0.72, $P < 0.01$), whereas there is a negative trend in the L-groups (r_s=-0.34, $P < 0.1$).
The peaks in the graph of Group L2 are caused by excessive pecking to litter particles on the backs and wings of dustbathing conspecifics. In all groups, most of the pecking was directed to the head and beak, back and wings of other birds (on average 75% of all pecks were directed to these areas). In many cases, animals chose inactive birds to peck at. This was the case in the L-groups, where 78.5% of all registered pecks were directed at resting birds, as well as in the NL-groups, where this percentage was 81.8. L- and NL-groups, however, differed with respect to the object that was pecked. About 20% of the pecking in the L-groups was at particles on the plumage of other animals (often during dustbathing), while this was about 1% in the NL-groups. Pecking at feathers, on the other hand, made approximately 25% of the total in the L-groups against approximately 55% in the NL-groups. The latter kind of pecking is the most damaging, as it includes pulling and plucking of feathers. Pecking at particles on other animals is a relatively harmless kind of pecking. The higher frequency of pecking and its damaging character in the NL-groups found expression in the severely damaged plumage of most animals in these groups. Plumage was in particularly bad condition on the backs of the birds. On the other hand, the plumage of all animals in the L-groups was in perfect condition. Animals of L-groups and of NL-groups showed a relatively high intra-group similarity in their pecking frequencies (Figure 2). In Group L2, one animal had a strikingly high pecking frequency, yet other animals in this group were not "infected".
There was a slight trend that high-ranking animals peck relatively more to the chest and low-ranking animals more to the back and tail of other birds (this was not significant). There appeared to be no

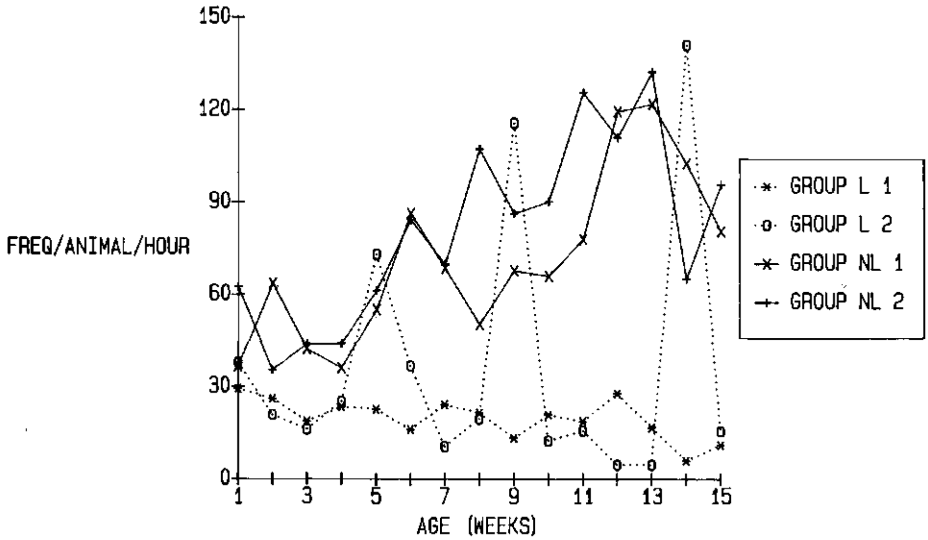


Figure 1. Pecking at conspecifics in litter (L) and no-litter (NL) groups.

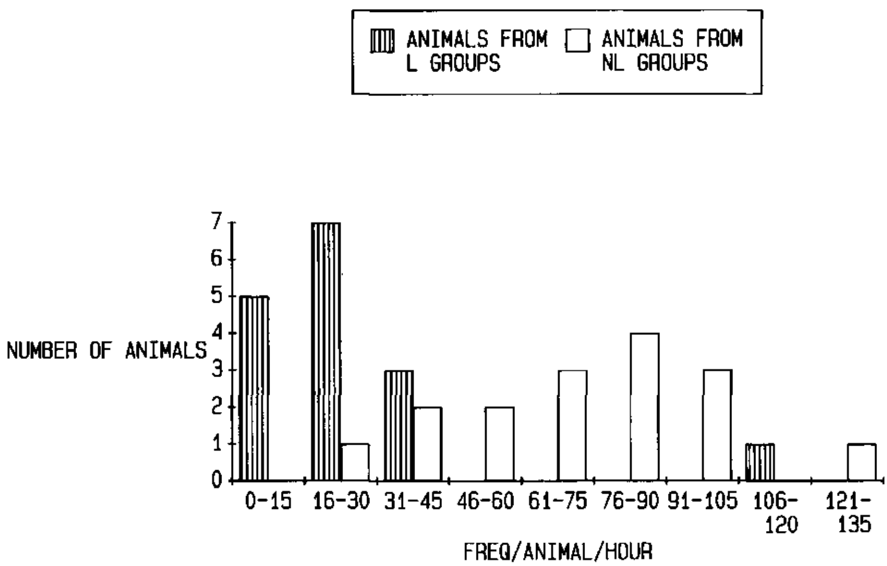


Figure 2. Distribution of animals of L- and NL-groups over frequency-classes of pecking at conspecifics.

relation between dominance and pecking frequency as found by Hughes and Duncan (1972) and Wennrich (1975c), and our results agree with those of Martin (1975), who dit not find such a relation either.

Aggressive pecking

Aggressive pecks were seldom registered and appeared to be a minor contribution to the total number of pecks at other animals (Table 1).

Table 1. Frequencies of pecking, comfort behaviour and ground scratching. Frequencies per bird per hour, average of 472 four-min observations per group.

	Group			
	L-1	L-2	NL-1	N1-2
Aggressive pecking	0.9	0.2	5.3	1.1
Pecking at: food	406.7	730.5	640.4	824.9
ground	700.2	630.3	110.9	96.0
Other pecking	117.5	155.6	73.0	80.9
Comfort behaviour	53.0	49.0	49.7	55.4
Ground scratching	25.4	21.9	4.4	3.9

Other kinds of pecking

In Table 1, the frequencies of pecks which were not directed to other animals are shown. Food pecking frequency was relatively high in all groups (the cause of the relatively low frequency in L1 is not clear). Other pecking was highest in the L-groups. In the L-groups, pecking at the ground was about 6 times higher than in the NL-groups.

Comfort behaviour

There were no major differences between groups in the frequencies of occurrence of comfort behaviour (Table 1).

Ground scratching

The frequency of ground scratching was much higher in the litter groups compared to the no-litter groups (Table 1).

EXPERIMENT 2

MATERIAL AND METHODS

The birds from Experiment 1 were used. At 17 weeks of age, each group was split into 2 groups of 4 animals. The a animal from each group was placed in one quartet, the b animal in the other, the c animal in the same set as the a, and so on. Next, 2 quartets of different groups were put together and housed on litter and slats as shown in Figure 3. A 9-h photoperiod was maintained. Food and water were *ad libitum*.

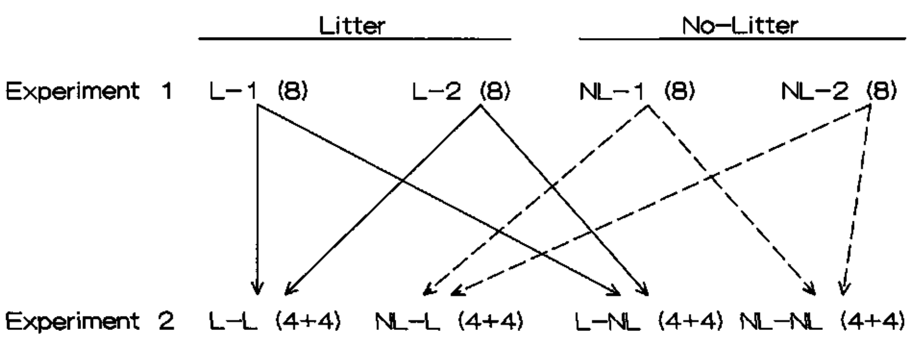


Figure 3. Schematic representation of the distribution of animals from Experiment 1 over experimental groups in Experiment 2.

From 17 to 27 weeks of age, 20 observation-days were completed (observer H.J.B.). The observations were carried out in the same way as described for Experiment 1, except that the observation days were a bit more spread out in time and no additional information was gathered as described for Experiment 1. During the last 4 observation days, only 5 animals were left in Group NL-NL; 3 had died of pecking injuries.

RESULTS

Pecking at conspecifics

In Table 2, mean pecking frequencies per group are given, each figure is an average for 4 observation days.
Pecking in Group L-L was at the same level as in Groups L1 and L2 during Experiment 1. The peak in Group NL-NL in the 24th week of age was associated with the occurrence of cannibalism. When an animal was severely wounded by persistent feather pecking, other processes then seemed to come into play which made the injured bird the favourite pecking object. The behaviour of the other animals in this situation may be better described as expelling behaviour (Wennrich, 1975a) rather than feather pecking behaviour. The lower frequency of pecking in this group at the end of the experiment was probably connected with the death of 3 animals in this period. This reduced the number of conspecifics which could possibly be pecked by 43% for each animal.
Group L-NL showed a significant increase of pecking with time (r_s=1, $P < 0.01$), together with increasing feather damage. This supports the idea that the no-litter situation is an important factor in the development of feather pecking.
In Group NL-L, pecking at conspecifics started at a very low level, which subsequently rose and then fell again. The cause of this fluctuation is not clear, but could be due to a process of adaptation toation to the new substrate. However, the animals' plumage recovered from the damage done to it in Experiment 1, so that it must be concluded that pecking was less damaging than in the no-litter groups.

Table 2. Pecking at conspecifics. Frequencies per bird per hour, averages of 4 observation days (32 four-min observations) per group.

Group	Age (weeks)					
	17.3	18.8	21.0	23.6	25.7	Mean
L-L	45.9	38.4	16.3	46.4	10.7	31.5
NL-L	6.5	123.2	184.2	41.6	58.5	82.8
NL-NL	64.6	32.7	72.1	148.1	35.3	70.5
L-NL	39.3	81.6	96.5	135.6	171.1	104.7

As in Experiment 1, most of the pecking was directed to head and beak, back and wings (on average, 85% of all pecks were directed to these areas). The wings were especially favoured by animals in Groups L-L and NL-L. Pecking in the latter groups was often at dustbathing conspecifics and did not affect the condition of the plumage. This was confirmed by examination of the animals' plumage in the different groups. Plumage was in perfect condition in the litter groups (including Group NL-L), but in many cases was in very poor condition in the no-litter groups. Bare patches were common in the latter, and some animals had injuries on the back.

In the 3 months after the new groups were formed, one animal in Group NL-NL and 6 in Group L-NL died or were culled as a result of severe injuries caused by pecking from other animals. Two more birds died in Group NL-NL from vent pecking.

The reaction to the changed floor-type was very similar for animals in Group NL-L and those in Group L-NL: the majority of animals in Group NL-L decreased pecking at conspecifics, the majority in Group L-NL dramatically increased pecking at conspecifics (Figure 4). In Groups L-L and NL-NL, about half the animals increased and half decreased pecking at conspecifics.

Aggressive pecking

As in Experiment 1, aggressive pecking was not very frequent and no clear differences between groups appeared (Table 3).

Other kinds of pecking

The most striking differences between groups were in pecking at food and in pecking at the ground (Table 3). The former was lower in litter groups, and was probably caused by the intake of litter particles in these groups.

Table 3. Frequencies of pecking, comfort behaviour and ground scratching. Frequencies per bird per hour, averages of 160 four-min observations per group.

	Group			
	L-L	NL-L	NL-NL	L-NL
Aggressive pecking	3.7	3.1	0.7	4.4
Pecking at: food	555.9	675.0	976.8	919.2
ground	1455.3	772.2	186.8	70.4
Other pecking	127.2	175.9	82.3	55.1
Comfort behaviour	20.7	27.8	24.9	23.3
Ground scratching	69.6	39.0	6.0	0.9

Pecking at the ground was at a higher level in litter groups compared to no-litter groups. However, there seems to be an influence from the rearing period: birds in Group L-L pecked more at the ground than birds in Group NL-L, and birds in Group NL-NL pecked more at the ground than those in Group L-NL. These differences are the other way around in the case of pecking at conspecifics (Table 2). This suggests a relationship between pecking at the ground and pecking at conspecifics; more pecking at the ground goes with less pecking at conspecifics, and vice versa.

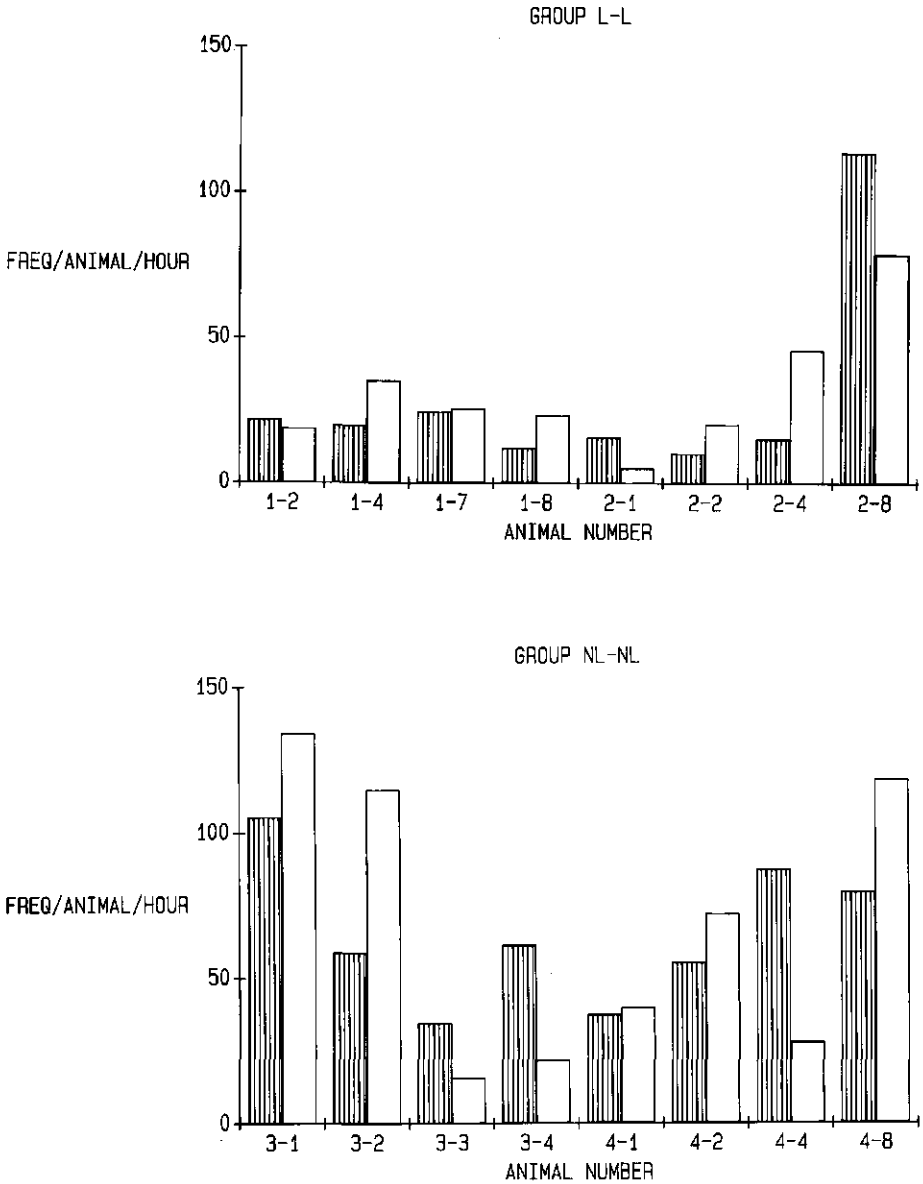
Comfort behaviour

There were no major differences between groups in the frequencies of occurrence of comfort behaviour (Table 3).

Ground scratching

Frequency of ground scratching was higher in the litter groups (Table 3).

Figure 4. Pecking at conspecifics by individual animals in the different groups of Experiment 2 (clear bars). Striped bars indicate pecking frequency of the same animal in Experiment 1. Averages of 60 four-min observations in Experiment 1 and 20 four-min observations in Experiment 2 (except for animals 4-1, 4-2 and 4-4, for which the average was based on only 16 four-min observations).



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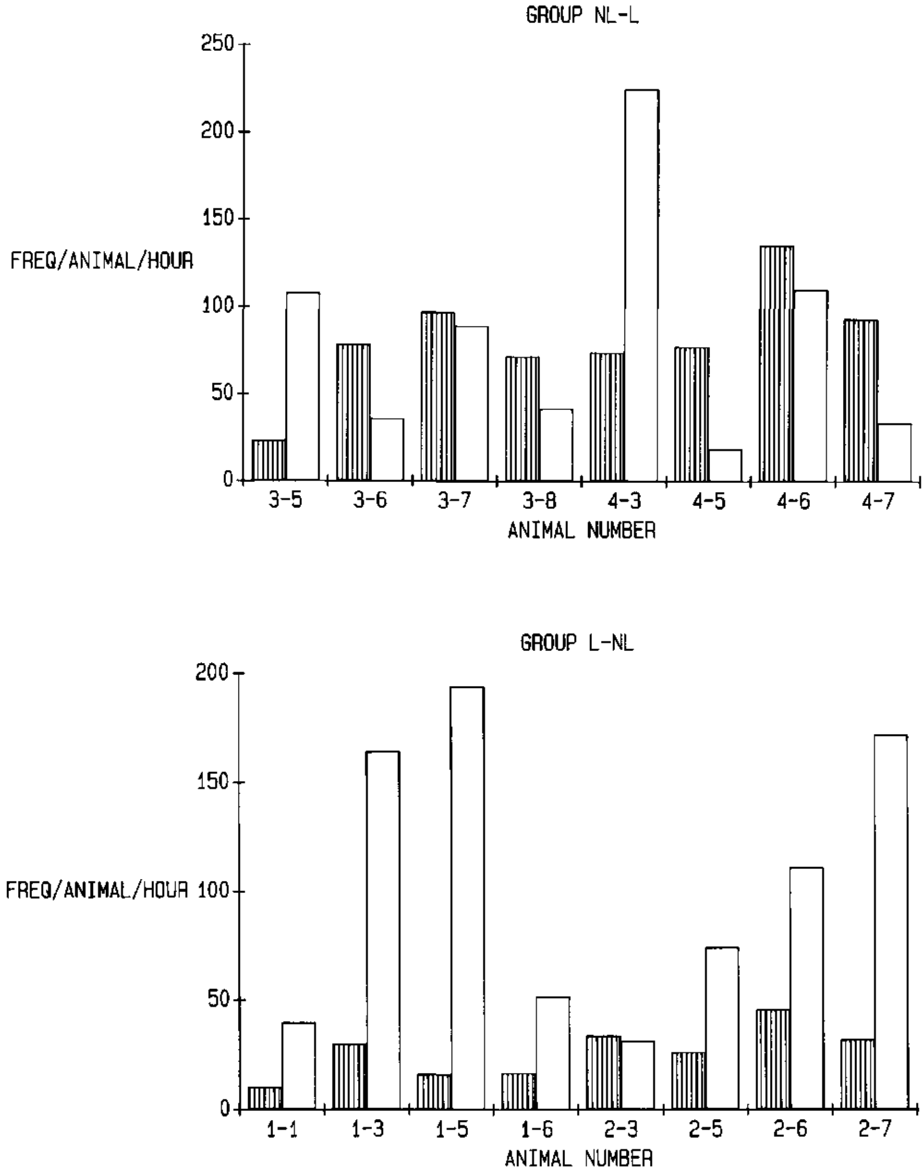

Figure 4. For legend see page 20

DISCUSSION

In his extensive study, Wennrich (1974a,b,c) described pecking movements at conspecifics in the context of feeding, allopreening (mutual preening) and aggression. In the present experiments, aggressive pecking appeared to make a minor contribution to the total amount of pecking at other animals in the group.

Allopreening in most birds resembles the type of preening normally applied by a bird to its own feathers (Harrison, 1965). In poultry, this behaviour is usually limited to careful pecking at the plumage or at foodparticles in the beak of another bird. Moreover, hens are often seen pecking litter particles from the back of another hen, but those pecks are obviously influenced by factors which are effective during food pecking behaviour (Wennrich, 1974b). This is especially clear when the pecked animal is dustbathing; ground pecking and -scratching are performed then on a dustbathing bird. The pecking movements in these cases are the same as in food pecking and ground pecking. The purpose of these pecks is intake of particles and they are less careful than pecks during preening.

We agree with Wennrich (1974b) that this food pecking behaviour can easily lead to feather pecking and feather eating. The hypothesis that this development is more likely when ground scratching and -pecking are frustrated by lack of an appropriate litter substrate seems obvious. In the latter situation, feather pecking evolves as "misdirected" ground pecking. The results from the present experiments strongly support this view.

(1) Ground pecking was high in groups with a low frequency of pecking at conspecifics and vice versa (Experiments 1 and 2).
(2) Pecking at conspecifics was higher in no-litter groups (Experiment 1).
(3) In no-litter groups, pecking at conspecifics was much more directed to feathers than in litter groups, where it was more limited to particles on the plumage (Experiment 1).

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CHAPTER 3

THE DEVELOPMENT AND CAUSATION OF FEATHER PECKING IN THE DOMESTIC FOWL

FEATHER PECKING IN POULTRY: ITS RELATION WITH GROUND PECKING

H.J. Blokhuis

Spelderholt Centre for Poultry Research and Extension, Spelderholt 9, 7361 DA Beekbergen, The Netherlands.

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FEATHER PECKING IN POULTRY: ITS RELATION WITH GROUND PECKING.

ABSTRACT

It was shown that the motivation for feather pecking varies along with ground pecking motivation. This supported the view of a common regulating mechanism. It was concluded that feather pecking is to be considered as redirected ground pecking, and hence that the latter is an important parameter in experiments comparing the risk of different environmental factors concerning the development of feather pecking.

INTRODUCTION

Feather pecking is considered as one of the serious problems in the poultry industry. It may result in feather damage, wounded birds and reduced productivity. A better understanding of its aetiology may help to find better measures to control it.

In a recent paper (Blokhuis and Arkes, 1984) it was stated that feather pecking in fowls evolves as "misdirected" ground pecking, in support of the view advocated by Hoffmeyer (1969) and Wennrich (1975). In that paper it was shown that pecking at conspecifics was high in groups of hens with a low frequency of ground pecking and vice-versa. Ground pecking in poultry is part of the feeding system and is mostly directed onto edible material, although the tendency to peck at inedible objects remains high throughout life (Kruyt, 1964).

Misdirection, commonly referred to as redirection, is a well known concept in ethology (Bastock *et al.*, 1953). It relates to situations in which motor patterns are directed towards an object or organism other than that at which it was initially directed. In relation to ground pecking, redirection may be described as the process resulting in ground pecks being directed onto objects other than particles on the ground. It implies at the same time that these redirected pecks as well as the original ones, are still under the control of the feeding system. If so, the occurrence of redirected ground pecks and of origi-

nal ground pecks will share causal factors.
The present experiment tested if ground pecks may be redirected onto other animals. The idea was to vary experimentally the motivation for ground pecking in groups of chickens and observe changes in the frequency of feather pecking. If some of the feather pecking is under the control of the mechanisms that regulate ground pecking, it should vary along with ground pecking motivation.
Pilot experiments with groups of chicks in litter pens showed a marked variation in ground pecking motivation when the animals were on a restricted feeding schedule. Ground pecking frequency was much higher in the second and third half hour after feeding was allowed than just before a feeding period. The present experiments investigated whether feather pecking shows a similar relationship to feeding periods.
As redirection is expected to take place in a situation with a less appropriate substrate, animals were tested on slatted floors. To control for the variation in ground pecking motivation, the same tests were carried out simultaneously with animals on litter floors.

MATERIALS AND METHODS

Animals and housing

For each of the six replications of the test, ten newly-hatched female chicks of a brown laying strain (Hubbard) were obtained from a commercial hatchery. The animals were not beak-trimmed. Five animals were randomly selected and assigned to a litter pen (wood-shavings); the other five were placed in a no-litter pen (slatted floor, covered with a plastic perforated mat during the first 11 days). The pens had a surface area of about 0.7 m^2. A photoperiod of 14 h was maintained and food and water were *ad libitum*. When the animals were 32 days old, one animal per group was randomly removed while the other 4 were placed in the test situation (see below) on the same flooring as they were used to (the fifth animal served as a substitute in case of the death of one of the birds).
In this way, two groups of birds were obtained, characterized by ei-

ther a high level of ground pecking, or of feather pecking.

Test situation

The test situation consisted of two adjacent pens (4.2 m^2 each), one with litter and one with a slatted floor. Three walls of each pen were of board material, the front walls were of wire netting. Four times a day (with an interval of about four h), food was available for 15 min; a timer-operated motor lowered a trough in each pen and lifted it again after 15 min. Water was *ad libitum* and a photoperiod of 14 h was maintained.

Observations

After a 10-day habituation period in the test situation, individual observations were carried out. Coloured rings around the animals' legs enabled individual recognition. The test was replicated six times with an interval of two weeks between the starts of successive tests, so in total six different "pairs" of a litter (L) and a no-litter (NL) group were tested.

Observations were organized as follows:

- all animals in a group were observed in a random order over four days, one animal per day per group;
- the L-animal and the NL-animal were observed alternately for five min over a 60-min period before and a 60-min period after the third feeding (Figure 1);
- the observer, sitting in front of the pens, in full view of the animals, recorded occurrences of the following behaviours on audio-tape:

  Ground pecking. Pecking directed to the floor while standing or walking.

  Feather pecking. Non-aggressive pecking at other birds. This category includes pecking and pulling feathers. Pecking at the legs and the beak and pecking at litter particles on the plumage of conspecifics were excluded.

  Stretching/shaking. Wing-stretching, wing/leg stretching, yawning, body/wing shaking, tail-shaking and wing-flapping, as described by Kruyt (1964).

Preening. As described by Kruyt (1964). A new occurrence was recorded when the duration of preening exceeded five s.

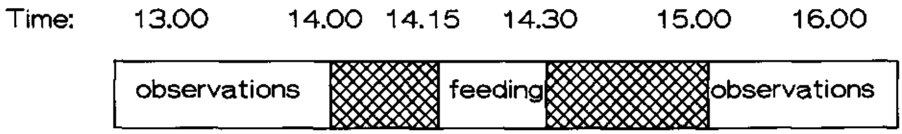

Figure 1. Schedule of observations.

RESULTS

Average frequencies of behaviour patterns were calculated for each group over all 4 animals for the hour before and the hour after feeding. Table 1 shows that the frequencies of ground pecking significantly increased after feeding in both L- and NL-groups. Frequencies of feather pecking did show an increase after feeding in NL-groups, while there was no change in L-groups.

For stretching/shaking and preening, only for preening in NL-groups was an increase after feeding detected. Significant differences (Wilcoxon matched pairs signed rank test, Owen (1962)) between N- and NL-groups were found only for ground pecking ($P < 0.025$), which was much more frequent in L-groups, and for feather pecking ($P < 0.05$), which was much more frequent in NL-groups.

Table 1. Frequencies of observed behaviours (per animal per hour), averaged over all L-groups and all NL-groups in the hour before and the hour after the feeding period.

Behaviour	Group	Before feeding		After feeding
Ground pecking	L	1392.7(362.2)	<	2101.1 (601.8)
	NL	279.2 (89.1)	<	418.3 (184.1)
Feather pecking	L	4.8 (2.4)		5.8 (2.6)
	NL	17.3 (14.0)	<	35.7 (20.5)
Stretching/ shaking	L	13.2 (3.8)		14.3 (5.6)
	NL	14.3 (6.7)		21.6 (4.9)
Preening	L	85.0 (31.9)		118.5 (29.6)
	NL	101.5 (37.2)	<	160.7 (26.8)

< : $P < 0.05$ (Wilcoxon matched pairs signed ranks test, Owen (1962)).

DISCUSSION

The results clearly indicate that the present method was successful in varying the motivation for ground pecking. Ground pecking was significantly more frequent shortly after feeding in both the L- and NL-groups.

The hypothesis that ground pecking and feather pecking share common causal factors is supported by the fact that the latter varied along with ground pecking in the NL-groups. Feather damage and serious fea-

ther pecking problems are likely to arise from this redirected ground pecking.
The (low) levels of feather pecking in L-groups do not show this same relationship with ground pecking. This may be explained by the fact that fowls have a high tendency to peck at inedible objects throughout life (Kruyt, 1964), and therefore a certain basal level of pecking at conspecifics is expected which is not controlled by the ground pecking regulating system. This feather pecking may therefore be considered as exploratory behaviour or allopreening (Harrison, 1965).
After the feeding period, NL-animals showed an increased level of preening. Such excessive preening may point to a frustrated tendency or conflict situation (Kruyt, 1964; Duncan and Wood-Gush, 1972). A possible conflict might arise from simultaneously-aroused tendencies to direct "ground" pecks at conspecifics and to keep a certain distance away from conspecifics.
An appropriate description of the process involved in the redirection of ground pecks might be in terms of incentive motivation theory (Bindra, 1969). This theory implies that the tendency to perform a particular behaviour is aroused by internal states (e.g. energy state) and external incentive stimuli (e.g. food particles). In terms of this theory, ground pecking in L-groups in the present experiment was aroused by some internal state and the presence of litter.
As litter was absent in the NL-groups, the slatted floor as well as feathers of conspecifics became incentives for "ground" pecking. The fact that the pecks at other animals in NL-groups did not fully compensate for the difference in ground pecking between L- and NL-groups is explained by the relatively low incentive value of feathers as compared to litter.
From the above, it follows that the occurrence as well as the direction of redirected ground pecking is very much dependent on the relative incentive value of environmental stimuli as well as on internal state. Consequently, a relatively low frequency of "real" ground pecking points to a low incentive value of the ground, and this holds the risk that other objects (feathers) have a relatively high incentive value, which may act synergistically with a specific internal state causing feather pecking. Therefore the frequency of ground

pecking is an important parameter in studies concerning effects of environmental factors on feather pecking.

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CHAPTER 4

THE DEVELOPMENT AND CAUSATION OF FEATHER PECKING IN THE DOMESTIC FOWL

THE EFFECT OF A SUDDEN CHANGE IN FLOOR TYPE ON PECKING BEHAVIOUR IN CHICKS

H.J. Blokhuis

Spelderholt Centre for Poultry Research and Extension, Spelderholt 9, 7361 DA Beekbergen, The Netherlands.

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THE EFFECT OF A SUDDEN CHANGE IN FLOOR TYPE ON PECKING BEHAVIOUR IN CHICKS.

ABSTRACT

An experiment was carried out with seven groups of four pullet chicks of a brown medium-heavy laying strain. When the birds were six weeks old, they were observed on five consecutive days. After the first day, which was the control day, the half-litter, half-slatted floor was changed into a fully slatted floor. Ground pecking and scratching decreased while scratching during feeding and feather pecking showed a significantly higher level on Day 5. The results fit earlier conclusions that feather pecking is to be considered as redirected ground pecking. Specific characteristics of a slatted floor appeared to contribute to this redirection process. In order to prevent feather pecking, it is important to provide poultry with floors which are highly appreciated as incentives for ground pecking.

INTRODUCTION

Recent experiments with poultry have shown that ground pecking and feather pecking share common causal factors, supporting the hypothesis that feather pecking is to be considered as redirected ground pecking (Blokhuis, 1986). In the latter study, this process of redirection was described in terms of incentive motivation theory (Bindra, 1969, 1978). According to this concept of motivation, both the internal state of the animal as well as external stimulation by environmental objects or events contribute to the tendency (motivation) to perform behaviour. Environmental stimuli are called (positive or negative) incentives. Incentive stimuli not only induce motivational states, but also make behaviour goal directed (towards or away from the incentive).

Following this line of thinking, redirection of ground pecking to another substrate (such as feathers) may occur when the relative incentive value of the latter is high compared to the incentive value of the ground. Thus, for the poultry industry, it is important to establish what factors influence the incentive value of the ground, as this may help to overcome the problem of feather pecking.

The outcome of the animal's commerce with environmental stimuli is crucial for the validation of these stimuli as incentives (Toates, 1986). When favourable consequences, like the reduction of a "hunger" state or copulation are monitored, this results in the appreciation of the stimulus (viz. food or a conspecific of the opposite sex) as an incentive and these stimuli will be favoured in future. Concerning ground pecking in poultry, several characteristics of a substrate affect the tendency of a bird to engage in pecking at that substrate. Thus, visual, tactile and gustatory properties are found to be important as well as long-term effects of ingestion (Hunt and Smith, 1967; Hogan-Warburg and Hogan, 1981). Moreover, there are indications that the possibility of performing specific consummatory behaviour patterns may also affect the validation of a substrate as an incentive. For example, Duncan and Hughes (1972) showed that hens preferred to obtain part of their diet by pecking a disc, instead of eating free available food, and Sterritt and Smith (1965) showed that tube feeding (delivering food directly into the crop) in young chicks appeared punishing, while tube feeding in combination with pecking at a stimulus panel was highly rewarding. These results suggest that consummatory stimulus components are important in the validation of stimuli as incentives (cf. Wiepkema, 1987).

The type of floor in poultry housing is important in relation to the development and occurrence of feather pecking (Levy, 1938; Hughes and Duncan, 1972; Blokhuis and Arkes, 1984). Floors without litter appear to stimulate feather pecking or, in other words, the redirection of ground pecking. In terms of incentive theory, this points to a relatively low incentive value of floors without litter as compared to litter floors. Although there are obvious differences between floors with and floors without litter, it is not clear which differences are essential. It is also not clear which characteristics cause feathers to obtain a favourable ranking as an incentive.

In the present experiment, changes in the behaviour of pullet chicks were observed after a sudden change from a litter floor to a slatted floor. The first aim was to study the effects of such a change on pecking behaviour. Secondly, other behavioural changes were studied in an attempt to improve our understanding of what determines the incentive value of floors and feathers.

MATERIALS AND METHODS

Animals and housing

With intervals of at least one week, seven groups of five pullet chicks of a brown egg-laying strain (Warren SSL) were obtained from a commercial hatchery at one day old. Birds were housed in small pens (104 x 66 cm) with half-litter, half-slatted floors. When they were 32 days old, one randomly chosen bird per group was removed while the others were placed in one of two available testing pens (the fifth chick served as a substitute in case of the death of one of the birds before 32 days of age). At this time, the birds were given a coloured ring around a leg to enable individual recognition. The floor of the testing pen (146 x 200 cm) was also half-litter, half-slatted floor.
The photoperiod ran from 06.00 to 20.00 h. Water was available *ad libitum*. Until 32 days of age, food was also supplied *ad libitum*. However, in the testing pen, food was only available during four feeding periods of 15 min every day. Four times a day, a timer-operated motor lowered a trough and lifted it again after 15 min. The interval between feeding periods was about four hours.
Food and water were offered on the slatted floor.

Experimental procedure

After a 10-day habituation period in the testing pen, behavioural observations were carried out on five consecutive days, starting with the third feeding period. On the second day of the observations, the litter floor in the testing pen was covered with slats just before the start of the third feeding period. This situation continued until the end of the observation period on Day 5, which was also the end of the experiment.

Observations

All chicks of a group were observed individually every day. The observer sat down in front of the pen just before the third feeding period. During the feeding period, only occurrences of "scratching" and "pecking at food" were registered (see below). In this period, all animals were observed, in random order, during one period of 3.5 min each. After the feeding period, the observer waited 10 min before starting the observations again. During this short pause, the food trough was lifted while the birds pecked at a few spilled food particles on the slatted floor. Individual birds were then observed continuously for five min each in the same order. This was repeated four times, resulting in a total observation time of 80 min (4 x 5 = 20 min per bird). Testing of all seven groups was completed during a period of nine weeks.

The following behaviours were selected for analysis.

Ground pecking. Pecks directed to the floor while standing or walking.

Ground scratching. The body bending forward, the bird makes a backward stroke with one leg. Usually one to four strokes with one leg are followed by one to four strokes with the other. Every stroke was registered as one occurrence.

Scratching during the feeding period. Birds make backward strokes with the legs, as with ground scratching, during pecking into the feed trough. This scratching is sometimes on the ground (slats) or against the feed trough. Every stroke was registered as one occurrence.

Pecking at food. Every peck into the feed trough was registered.

Feather Pecking. Non-aggressive pecks at the feathers of other birds. This category includes pecking and pulling feathers. Pecks at the legs, the beak or at litter particles on the plumage were excluded.

Pecking at litter on plumage. As litter was only present on the first day of testing, the pecking of litter particles from the plumage of conspecifics could only occur then.

Statistical analysis

The data of the first testing day were used as controls and compared with the data of Days 2 to 5 using the Wilcoxon matched-pairs signed-ranks test (Siegel, 1956). The data of Days 2 to 5 were tested against trend over time (Lehmann, 1975).

RESULTS

Figure 1 shows the averaged results for the different behaviours on the five experimental days. Occurrences of the different behaviours are expressed as frequencies per animal per hour.

Ground pecking and ground scratching were significantly lower on the first day after the litter was covered. Also on days thereafter, the levels of these behaviours were significantly lower compared to Day 1. There were no significant trends over time in the frequencies of ground pecking and scratching from Days 2 to 5. Ther was an increasing scratching during the feeding period and tendency for feather pecking after the litter was covered. However, these increases were not significant. On Day 5, the level of both behaviours was significantly higher compared to Day 1. This suggests an increase over time after the change in floor type. However, no significant trends were detected. Pecking at food was not significantly affected by the change in floor type. Although the data suggest a weak increase over time, this was not significant.

Pecking at litter particles on the plumage of conspecifics was only observed on Day 1.

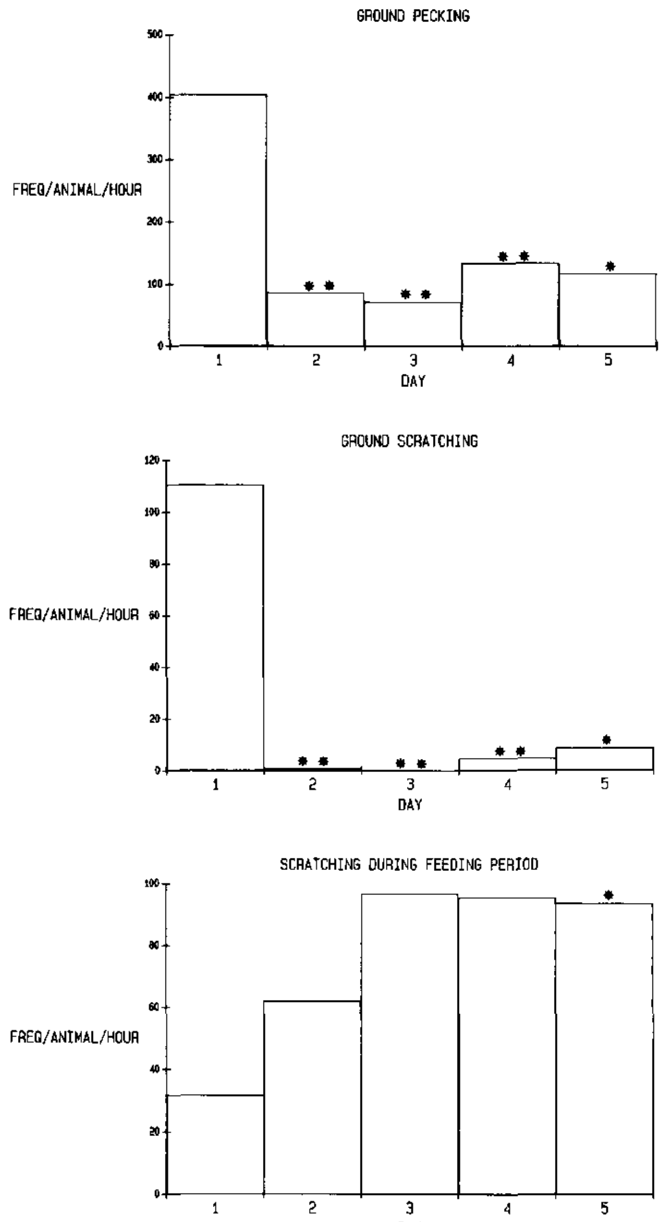

Figure 1. Frequencies of observed behaviours (per animal per hour) on the five experimental days, averaged over all seven groups. Significant differences between experimental days and Day 1 (control) are indicated (*: $p < 0.05$, **: $p < 0.01$).

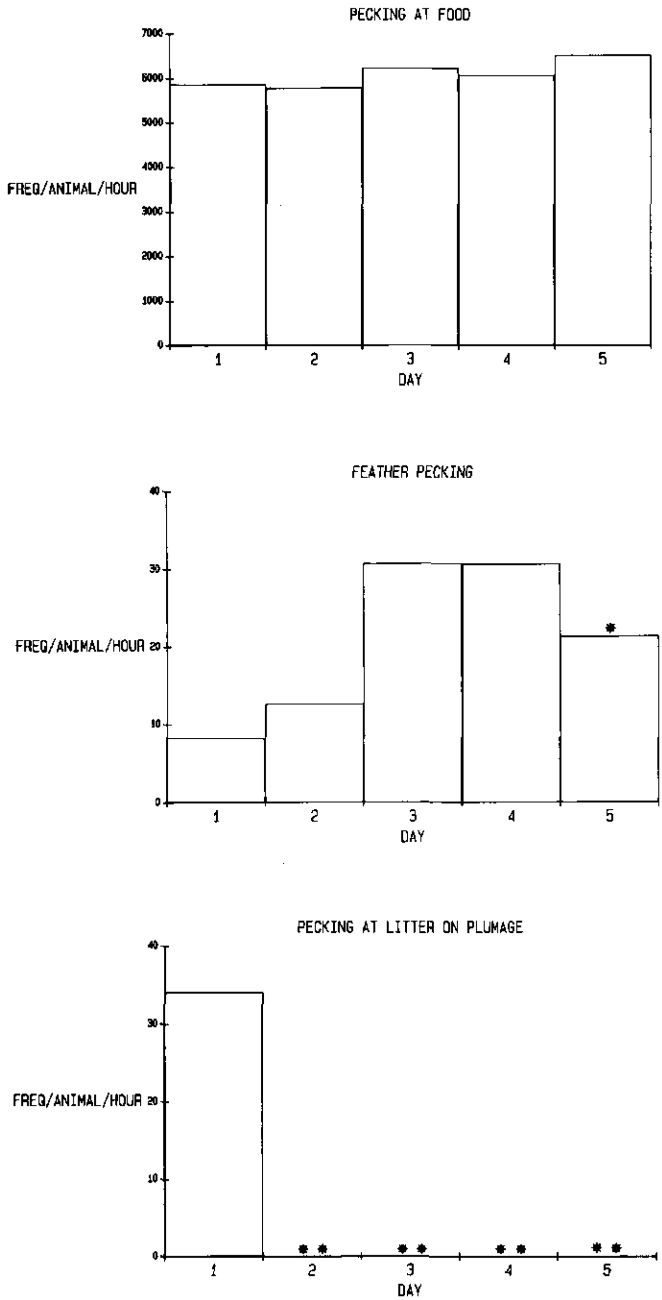

Figure 1. For legend see page 44

DISCUSSION

As expected, the sudden change of floor type caused a very clear decrease in ground pecking. Feather pecking was only significantly higher on Day 5. However, the data also show an increase not significant on Days 2, 3 and 5, rejecting the idea of a chance occurrence. An increase also fits the conclusion of an earlier experiment (Blokhuis, 1986) that feather pecking is to be considered as redirected ground pecking. A frequency of about 20-30 feather pecks per animal per hour is reached in the present experiment after only two days without litter. This is about the same level as was found in an earlier experiment (Blokhuis, 1986) in birds of about the same age, which had been without litter all their life. This suggests that redirection of ground pecking on a slatted floor is a short-term process which is rather independent of foregoing experience with litter. As the birds in the present experiment were reared on half-litter, half-slatted floor, they were familiar with a slatted floor. Perhaps redirection would have taken more time if this had not been the case. In terms of incentive motivation theory, redirection of ground pecking occurs when the incentive value of the slatted floor is low and feathers are a relatively favourable incentive. The relatively low incentive value of the slatted floor, compared to the litter floor, may be illustrated by the finding that only 14 % of all ground pecks on Day 1 were directed at the slatted floor. It is obvious that a slatted floor offers almost no possibilities for the birds to peck and manipulate particles. Positive visual, tactile and gustatory feed-back signals as well as positive long-term effects of ingestion are, therefore, likely to be much less compared to litter floors. These characteristics are likely to be very important in the validation of a slatted floor as an incentive.
Ground scratching almost ceases on the slatted floor. At the same time, scratching during the feeding period increases to almost the same level as ground scratching on Day 1. This shows that scratching is preferably performed when it can be alternated by ground pecks at litter instead of pecks at food. However, when no litter particles are available on the ground, it occurs during food pecking rather than during pecking at the slatted floor.

Apparently scratching is only performed in alternation with pecking at particles such as food or litter. This is not surprising as pecking and scratching are functionally related in the feeding system. Moreover, this common factor makes it likely that the occurrence of one is affecting the occurrence of the other. It is therefore suggested here that the very low frequency of ground scratching on the slatted floor is a contributory cause of the lower frequency of ground pecking on slats compared to litter. In terms of incentive motivation theory, this means that in the case of pecking, the incentive value of a litter floor is higher than that of a slatted floor, because of consummatory stimulus feed-back from scratching. The reason for the choice of feathers as alternative pecking objects is not clear, although some tactile and gustatory feed-back may play a role. When litter was available, pecking at litter particles on the plumage of (mainly dustbathing) conspecifics occurred frequently. This pecking is, at least partly, controlled by the feeding system, as supported by the observation of scratching movements which accompany this kind of pecking (Wennrich, 1974; Blokhuis and Arkes, 1984). This may have resulted in the appreciation of conspecifics as places where particles may be found. When litter particles are no longer present, this previous experience may facilitate the direction of pecking onto feathers and the validation of feathers as incentives for pecking.
Although there was no significant change in food pecking, the data suggest a weak increasing trend. It is obvious that food is appreciated as a pecking substrate and one might have expected a stronger increase in the present experiment. However, as food was not available *ad libitum* pecking frequency was already at a high level, which makes a strong increase unlikely. In another experiment (Blokhuis *et al.*, 1987), in which pullets were housed on litter or wire floors and fed *ad libitum*, feed consumption was significantly higher on wire floors. This suggests that some redirection of ground pecking onto food may occur.
The present results again support the idea that feather pecking is a redirected form of ground pecking. The fact that the increase in feather pecks is not fully compensating for the decrease in ground pecks may be explained by the lower level of external stimulation (incen-

tives) which, in interaction with internal states, contribute to the tendency to perform pecking behaviour.
Moreover, it is suggested that the redirection of ground pecking takes place because of the relatively low incentive value of a slatted floor. For practical poultry farming, it is therefore important to provide highly appreciated incentives for pecking and scratching.

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CHAPTER 5

THE DEVELOPMENT AND CAUSATION OF FEATHER PECKING IN THE DOMESTIC FOWL

EFFECTS OF FLOOR TYPE DURING REARING AND OF BEAKTRIMMING ON GROUND PECKING AND FEATHER PECKING IN LAYING HENS

H.J. Blokhuis and J.W. van der Haar

Spelderholt Centre for Poultry Research and Extension, Spelderholt 9, 7361 DA Beekbergen, The Netherlands.

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EFFECTS OF FLOOR TYPE DURING REARING AND OF BEAK TRIMMING ON GROUND PECKING AND FEATHER PECKING IN LAYING HENS.

ABSTRACT

Forty groups of 12 1-day-old chicks of a brown egg-laying strain were housed on either litter (n=20 groups) or wire floors (n=20 groups). Ten groups of birds on wire floors and 10 groups on litter floors were beak trimmed at 45 days of age. At 18 weeks of age, each group was moved to one of 40 identical pens with a partly litter, partly slatted floor. Behavioural observations took place at 7, 10, 14, 17, 18, 23, 30, 36 and 42 weeks of age. Feather damage was scored at 17, 30 and 42 weeks of age.

During the rearing period, beak trimmed birds showed a lower frequency of ground pecking. Ground pecking as well as ground scratching was highest in non beak trimmed groups on litter. Both beak trimming and litter floors reduced the average level of feather pecking and pecking at objects during rearing.

In the laying period, no differences in the frequency of ground pecking were detected between treatments. Birds reared on wire showed a higher frequency of feather pecking. Feather damage was significantly higher in non beak trimmed groups.

It was concluded that experiences during rearing influence pecking preferences during the laying period. Moreover, it was concluded that beak trimming does not change pecking preferences nor does it decrease the frequency of feather pecking.

INTRODUCTION

Several authors have suggested that feather pecking in poultry may be considered as redirected ground pecking (Levy, 1938; Wennrich, 1975; Blokhuis and Arkes, 1984). These suggestions were mainly based on strong similarities in the performance of both behaviours and on the observation that when ground pecking was stimulated by offering an adequate pecking substrate (e.g. litter), this resulted in less feather pecking. The latter was also observed in pheasants (Hoffmeyer, 1969).

In a recent study (Blokhuis, 1986), it was shown that the same experimental treatment which induced an increase in ground pecking frequency of birds on litter, induced an increase in the frequency of feather pecking of birds on a slatted floor. These correlated changes were interpreted as indicating common causal factors for both behavioural elements. Moreover, the redirection hypothesis appeared to explain the correlation between both types of pecking adequately. Also in line with this hypothesis was the outcome of another recent experiment (Blokhuis, 1989), in which young hens were suddenly deprived of a litter floor. This resulted in a strong decrease of ground pecking and scratching, and an increase in feather pecking.

In terms of incentive motivation theory (Bindra, 1969, 1978), redirection of ground pecking takes place when the relative incentive value of the ground is low, compared to the incentive value of other objects such as feathers. It was suggested (Blokhuis, 1989) that litter floors have a higher incentive value compared to floors without litter (slats or wire) because of visual, tactile and gustatory properties of litter, as well as long-term effects of ingestion of litter. Moreover, it was suggested that consummatory stimulus feedback from ground pecking and scratching may also play a role.

The animal's past experience with environmental stimuli is crucial in the validation of such stimuli as incentives (Toates, 1986). In the case of pecking, it has been shown that when a chick assimilates information about incentives, it changes its pecking behaviour accordingly (e.g. Hogan, 1973; Martin *et al.*, 1977). Experience in early life concerning the validation of the ground as an incentive for pecking may, therefore, exert a significant influence on pecking behaviour in later life.

In the present experiment, the effects of early experience were studied. Hens were reared on litter or wire floors and it was tested if this affected pecking behaviour in the rearing and the laying period.

As the beak of the chicken has a variety of sensory receptors (Gentle and Breward, 1981, 1986; Desserich *et al.*, 1983, 1984), beak trimming is likely to result in sensory deficits. This may affect tactile discrimination and interfere with the validation of an object as an incentive for pecking, therefore, the effects of beak trimming were also studied in this experiment.

MATERIALS AND METHODS

Animals and housing

Rearing period

A total of 480 pullet chicks of a brown egg-laying strain (Warren SSL) were used. At one day old, the chicks were housed in groups of 12 in small pens (150 x 100 cm^2), in the same house. Pens had either litter floors (wood shavings) or wire floors. Continuous light was provided for the first 24 h, thereafter the photoperiod ran from 08.30 to 16.30 h. The intensity of illumination was about 15 lux at floor level. Food (mash) and water were supplied *ad libitum*. Diets were changed from starter to grower at 10 weeks of age. Half of the groups were beak trimmed at 45 days of age using a Lyon Debeaker (Lyon electric Company Inc., San Diego, CA). About one-third of both the upper and lower mandible was removed with a heated blade which both cut and cauterized.

Laying period

At 18 weeks of age, hens were moved to a laying house, each group to one of 40 identical pens (2.0 x 3.2 m^2). The floors of the pens were partly litter (4.4 m^2) and partly slatted (2 m^2). A 15-h photoperiod was maintained. Light intensity was about 50 lux at floor level. Food (layer mash) and water were supplied *ad libitum*.

Treatments

The experiment consisted of four treatments in the rearing period:

- litter floor, non beak trimmed (L/N)
- wire floor, non beak trimmed (W/N)
- litter floor, beak trimmed (L/B)

- wire floor, beak trimmed (W/B)

All treatments were replicated 10 times. Chicks were randomly assigned to the various treatments and pens. Rearing pens as well as pens in the laying house were grouped in blocks of four with each treatment occurring in every block. Groups in one block during rearing were randomly assigned to one of four pens in a block in the laying house.

Observations

Behavioural observations were carried out during the rearing period in Weeks 7, 10, 14 and 17, and during the laying period in Weeks 18, 23, 30, 36 and 42. Every observation week, two animals were randomly selected from each group and marked. Observations were carried out by two observers. The behaviour of one marked bird in a group was observed continuously during 10 min by the first observer on Day 1, the behaviour of the second marked bird was observed, also during 10 min, on Day 2 by the second observer. Behavioural data recorded by the two observers were averaged. All observations took place between 9.00 and 15.30. The observers, standing in front of the pen within sight of the birds, recorded occurrences of the following behaviours on audio tape:

Ground pecking. Pecks directed to the floor while standing or walking. Every peck was counted as one occurrence.

Ground scratching. The body bending forward, the bird makes a backward stroke with one leg. Usually 1-4 strokes with one leg are followed by 1-4 strokes with the other. Such a series was registered as one occurrence.

Feather pecking. Non-aggressive pecks at other birds. This category includes pecking and pulling feathers. Pecks at the legs, the beak or at litter particles on the plumage were excluded.

Pecking at food. Every peck into the feed trough was registered.

Pecking at objects. Pecks at walls, door, etc. Every peck was registered as one occurrence.

At the age 17, 30 and 42 weeks, four randomly selected birds from each group were scored for damage to the integument. Scoring was performed by one person and involved the awarding of marks between 0 and 9 (0:

no sign of damage; 5: denuded skin; 9: severe wounds) to each of nine feathered body areas (back of the head, neck, breast, abdomen, saddle, wings, tail, thighs and shins). For a total feather score, these marks were added per bird. Mean feather scores per pen were averaged for the three scoring weeks and used for analysis.

Zoötechnical results of the laying period have been published elsewhere (Blokhuis *et al.*, 1987).

Statistical analysis

For the rearing period as well as for the laying period, the frequencies of the recorded behaviours were averaged over the two observers and the observation weeks. The main effects and interactions between floor type and beak trimming were examined by performing analyses of variance using the model for a 2x2 factorial randomized block design. Separate analyses of variance were performed on the averages for the rearing and the laying period. Moreover, possible changes of treatment effects over time were assessed by an analysis of contrasts over time (Rowell and Walters, 1976). Mean feather scores per pen were analysed in the same way, using analysis of variance. Analysis of contrasts over time was also used here to assess possible changes of treatment effects over time.

RESULTS

Rearing period

Table 1 shows the significant effects and interactions resulting from the analyses of variance of the different behaviours. The frequencies of the recorded behaviours, averaged per treatment over the four observation weeks, are given in Table 2.

Floor type as well as beak trimming significantly influenced ground pecking. The interaction between floor type and beak trimming was caused by the fact that beak trimmed birds showed a relatively low frequency of ground pecking, irrespective of whether they were housed

Table 1. Levels of significance of main effects and interactions between floor type and beak trimming for the different behavioural elements during the rearing period.

Behaviour	Floor type	Beak trimming	Interaction
Ground pecking	**	***	*
Ground scratching	***	ns	ns
Feather pecking	*	*	ns
Pecking at food	ns	ns	ns
Pecking at objects	***	**	ns

*: $p < 0.05$
**: $p < 0.01$
***: $p < 0.001$

Table 2. Frequencies of observed behaviours (per animal per hour). Data of the four observation weeks during the rearing period are averaged per treatment group.

Behaviour	Treatment			
	L/N	W/N	L/B	W/B
Ground pecking	190.8	65.4	24.6	22.8
Ground scratching	11.4	1.4	5.9	0.9
Feather pecking	18.1	24.2	8.1	17.6
Pecking at food	972	942	882	552
Pecking at objects	40.2	63.1	14.22	45.6

on wire or litter, while in non beak trimmed birds ground pecking was much more frequent on litter floors. Ground scratching was highest on litter floors, in beak trimmed as well as non beak trimmed groups. Neither ground pecking nor ground scratching showed any significant trend over time.

Feather pecking was more frequent on wire floors and in non beak trimmed birds. However, differences between treatments changed over time ($p < 0.05$). In Weeks 7 and 10, W/N birds showed more feather pecking than birds in the other groups, but at 14 and 17 weeks, W/B and L/N birds showed about this same level of feather pecking and only L/B birds were still at a lower level.

Treatments had no significant effect on pecking at food, nor were there any trends over time. However, there was a tendency to less food pecking in beak trimmed birds and this corresponds to the zoötechnical data, where a significant decrease in food consumption was observed in these groups (Blokhuis *et al.*, 1987). The frequency of pecking at objects was higher in groups on wire floors and in non beak trimmed birds. The difference between groups on wire and groups on litter floors increased linearly over time ($p < 0.05$). This was caused by an increase in pecking at objects on wire floors, while this frequency stayed at the same level on litter floors.

Laying period

Table 3 shows the significant effects and interactions resulting from the analyses of variance of the different behaviours. The frequencies of the recorded behaviours, averaged per treatment over the five observation weeks, are given in Table 4.

Ground pecking frequency, averaged over weeks, was somewhat higher in litter-reared groups, but this was not significant. However, the difference between groups reared on wire and groups reared on litter decreased significantly over time. In the last week of observation (Week 42), ground pecking was even higher in groups reared on wire. Rearing on wire caused a higher ground scratching frequency.

The analysis showed a significant effect of floor type as well as beak trimming on the frequency of feather pecking. Feather pecking was less

Table 3. Levels of significance of main effects and interactions between floor type during rearing and beak trimming for the different behavioural elements during the laying period.

Behaviour	Floor type	Beak trimming	Interaction
Ground pecking	ns	ns	ns
Ground scratching	*	ns	ns
Feather pecking	**	*	*
Pecking at food	ns	ns	ns
Pecking at objects	ns	ns	ns

*: $p < 0.05$
**: $p < 0.01$
***: $p < 0.001$

Table 4. Frequencies of observed behaviours (per animal per hour). Data of the five observation weeks in the laying period are averaged per treatment group.

Behaviour	Treatment			
	L/N	W/N	L/B	W/B
Ground pecking	312.2	262.2	314.4	225.0
Ground scratching	5.2	13.0	8.7	11.9
Feather pecking	9.6	30.0	8.4	313.2
Pecking at food	1036	1160	1277	798
Pecking at objects	23.4	21.6	49.8	116.4

in litter-reared groups compared to wire-reared groups and beak trimmed birds showed the most feather pecking. However, there was a significant interaction between floor type and beak trimming; there was no significant difference between L/N and L/B groups, while there was a huge difference between W/N and W/B groups. Although there were no main effects of treatments on pecking at food and pecking at objects, there was a tendency for W/B hens to show a higher frequency of pecking at objects and a lower frequency of pecking at food.

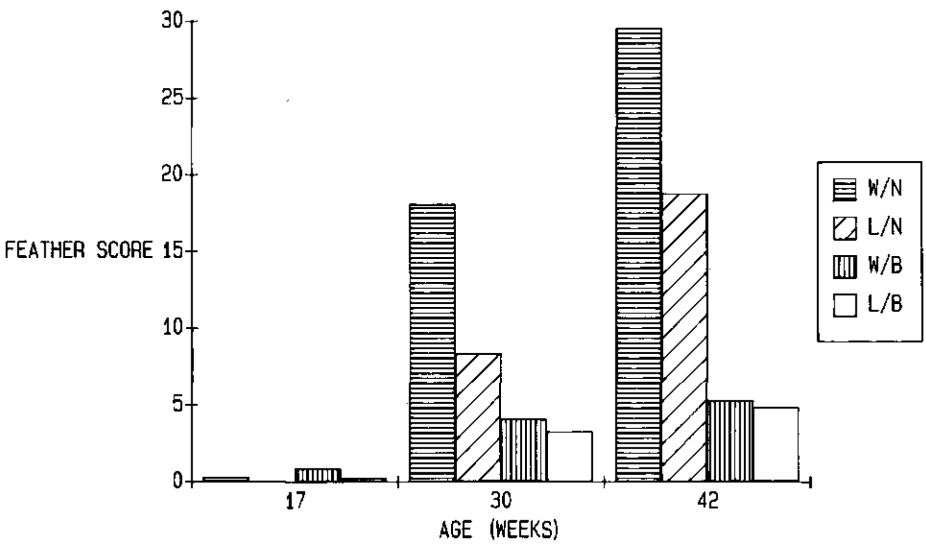

Figure 1. Mean feather scores at 17, 30 and 42 weeks of age. A high feather score corresponds with a bad feather condition. L/N = groups reared on litter, non beak trimmed; W/N = groups reared on wire, non beak trimmed; L/B = groups reared on litter, beak trimmed; W/B = groups reared on wire, beak trimmed).

Figure 1 shows the mean feather scores for the treatment groups at the three points of time. There were no significant differences at 17 weeks of age. Feather damage increased significantly in all groups over time ($p < 0.01$), but the strongest increase was seen in the non beak trimmed birds. In the non beak trimmed birds, damage was significantly higher in the wire-reared groups ($p < 0.05$). In the beak trimmed groups, no significant difference was found between groups reared on litter and groups reared on wire.

DISCUSSION

Floor type

During the rearing period of the present experiment, the lowest frequency of ground pecking was found on wire floors. This agrees with the results from other experiments (Blokhuis and Arkes, 1984; Klinger, 1985; Blokhuis, 1986, 1989); on the basis of previous results, also, a consequent higher level of feather pecking was anticipated on wire floors. Indeed, the frequency of feather pecking was significantly higher in groups on wire. However, differences between treatment groups changed over time. For instance, feather pecking frequency was relatively low in W/B groups (as compared to W/N groups) during Weeks 7 and 10, while it was at the same level as the W/N groups during Weeks 14 and 17. This is probably caused by beak trimming (see below). An increase over time in the frequency of feather pecking was also observed in the L/N groups (but not in the L/B groups). There is no clear explanation for this effect.

In the laying period, the average ground pecking frequency was much higher than during the rearing period. The reason for this is not clear. Possibly, the considerable lower housing density (8 birds per m^2 during rearing compared to 1.9 per m^2 during lay) might have played a role. Thus, in a previous experiment, it was shown that birds at a density of 8 per m^2 showed less ground pecking than birds at a density of 2.7 per m^2 (Chapter 6). Although the average frequency of ground pecking during lay was not affected by floor type during rearing, the

wire reared groups showed a significant increase over time. This suggests that the birds learn to appreciate litter as an incentive.
As to feather pecking, the present data show a significant effect of floor type during rearing. However, this is mainly caused by the very high frequency of feather pecking in the W/B groups. The W/N groups also showed more feather pecking than the L/N and L/B groups ($p < 0.055$ and < 0.05, respectively). The results of the scoring of plumage damage show that this higher level in W/N groups is relevant; the plumage deterioration at 42 weeks in the W/N groups (29.6) was significantly higher than in the L/N groups (18.8).
The present results clearly show that feather pecking during lay is enhanced in those groups reared on wire. Possibly, these birds learned that the ground is not an attractive substrate for pecking (low incentive value), resulting in redirection of pecking to other objects such as the feathers of conspecifics. Although the data on ground pecking during the rearing period support this view, the data on feather pecking in this period are not completely unambiguous. Until 10 weeks of age, feather pecking is clearly higher in the wire groups, but this is not the case at 14 and 17 weeks of age, where the L/N groups were also at the same high level. The reason for this increase is not clear. However, the results from the laying period show that where the wire-reared groups stay at that level, the L/N groups return to a low level of feather pecking comparable to that in the L/B groups. This shows that whatever caused the increase in feather pecking at the end of the rearing period, it was only temporary. Moreover, it suggests that there are relevant differences between wire- and litter-reared birds concerning their pecking preferences.

Beak trimming

In the present experiment, beak trimming resulted in a very low level of ground pecking during rearing. Moreover, the effect of floor type, which was so obvious in birds with intact beaks, was not demonstrated in beak trimmed birds. This may well be an effect of acute and chronic pain in the beak trimmed birds, originating from the activation of specific nociceptors and from spontaneous discharges originating from neuromas which develop after beak trimming in the stump of the beak (Breward and Gentle, 1985; Gentle, 1986). The possibility that pain is an important factor in beak trimmed birds may also explain the lower frequencies of other pecking behaviours. Feather pecking and pecking at objects were significantly less frequent in beak trimmed birds, while pecking at food showed a tendency in the same direction.

In contrast to the rearing period, the average level of ground pecking in the laying period was at the same level for both the beak trimmed and the non beak trimmed birds. However, at an age of 18 and 23 weeks, the observed frequencies were still lower in the beak trimmed groups. This suggests that if pain is indeed involved, it wears off and does not affect ground pecking at a later stage of the laying period.

The present data suggest that beak trimming also causes a decrease in the frequency of ground scratching during rearing. As ground scratching is functionally related to ground pecking in the feeding system, this is probably an indirect effect, caused by the decrease in ground pecking. This explanation fits the results of the laying period where no differences were found in either the level of ground pecking or ground scratching between beak trimmed and non beak trimmed birds.

Beak trimming reduced the average level of feather pecking during the rearing period, but only on litter was it at a relatively low level in all four observation weeks. On wire floors, feather pecking was low in Weeks 7 and 10, but was on a much higher level in Weeks 14 and 17. A possible cause of the low frequency in the first two weeks may be pain from the stump of the beak. As suggested above, the latter may wear off, which may explain the higher level of feather pecking in Weeks 14 and 17.

From the observations in the laying period, it appears that beak trimming did significantly reduce the plumage damage inflicted upon the birds. Scoring of the plumage revealed a good plumage condition in the beak trimmed groups. This was in spite of the fact that beak trimming may cause inadequate preening and consequently a sub-optimal plumage condition. However, beak trimming did not reduce the frequency of feather pecking. On the contrary, the data show that feather pecking may even be enhanced by beak trimming (in group W/B especially the frequency of feather pecking was extremely high, while in group L/B the

frequency did not significantly differ from that in group L/N). The reduced plumage damage is, therefore, clearly the result of a decreased efficiency of feather pecking in beak trimmed birds. From the foregoing, it may be deduced that when almost complete regrowth of the beak and recovery of its efficiency occurs, the risk for serious plumage damage and cannibalism is as high or even higher in beak trimmed birds.
The reason for the very high frequencies of feather pecking and pecking at objects in the W/B groups is not clear. The lack of relevant sensory feedback signals from the tip of the beak might play a role. It was often observed, for example, that a bird performed a long series of pecks directed at feathers or an object, but not touching it. This created the impression that the bird was not aware that its bill tip was missing and that it kept on trying to peck a visually selected goal.

The present results strongly suggest that the hens' validation of incentive stimuli for pecking (ground, objects, conspecifics), is influenced by experience during the rearing period. Although the birds learn to appreciate new incentives, viz. litter, during the laying period, the effects of previous experiences are still present. Moreover, it is clearly shown that beak trimming does not change pecking preferences nor does it decrease pecking frequency.

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CHAPTER 6

THE DEVELOPMENT AND CAUSATION OF FEATHER PECKING IN THE DOMESTIC FOWL

HOUSING DENSITY AFFECTS GROUND PECKING OF PULLETS IN SMALL GROUPS

H.J. Blokhuis and J.W. van der Haar

Spelderholt Centre for Poultry Research and Extension, Spelderholt 9, 7361 DA Beekbergen, The Netherlands.

HOUSING DENSITY OF PULLETS IN SMALL GROUPS AFFECTS GROUND PECKING.

ABSTRACT

An experiment was carried out to study the effect of housing density on pecking behaviour in young domestic fowl. 288 pullet chicks of a brown egg laying strain were housed in groups of 12 in litter pens, at densities of 2.7, 8 and 16 birds per m^2. Behavioural observations were carried out during the third, sixth and tenth week of age. Treatments significantly affected ground pecking and scratching. Especially at the lowest density the frequency of these behaviours was high. On the other hand, there was a tendency towards a higher frequency of feather pecking in the high density groups. The results suggest that high housing densities stimulate the redirection of ground pecking which may result in the development of feather pecking.

INTRODUCTION

When favourable incentives are provided, ground pecking and scratching is a very prominent behaviour in the domestic fowl. Thus in a spacious and varied surrounding, consisting of a litter pen and a large outside run with bushes and perches, hens spend about 35 % of their active daytime ground pecking and scratching (Blokhuis and van der Haar, unpublished data). In practical poultry housing, floors may consist of wire (e.g. in battery cages), slats, concrete covered with litter or a combination of these. On wire and slatted floors, hens show a relatively low frequency of ground pecking and scratching (Blokhuis and Arkes, 1984; Klinger, 1985). This is likely to be an effect of the lack of positive feed-back signals (visual, tactile, gustatory and consummatory), resulting in a low incentive value of these floors (Blokhuis, 1989; Hughes and Duncan, 1972). It has been shown that, under such conditions, chicks tend to redirect their pecking behaviour and this may result in the pecking of other animals and the development of feather pecking (Blokhuis, 1986; Blokhuis, 1989; Blokhuis and van der Haar, 1989). For practical poultry farming it is therefore important to provide highly appreciated incentives for ground pecking. On litter floors hens show a much higher frequency of ground pecking (higher incentive value) than on floors without litter and this results in a lower tendency for feather pecking (Blokhuis and van der Haar, 1989). However, housing poultry on litter is not always effective in preventing the development of feather pecking. Apparently other housing factors, e.g. the quality of the litter, lighting or housing density, may affect the incentive value of a litter floor and subsequently induce the risk of feather pecking. In the present experiment the effect of housing density on ground pecking and feather pecking was studied.

MATERIAL AND METHODS

Animals and housing

288 pullet chicks of a brown egg laying strain (Hubbard) were used. At one day of age the chicks were housed in groups of 12 in litter pens (wood shavings on a concrete floor), in a rearing house. Continuous light was provided for the first 24 hours, thereafter the photoperiod ran from 07.00 to 21.00 h. A feed trough with a length of 75 cm was available at one side of each pen. Two drinking cups were provided at the opposite side of each pen. Food (mash) and water were available *ad libitum*. The birds were not beak trimmed.

Treatments

Groups were housed at three different densities: 2.7, 8 and 16 birds per m^2. As group size was held constant, the size of the pens differed for the three densities. For 2.7, 8 and 16 birds per m^2 sizes were 2.1x2.1 m, 1.0x1.5 m and 1.0x.75 m respectively. All densities were replicated 8 times. Chicks were randomly assigned to the various densities and pens. Pens were grouped in blocks of three with each density occurring in each block.

Observations

Behavioural observations were carried out when the birds were 3, 6 and 10 weeks of age. Before the start of the observations in a particular week a randomly chosen animal in each cage was marked. The behaviour of this bird was recorded during 10 minutes observation periods on four days. Observations were carried out by two observers between 9.00 and 16.00 h. Both watched the marked birds once in the morning and once in the afternoon. Behavioural data recorded by the two observers were averaged. The observers, standing in front of the pen within sight of the birds, recorded occurrences of the following behaviours on audio-tape:

Ground pecking. Pecking directed to the floor while standing or walking. Every peck was counted as one occurrence.

Ground scratching. The bird makes backward strokes with the legs. Usually one to four strokes with one leg are followed by one to four strokes with the other. Such a series was registered as one occurrence.

Feather pecking. Non-aggressive pecks at other birds. This category includes pecking and pulling feathers. Pecking at the legs and the beak, and pecking at litter particles on the plumage of conspecifics, were excluded.

At the end of the experimental period (10 w) five randomly selected birds from each group were scored for damage of the integument. Scoring was done by one person and involved the awarding of marks between 0 and 9 to each of nine feathered body areas (back of the head, neck, breast, abdomen, saddle, wings, tail, thighs and shins; 0: no sign of damage; 5: denuded skin; 9: severe wounds). These marks were summed per bird and averaged over the five birds in a pen.

To get an indication of the quality of the litter at the end of the experiment, representative litter samples were drawn from each pen and analysed for percentage of dry matter.

Statistical analysis

Frequencies of the recorded behaviours in week 3, 6 and 10 were averaged for each pen. Analyses of variance were performed on these averages. Moreover, possible changes of treatment effects over time were assessed by an analysis of contrasts over time (Rowell and Walters, 1976).

The averaged feather scores and percentages of dry matter in the litter were also subjected to analysis of variance. Differences between two means were assessed using paired t-test.

RESULTS

Table 1 shows the results of the behavioural observations. There were very significant effects of housing density on ground pecking and ground scratching ($p < 0.001$ and $p < 0.01$ respectively) over the whole experimental period. Frequencies of those behaviours appeared to be significantly higher at a density of 2.7 animals per m^2, compared to 8 and 16 animals per m^2. The frequency of ground pecking was signifi-

Table 1. Frequencies of observed behaviours (per animal per hour). Data of the three observation weeks are averaged per housing density.

Behaviour	Housing density (animals/m^2)		
	2.7	8.0	16.0
Ground pecking	598.2^a	213.0^b	141.0^c
Ground scratching	32.2^a	6.9^b	4.1^b
Feather pecking	10.6^a	20.3^a	21.4^a

[a,b] Means (n=8) within rows with different superscripts differ significantly ($p < 0.05$).

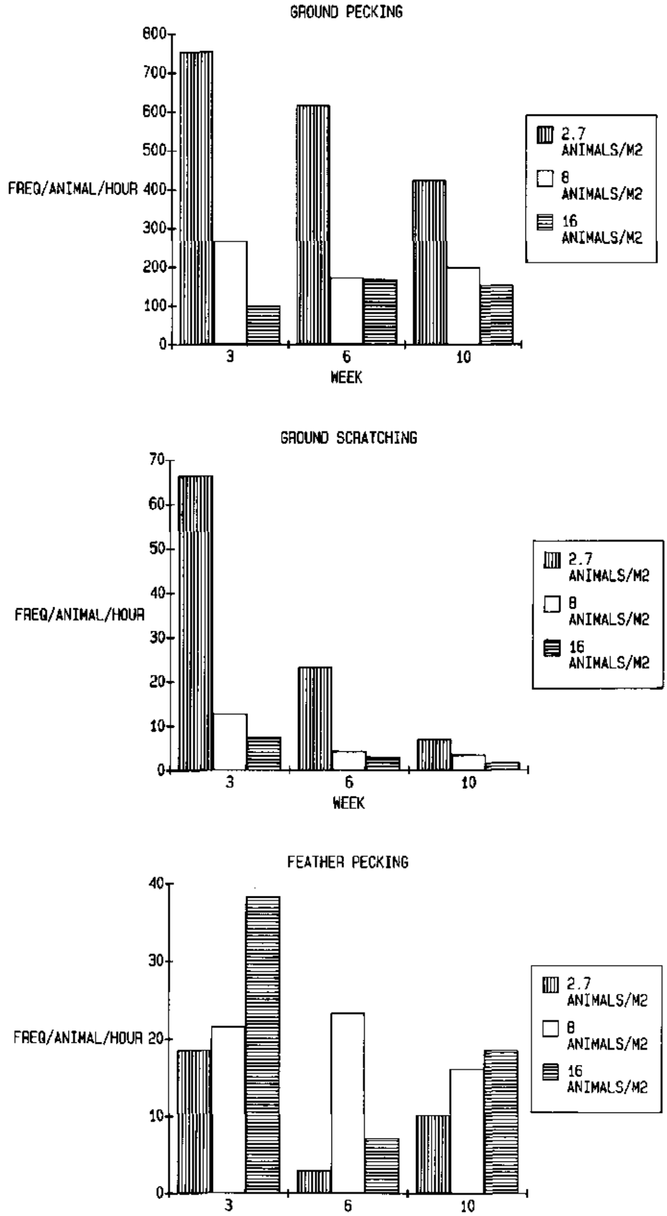

Figure 1. Frequencies (per animal per hour) of ground pecking, ground scratching and feather pecking in the three observation weeks, averaged for the different treatment groups.

cantly higher at 8 animals per m^2 compared to 16 animals per m^2. Ground scratching frequency in the groups at 8 and 16 animals per m^2, is not significantly different. Ground scratching shows a significant decrease over time ($p < 0.025$) which was mainly caused by the decrease of ground scratching in groups with the lowest density (Figure 1). Ground pecking shows the same trend but this is not significant.

There was no significant effect of housing density on the frequency of feather pecking. Although this frequency was lowest in the low density group, it did not significantly differ from the higher densities ($p < 0.15$).

At the end of the experiment the plumage of all birds was in a very good condition (mean scores for the different densities were 1.0 (2.7 animals/m2), 1.0 (8 animals/m2) and 1.2 (16 animals/m2)) and no differences between housing densities were detected.

Housing density affected the (subjectively estimated) quality of the litter. At the lowest density it was much more easily crumbled than at the higher densities. The percentage of dry matter in the litter was significantly ($p < 0.01$) influenced by housing density. The water content became higher at higher housing densities (Table 2).

Table 2. Percentages of dry matter of litter from pens with different housing densities (SED = 1.56).

Housing density (animals/m2)	% dry matter
16.0	55.5
8.0	66.6
2.7	79.4

DISCUSSION

A striking observation in the present experiment, was the decrease of ground pecking and scratching over time in the birds at a density of 2.7 per m^2. This is in contradiction with the data from a previous experiment (Blokhuis and Arkes,1984) with birds at the same density (in two groups of eight), which showed an increase rather than a decrease in ground pecking and scratching. At three and six weeks of age the levels of these behaviours in the present experiment were higher but at ten weeks of age they were about half the levels in the earlier experiment. A clearly different factor in the earlier experiment was that the birds were housed under natural light conditions. This might have increased the attractiveness or incentive value of the floor for pecking and scratching. The influences of natural and artificial light on pecking and scratching remain to be studied.

The present results suggest that the incentive value of a litter floor to elicit ground pecking and scratching is reduced by a high housing density; both behaviours were less frequent at higher densities. The explanation for this may be the relatively high manure content, causing a (visually) dirty litter with a low percentage of dry matter at the end of the experiment. This type of litter may be less appreciated by the birds. If this hypothesis were right, a decrease of ground pecking and scratching over time would be expected, especially at the higher densities as the increase of the manure content of the litter would be expected to be strongest then. This was not found in the present experiment, suggesting that manure content was not the relevant factor causing a lower incentive value of the litter at higher densities.

Another explanation for the effect of housing density on ground pecking and scratching may be that ongoing behaviour like pecking and scratching is more likely to be interrupted by conspecifics when there are more birds per square meter. Here also, a decrease of pecking and scratching over time is expected as the birds grow larger and take more room. This effect of growth is relatively larger in the small pens (high densities) and a stronger decrease over time is therefore expected there. Again this is not in accordance with the results.

Possibly pecking and scratching are not only related to space expressed as the number of animals per m^2, but also to total space and to the time it takes to explore it while searching for edible particles. Since in this experiment total space (pen size) was larger and ground pecking and scratching were more frequent at lower densities, the results fit this hypothesis. If this explanation were valid, ground pecking and scratching would be expected to be more frequent in a larger group than in a small group at the same density. This could be experimentally tested.

Although the effect of housing density on feather pecking was not significant, there was a tendency for a higher frequency in the groups with densities of 8 and 16 birds per m^2. As the latter are the very groups which showed significantly less ground pecking, these results fit the interpretation of feather pecking being redirected ground pecking and suggest that high housing densities lead to more feather pecking.

In a related experiment, hens were also observed during the rearing period (Blokhuis and van der Haar, 1989). Here the birds showed a much higher frequency of ground pecking on litter floors compared to wire floors. Also in that experiment only a trend towards more feather pecking in groups with a low ground pecking frequency could be detected. However, when all groups were housed under the same conditions (half-litter, half-slatted floor) during the laying period, more feather pecking occurred in the groups reared on wire. Therefore, from the present results it is suggested that the risk that serious feather pecking may develop in a later stage is higher when birds in small groups are reared at high densities.

In practical poultry farming, housing density is normally much higher than 2.7 animals per m^2. However, group sizes are also much larger. On the basis of the present data, it is not possible to define optimal rearing conditions, which provide favourable incentives for ground pecking and scratching and subsequently minimise the risk of feather pecking. However housing density seems a very important factor in this respect.

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CHAPTER 7

GENERAL DISCUSSION

INTRODUCTION

One of the main conclusions from the experiments reported in this thesis is, that feather pecking in poultry is a form of redirected ground pecking. This knowledge about the relation of ground pecking and feather pecking may give direction to what might be called a "practical way forward":

- husbandry practices holding a risk for feather pecking to occur, can be indicated;
- several husbandry measures to prevent the occurrence of feather pecking can be suggested.

However, the knowledge that feather pecking stems from ground pecking, raises the following important question: what motivates birds to groundpeck? The answer may give the poultry farmer control over the ground pecking motivation and with that over feather pecking. Or he may be able to provide his birds with stimuli which match their needs better than do feathers.

The above question as well as some aspects of a practical way forward are selected for discussion in this chapter. First, however, an attempt is made to describe ground pecking behaviour in an appropriate model.

A MODEL OF GROUND PECKING

In the different chapters of this thesis, redirection has been described in terms of incentive motivation theory (Bindra, 1969). This theory acknowledges that both internal ("drives") and external factors ("incentives") jointly determine motivation. Moreover, it states that a behaviour is directed towards the same environmental object that helps to arouse its motivational state. As redirection is also a problem of stimulus selection, this theory offered a way to describe the redirection process. And, what is more, this resulted in relevant discussions of incentives and their characteristics in the different chapters. Thus, the emphasis on the role of incentives can be very helpful to define relevant problems at this level. However, descriptions based on incentive motivation theory have also a disadvantage, as they tend to distract attention from more fundamental concepts in the causation of behaviour, like homeostasis and the basic negative feedback relation between the effect of a behaviour and its driving

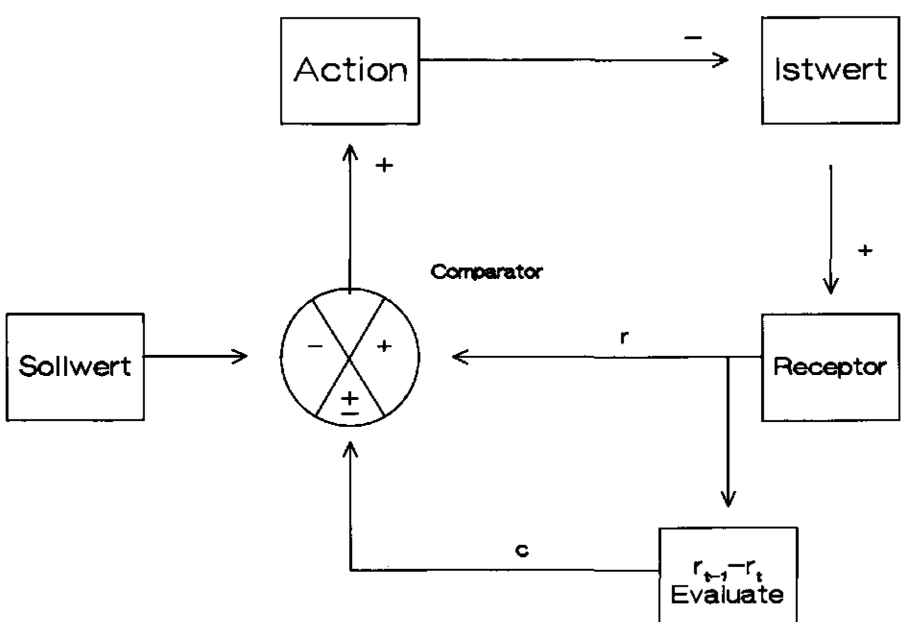

Figure 1. Regulatory model of behaviour (Derived from Wiepkema, 1985).

force (c.f. Baerends, 1976; Broom, 1985; Wiepkema, 1985). When questions about the motivation of behaviour and its function are to be answered, models should explicitly incorporate these factors and so-called homeostatic models seem appropriate then.

According to homeostatic or regulatory models, motivation arises when some aspect in the animal's (internal or external) environment falls below some optimal or "Sollwert" level. The motivation exists until the variable in question is returned to its Sollwert by the motivated activity. Figure 1 shows an example of a regulatory model of behaviour. An "Istwert" is perceived and compared (comparator) with its corresponding Sollwert.

If there is a mismatch a behaviour (Action) is performed. The larger the mismatch the more intensive the resulting behaviour. The latter will diminish the difference between Istwert and Sollwert (negative feed back). A system, represented in the lower part of the figure, evaluates the effect of the behaviour by registrating the change of the Istwert (r) over time ($r_{t-1}-r_t$). When the behaviour is effective, this change is positive and the evaluation system will add positively to the comparator and strengthen the behaviour. When the change of r is negative, this will counteract the performed behaviour. The output of the comparator may be called motivation.

To adapt the model in Figure 1 for ground pecking, we can change "Action" into "Ground pecking", but we don't know the Sollwert and Istwert in relation to ground pecking, nor do we know how the Istwert is perceived. However, as stimulus selection seems a relevant part of a model describing the redirection of ground pecking, the above model might be adapted to incorporate the role of incentives in ground pecking. This role may be divided in two aspects: a) incentive stimuli may increase or decrease motivation, depending on the animal's past associations with the incentives and b) on the basis of the same associations the animal directs its behaviour towards a specific incentive object.

Figure 2 shows a tentative model of ground pecking in which these aspects are incorporated. When a mismatch between Istwert and Sollwert is perceived, pecking is performed. The effectiveness of pecking directed at object i (i=1...n) is evaluated and this results in the ran

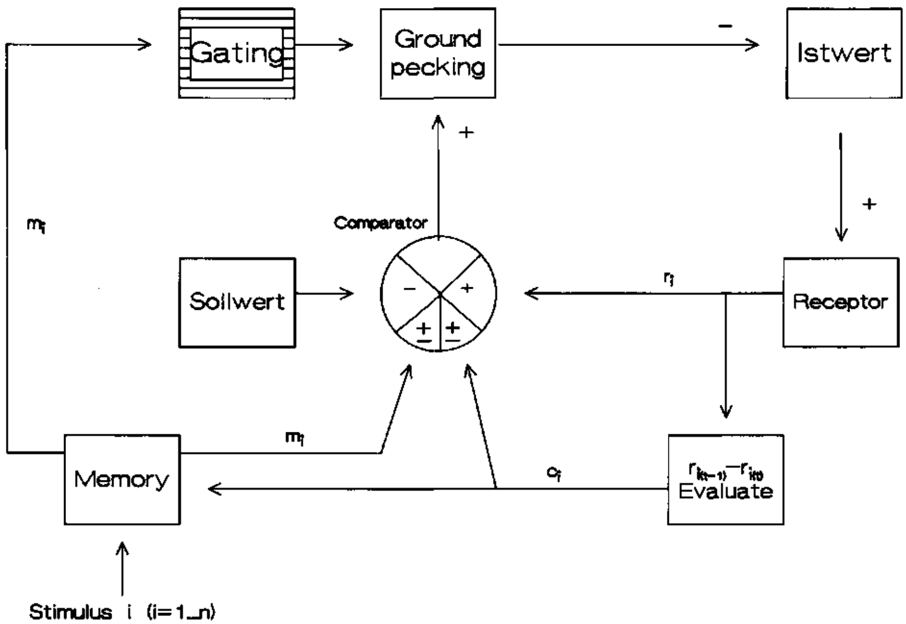

Figure 2. A tentative model of ground pecking.

king (high or low, positive or negative) of the object as an incentive. This result is stored in memory and is used on later occasions to direct pecking to the most effective incentive. This proces of stimulus selection is represented in the model by a "gating" system. Here the "gate" to a specific stimulus may be opened on the basis of information from the memory (m_i). When there is no information available all gates may be opened at the same time and the direction of pecking will get a "trial and error" character. Stimulus i may also revive its memory representation (m_i) and increase or decrease pecking motivation. Whether or not ground pecking is performed depends on the weighing of its priority or relevancy against other behaviours. The latter process is not represented in the model. Moreover, some kind of threshold level may be present, above which the motivation has to rise before behaviour is performed and this is also not represented.

The above model, however tentative, describes the relevant factors underlying ground pecking and it gives an idea how other objects for pecking, such as feathers, may be selected. When more detailed information is brought in, it may also help to find out *why* other objects are selected. Moreover, it should stimulate the re-interpretation of the results of experiments on feather pecking and the consideration of biologically more relevant explanations for the effect of different factors on feather pecking. Nevertheless a lot of questions remain, like "what is the exact character of the pecking motivation" and in relation to that "what factors contribute to the incentive value of objects"? In the next paragraph these points are discussed in some more detail.

THE MOTIVATION OF PECKING

In the birds' "natural" environment, pecking the ground and ground scratching serve the foraging of food. Junglefowl hens, as well as domestic hens, in a "natural" or "semi-natural" environment, spent a large part of their active time of day ground pecking and scratching. Junglefowl hens were observed groundpecking in 60.6 % of all minutes of observation (observations spread over the whole light period) (Dawkins, 1989) and the average percentage of time in which domestic hens were observed to peck and scratch was 47.9 (Savory *et al.*, 1978). The lengths of feeding bouts of domestic hens under these conditions varied from 10 minutes to an hour, with an average pecking rate of about 50 per minute (Savory *et al.*, 1978).

Feeding behaviour of domestic fowls in the wild was affected by the wheather as well as variations in food density (Savory *et al.*, 1978). In nature these factors may easily result in short-term changes in food availability and it was suggested that the crop may act as a buffer here. When allowed only restricted access to food, it was shown that birds with intact crops were able to consume much more food than cropectomized birds, apparently by using their crop as a "storage" (Richardson, 1970). The crop also seems to play a direct role in the regulation of feed intake. Thus, Richardson (1970) showed that distention of the crop produces a drop in feed intake and Shurlock and Forbes (1981) found evidence of an osmotic control from the crop.

These are rather short-term regulatory mechanisms. Several other, more or less long-term, factors affect feed intake such as the circulating level of specific nutrients, blood glucose concentration, amino acid profiles in plasma etc. (e.g. Hughes, 1979; Kuenzel, 1983; Shurlock and Forbes, 1984). All such different factors are integrated in a regulatory mechanism, directed at nutritional homeostasis under natural conditions.

The effective monitoring, both qualitatively and quantitatively, of the selection and ingestion of food items from the environment forms an essential part of this regulatory mechanism. This monitoring is accomplished by a variety of sensory systems such as vision, smell, proprioception, mechanoreception, thermoreception, chemoreception and osmoreception (Gentle, 1985).

When domestic hens were provided with *ad lib* compounded feed in a spacious and varied surrounding (described by Blokhuis, 1984), they spent about 35 % of daytime pecking and scratching and about 12 % of daytime feeding from the trough (Blokhuis, unpublished data). Also in a rather simplified environment like a deep litter system, hens spent a considerable amount of time ($\pm$ 9 %) pecking and scratching in the litter (Blokhuis and Haije, 1986). Even in a barren environment like a battery cage, hens spent about 3.5 % of their active time in floor-oriented (looking and pecking) behaviour (Braastad, 1988). In all these environments, this type of pecking is obviously related to feeding. However, most of the nutritive demands will be met from the compounded feed and this suggests that pecking is partly motivated by other factors.

Several experimental results from different animal species, also suggest that the function of food related behaviour is not merely the intake of nutrients. For instance in rats, pigeons and starlings, it was found that the animals preferred to work for food rather than eat identical free available food (Neuringer, 1969, 1970; Inglis and Ferguson, 1986). Also in domestic fowls, it was shown that birds preferred to obtain at least part of their diet by performing an instrumental respons (pecking a disc), in the presence of free available food (Duncan and Hughes, 1972). In other words: birds tend to make more pecks than is strictly necessary for the intake of nutrients in concentrated form (pellets). This tendency appears also from experiments of Savory (1974) in which he showed that chicks consistently preferred mash to pellets. As, with the same daily intake, birds fed on mash spent more time feeding than birds fed on pellets (Fujita, 1973), they thus preferred the feed for which they had to peck more.

Obviously pecking is not only affected by the need for food but there are also other functions involved. The gathering of food related information may possibly be such another function of pecking behaviour (c.f. Inglis and Ferguson, 1986). Indeed, exploratory pecking and scratching is difficult to distinguish from the appetitive component of feeding behaviour (Wood-Gush *et al.*, 1983). This does not mean that exploratory pecking is completely independent from food pecking. On the contrary, as stated above, the effective monitoring of the selection and ingestion of food items from the environment forms an essential part of the regulatory mechanism of food intake. It is very likely that part of this monitoring takes place by exploratory pecking. In a natural surrounding detailed information about a wide range of possible food items is obviously important to a chicken. It helps to fit the diet to specific nutritional needs and it provides alternatives in case some favourite food item is no longer available (e.g. changing of the season). This function of pecking may therefore urge the bird to peck at possible food items and store relevant information in memory.

Still another possible motivation of pecking was discussed in Chapter 4. Here it was stated that the possibility to perform specific consummatory behaviour patterns, may also affect the validation of a substrate as an incentive. In relation to this it was also suggested that the possibility to perform groundscratching in combination with pecking, may add to the stimulus feedback. In terms of the model of Figure 2 this means that there is some optimal level (Sollwert) of proprioceptive feedback from pecking. When this optimal level is not yet reached (Istwert), pecking is performed at a substrate which gives the best consummatory stimulation (incentive). The reason that food is not selected may be the low level of nutritive demand at the time, resulting in a low deficit between Istwert and Sollwert related to nutrition. The biological function of pecking which is only motivated by consummatory stimulation is not clear and it may well be an "artefact" under experimental or other "unnatural" conditions like intensive husbandry. Under natural conditions consummatory stimulation of pecking may cause feeding to continue although the nutritive demand is already lowered.

It will be obvious that although pecking may have several functions and may be affected by several factors such as hunger, an information deficit or a consummatory stimulation deficit, this does not exclude that pecking meets more than one or all functions at the same time: while food particles are consumed, information is gathered and consummatory stimulation perceived. Indeed in a natural surrounding and food situation, different functions of pecking will be efficiently combined during foraging.

It seems very likely that the evaluation of the effectiveness of pecking, as suggested in the model of Figure 2, refers to different but often coinciding functions of pecking (e.g. energy supply, consummatory stimulation or information gathering).

In an agricultural surrounding only one food is offered to the birds, which has completely different characteristics as compared to the whole complex of natural food (diversity, availability, nutritive density, composition, structure, etc.). In a husbandry situation, the nutritive function of pecking may be met by the food, while other (in nature vital) functions are not. Following the above line of reasoning, this results then in a desintegration of functions of pecking and in a different effectiveness of pecking at food in relation to nutrition (high) and in relation to other needs (low). Consequently this results in separate incentive values of the food: a high incentive value in relation to nutritional demands and a low incentive value in relation to other demands.

It is suggested here that when nutritional demands are met to a certain extent, pecking is directed towards other objects which have a favourable ranking as an incentive in relation to other demands, such as information gathering or just consummatory stimulation. This may explain why, under husbandry conditions, feeding bouts are relatively short (Savory, 1979; Strempel, 1983) and why the litter, the wire floor or feathers of conspecifics are pecked.

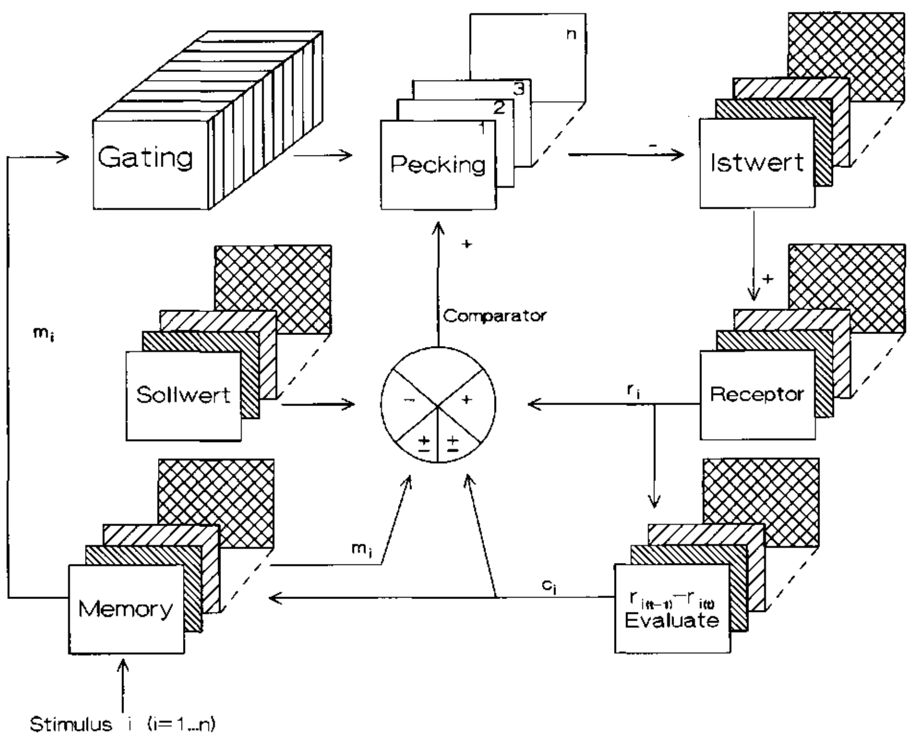

Figure 3. A tentative model of pecking behaviour, incorporating differently directed pecking as well as different functions of pecking.

On the basis of the above, the model of Figure 2 is slightly modified as represented in Figure 3. The behaviour which is regulated is called "pecking" here, as it not only involves ground pecking but also pecking at food, feathers, wire etc. Pecking may be directed at different stimuli and this is visualized as a range of boxes, representing pecking at stimulus 1....n. Because different functions of pecking are involved, the model incorporates different Istwerte, Sollwerte and Receptors, specific for every function (these are not coupled with specific stimuli because one stimulus can serve several functions and one function may involve differently directed pecks). Of course for every function of pecking there is also an system which evaluates the effectiveness of differently directed pecking (in relation to a specific function) and a memory where the result of the evaluation is stored. Also in this model a gating system gives direction to pecking behaviour on the basis of available information.
It is of course important to determine which effects of pecking at litter, wire floor or feathers cause the favourable ranking as an incentive. On the basis of the above, it seems worthwhile to carry out experiments to study information gathering as a motivating factor of pecking. As this proves to be the case "natural" feeding behaviour should be studied in more detail. As this probably constitutes the optimal strategy to realise an optimal integration of feeding and information gathering, detailed analyses may indicate the type of information that is gathered and how it is gathered. Secondly, the effects of consummatory stimulation should be studied. What are the effects of tactile and gustatory properties of the food and of the mere performance of consummatory behaviour patterns like pecking and scratching?

Abnormal behaviours such as stereotypies and redirected behaviours are considered relevant indicators to farm animal welfare (Wiepkema, 1983; Broom, 1983). However, the exact relationship of the different abnormalities with welfare is not always clear. Therefore it is of primary importance to clarify the biological significance of the different types of abnormal behaviours as was recently done by Cronin (1985) for stereotypies in thethered sows.
The model presented here is a first attempt to account for the causa-

tion and function of abnormal redirected (injurious) behaviour in farm animals. The model may help to understand the development and causation of this type of abnormal behaviours in husbandry environments.
Disturbed behaviours like feather pecking in poultry are also seen in other animal species under intensive husbandry conditions. Thus, fattening pigs show for instance tail and ear biting and nibbling and rooting at penmates (Blackshaw, 1981; Van Putten, 1969; Ruiterkamp, 1985) and veal calves show sucking of objects or conspecifics, tongue playing, gnawing and nibbling at objects etc. (Van Putten, 1982; De Wilt, 1985).
The feeding situations of these animals show similarities with that of poultry. They are also fed one food, of which the availability, nutritive density, composition, structure, etc. is completely different from the diet in a natural situation. Results from experiments on the causation of these behaviours show a strong resemblance with the present results on pecking in poultry. The possibility to perform "normal" feeding related behavioural patterns, diminishes disturbed behaviours in pigs (e.g. Ruiterkamp, 1985; Schouten, 1986) and veal calves (e.g. De Wilt, 1985). It is suggested here that also in pigs and calves an analysis of the different aspects of food related behaviour, as visualized for pecking in poultry in the model of Figure 3, may be helpfull in making relevant changes in the food or the feeding situation, to overcome behavioural problems in these animals.

THE PRACTICAL WAY FORWARD

The different causes of feather pecking mentioned in the literature fall into four main groups (Hughes, 1982): dietary composition, environment, hormonal influence and psychic factors. With the accent on the results of the present experiments and on the basis of the above discussion, the risk of some husbandry factors in relation to the occurrence of feather pecking will be discussed and some measures to prevent feather pecking will be suggested.

Dietary composition

As the present data show that feather pecking is related to the feeding system, it is obvious that dietary composition may be a relevant factor. When a need for some specific nutritional substance is not covered by the available food (incentive of the food in relation to that substance is low), pecking is directed towards other substrates in an attempt to diminish the deficiency. This may also result in pecking the feathers of conspecifics and although this may not help to control the deficiency, feathers are recognized as a substrate for pecking. In an otherwise deficient environment (no substrates with high incentive values for pecking) this may lead to a feather pecking problem. A nutritional deficiency is therefore usually not a primary cause but it may stimulate pecking (c.f. Hughes, 1982).

The texture of the diet as well as the nutritive density are also relevant factors in relation to feather pecking. On a diet with a high energy content (which is a main factor in regulating intake of compounded feed (Gleaves *et al.*, 1968) or on a pelleted diet, birds can cover their nutritional needs in a relatively short period of time. This may leave more time for other functions of pecking to gain priority, resulting in pecking at non-food objects. This fits results from literature showing more feather pecking in birds on high energy diets (Gerum and Kirchgessner, 1978) or on pelleted diets (Bearse *et al.*, 1949).

Although one might expect a similar effect on feather pecking when birds are given restricted access to food, this was not the case (Preston, 1987a). The reason for this is not clear. Possibly, because there is still a need for food, the bird is concentrating on nutritional pecking, and the kind of pecking in which feathers are functional gets no priority (although cage pecking showed an increase). A comparable phenomenon was observed in veal calves where a strong need for milk tended to shorten the time spent non-nutritive sucking (Metz, 1984).

Environmental factors

A main environmental factor related to feather pecking is the character of the floor on which the birds are housed. Clearly the stimulus content of litter is much higher than that of wire or slatted floors, and consequently the risk for feather pecking is lowest on litter floors. However, when birds are housed on litter, several other environmental factors seem to affect the risk for feather pecking such as light intensity and colour (Hughes and Black, 1974; Schumaier *et al.*, 1968) and housing density (Simonsen *et al.*, 1980). In Chapter 6 it was shown that birds housed at higher densities show less ground pecking and it was concluded that the incentive value of the floor is apparently lower at higher densities and this holds a higher risk for feather pecking to occur. Thus housing density affects feather pecking indirectly via its effect on the incentive value of the floor. It is suggested here that the same holds for several other environmental factors. This would also fit the idea of a multifactorial causation of feather pecking (Hughes and Duncan, 1972) where the final common path of all these factors is the incentive value of the ground.

As discussed before, it is not exactly clear what the relevant characteristics of the ground are and how environmental factors affect them. However, practical measures may be taken on the basis of their positive effect on ground pecking. It is obvious that good litter management, preventing wet and sticky litter, is such a measure. Supplying the birds with grain in the litter may be another one. The grain should be supplied during the afternoon as pecking motivation is highest than (Blokhuis, 1984; Preston, 1987b; Savory *et al.*, 1978). Because the birds' validation of the ground as an incentive is influenced by experience during the rearing period (Chapter 5), measures should apply to the laying as well as the rearing period.

Because about 80 % of feather pecking is directed to inactive birds (Chapter 2), it should be considered to arrange the lay-out of the house in such a way that birds motivated to peck and resting birds are separated. Therefore perches may best be placed away from the feeders and the litter.

Hormonal factors

There are some indications that hormonal status (male/female, in lay or not) of the birds affects the occurrence of feather pecking (c.f. Cuthbertson, 1978). There have been only very few experimental studies and from those no firm conclusions can be drawn about the background of the hormonal effect. Differences in hormonal status are very likely to coïncide with differences in the demands of the organism. Possibly such differences or changes in (nutrional or other) demands affect the redirection of pecking.

Psychic factors

These factors refer to individual differences between birds. Not all birds are equally likely to featherpeck and there is a significant genetical component (Cuthbertson, 1978; Hughes and Duncan, 1972). This may be interpreted as genetical differences affecting the Sollwerte for the different functions of pecking. This opens the way for selection against feather pecking. Or in other words a selection in which preference is given to the birds which pecking demands are met by just compounded feed or compounded feed with litter (the latter is a higher risk because litter is not of a standard quality and selected birds may still redirect their pecking when housed on the "wrong" litter). One might therefore select those birds showing the smallest number of not at feed directed pecks. Untill now the estimation of such a parameter can only be done by behavioural observations. To facilitate evaluation of a pecking parameter and the possible incorporation in a selection index, an automatic recording device should be developed.

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GENERAL SUMMARY

Feather pecking in poultry consists of pecking directed at the feathers of other birds, sometimes pulling out and eating these feathers. It may result in severe damage of the integument of the birds, including wounds of the skin. Finally wounded birds may be pecked to death (cannibalism). About 30 years ago, when most poultry was kept in traditional floor systems, this behaviour was an important cause of mortality. Nowadays most birds are housed in small groups in battery cages in modern poultry houses and in The Netherlands they are usually beaktrimmed (partial amputation of the beak). This resulted somehow in a decreased mortality due to feather pecking.

However, the effects of feather pecking may have become less fatal, the behaviour as such did not decrease and pecking still causes a lot of (feather) damage and feather pecking is still a problem in modern poultry farming.

Firstly, the problem relates to animal welfare, which is clearly at stake for the pecked birds. Moreover, beaktrimming may counteract the occurrence of cannibalism and may prevent a lot of suffering, it is a painful operation which should be omitted if possible.

Secondly, feather pecking is also economically detremental. Defeathering has a pronounced increasing effect on heat production, leading to an estimated increase of energetic needs between 5 and 20 % for laying hens in battery cages.

The development and expected practical use of alternative systems for laying hens is also relevant with respect to feather pecking. As these systems often incorporate characteristics of traditional floor systems, this may enhance feather pecking.

The present study was aimed at elucidating the basic motivation behind feather pecking and the process leading to it.

In Chapter 2 pecking behaviour of birds on a litter floor was compared with that of birds on a slatted floor, from hatching until 17 weeks of age. The average frequency (per animal per hour) of pecking at conspecifics was 73.2 in groups on slatted floors and 27.8 in groups on litter. It increased over time in groups on slatted floors, whereas it tended to decrease in groups on litter floors. Moreover, in the latter pecking at conspecifics was much less damaging. Here about 20 % of the pecks was directed at particles on the plumage of other birds, which is relatively harmless, and about 25 % at feathers. In the groups without litter, these percentages were 1 and 55 respectively.

Ground pecking frequency appeared to be about 6 times higher in groups on litter compared to groups on a slatted floor.

At 17 weeks of age the experiment was continued by transferring half of the animals from each floor-type to the other type of flooring material. Most striking was that animals reared on litter and changed to slats, showed a strong increase of pecking at conspecifics (together with an increase in feather damage) and a strong decrease of ground pecking. Birds reared on slats and moved to litter showed a strong increase in ground pecking and the majority showed a decrease of pecking at conspecifics. In the latter birds, plumage recovered from the damage done to it in the first part of the experiment.

It was concluded that the results supported the hypothesis that feather pecking evolves as redirected ground pecking.

Experimental evidence to support this hypothesis is presented in Chapters 3 and 4. In Chapter 3 the motivation for groundpecking was experimentally varied in 6 week old female chicks, housed on litter. The same experimental procedure that stimulated ground pecking in chicks on a litter floor, appeared to stimulate feather pecking in chicks on a slatted floor. This supports the hypothesis that ground pecking and feather pecking share common causal factors. Chapter 4 takes another approach to test the same hypothesis. Here, again using 6 week old chicks, floor-type was suddenly changed from a half litter half slatted floor into a full slatted floor. The fact that groundpecking decreased and feather pecking increased again supported the above hypothesis.

The redirection of ground pecking was described in both chapters in terms of incentive motivation theory. In this concept of motivation the role of incentive stimuli in inducing motivational states and in directing behaviour is emphasized. Specific characteristics of litter, a slatted floor or feathers which may affect their ranking as an incentive are discussed. Possibly visual, tactile or gustatory feedback signals play a role, as well as positive long-term effects of ingestion. Moreover, it was stated that the possibility to perform specific consummatory behaviour patterns, may also affect the validation of a substrate as an incentive. In relation to this it was also suggested that the possibility to perform groundscratching in combination with pecking, may add to the stimulus feedback. Obviously the animal's past experience with environmental stimuli is crucial in the validation of stimuli as incentive.

In Chapter 5 the effects of early experience with litter were studied. Hens were reared on litter floors (20 groups) or on wire floors (20 groups) until 17 weeks of age. Then all groups were moved to pens with half litter half slatted floors. It appeared that feather pecking was less in litter reared hens compared to hens reared on wire. Also feather damage was less in the litter reared groups. It was concluded that experiences during rearing influence pecking preferences during the laying period.

In the same experiment the effect of beaktrimming was studied. As the beak of the chicken has a variety of sensory receptors, beaktrimming is likely to result in sensory deficits. This may affect tactile discrimination and interfere with the validation of an object as an incentive for pecking. During the rearing period beaktrimmed birds showed a lower frequency of ground pecking as well as feather pecking, on litter as well as wire floors. During the laying period all groups showed the same level of ground pecking irrespective of beaktrimming or floor type. Beaktrimming only showed an effect on feather pecking in the wire reared groups. Here feather pecking reached a very high level, although it did not much harm to the plumage of the birds. It was concluded that beak trimming does not change pecking preference nor does it decrease pecking frequency. Beaktrimming is effective in reducing feather pecking damage.

In Chapter 6, it is reported that a high housing density significantly decreases ground pecking and scratching in young domestic fowl. Although no serious feather pecking occurred, it is suggested that a high housing density stimulates the redirection of ground pecking which may result in the development of feather pecking.

In the general discussion (Chapter 7) a regulatory model of ground pecking is presented, in which the role of incentives is incorporated. The motivation of pecking is discussed and it is concluded that pecking serves several functions such as energy supply, consummatory stimulation or information gathering. The model of ground pecking is modified to allow the incorporation of these different functions. On the basis of this model some suggestions for future research are made. In a last paragraph the risk of some husbandry factors in relation to the occurrence of feather pecking are discussed and some measures to prevent feather pecking are suggested.

SAMENVATTING

Verenpikken bij kippen is het gedrag waarbij dieren pikken naar de veren van een soortgenoot en daarbij soms veren uittrekken en die dan vervolgens ook wel opeten. Dit gedrag kan aanzienlijke beschadigingen van het verenpak veroorzaken en ook verwondingen. Verwonde kippen kunnen zelfs doodgepikt worden (kannibalisme). Zo'n 30 jaar geleden, toen de meeste leghennen in traditionele grondhuisvesting werden gehouden, was verenpikkerij een belangrijke oorzaak van uitval van de dieren.
De leghennenhouderij is sindsdien sterk veranderd. Tegenwoordig worden de meeste leghennen gehouden in moderne stallen met batterijkooien. Per kooi worden vier of vijf hennen gehouden. In Nederland wordt gewoonlijk op jonge leeftijd een deel van de snavel van een hen verwijderd (snavelkappen). Eén en ander heeft er hoogstwaarschijnlijk toe bijgedragen dat de sterfte als gevolg van verenpikken is afgenomen. Dit betekent echter niet dat het gedrag als zodanig ook is afgenomen. In tegendeel, ook in de moderne pluimveehouderij veroorzaakt verenpikken nog steeds veel (veer) schade hetgeen om een aantal redenen nadelig is.
Het heeft uiteraard implicaties ten aanzien van het welzijn van de dieren. Het is duidelijk dat het welzijn van ernstig gepikte dieren (hetgeen ook voorkomt bij gesnavelkapte hennen) is aangetast. Ook anderszins heeft verenpikken gevolgen voor het welzijn van de dieren. De pluimveehouder ziet zich namelijk genoodzaakt de dieren te snavelkappen. Dit snavelkappen voorkomt weliswaar veel dierenleed maar is op zichzelf een pijnlijke ingreep die zo mogelijk achterwege moet worden gelaten.
Verenpikken veroorzaakt verder een aanzienlijke economische schade. De aantasting van de kwaliteit van het verenpak heeft een verhoging van de warmteproduktie door het dier tot gevolg. De toename van de energie behoefte wordt voor hennen in batterijkooien geschat op 5 tot 20 %.
Ook in relatie tot de ontwikkeling en praktische toepassing van alternatieve huisvestingssystemen voor leghennen is de problematiek rond verenpikken van belang. Dergelijke alternatieve systemen vertonen namelijk veelal karakteristieken van de traditionele grondhuisvesting en

dat zou verenpikken kunnen stimuleren.
Het hier beschreven onderzoek had tot doel te achterhalen welke motivatie hennen tot verenpikken aanzet en hoe dit tenslotte tot verenpikken leidt.

In Hoofdstuk 2 wordt het pikgedrag van hennen op een vloer met strooisel vergeleken met dat van hennen op een roostervloer. De waarnemgen vonden plaats van één dag tot 17 weken leeftijd. De gemiddelde frequentie (per dier per uur) van het pikken naar soortgenoten bedroeg 73.2 in groepen op roostervloer en 27.8 in groepen op strooisel. Het nam toe in de groepen op roosters terwijl het leek af te nemen in de strooisel groepen. Bovendien was het in de laatste veel minder schadelijk. Twintig procent van de pikken werd in deze groepen gericht op strooiseldeeltjes op het verenpak van andere dieren hetgeen vrij onschadelijk is, terwijl 25 % van de pikken was gericht op veren. In de groepen zonder strooisel waren deze percentages respektievelijk 1 en 55.
De frequentie van het bodempikken bleek in de strooiselgroepen zes keer hoger te liggen in vergelijking met de roostergroepen.
Na de leeftijd van 17 weken werd het experiment voortgezet door de helft van de dieren van ieder bodemtype over te plaatsen naar de andere bodem. Het meest opvallende gevolg hiervan was dat dieren die op strooisel waren opgefokt en naar roosters werden overgeplaatst, een sterke toename lieten zien van het pikken naar andere dieren (gepaard met een toename van de veerschade) en een sterke afname van bodempikken. Hennen die waren opgefokt op rooster en vervolgens overgeplaatst naar strooisel vertoonden een sterke toename van bodempikken, terwijl het merendeel minder naar andere hennen ging pikken. Bij deze dieren was ook sprake van een duidelijk herstel van de schade die in het eerste deel van het experiment aan het verenpak was toegebracht.
De resultaten pasten in de hypothese dat verenpikken kan worden beschouwd als een vorm van omgericht bodempikken.
Deze hypothese werd nader getoetst in experimenten die worden beschreven in Hoofdstuk 3 en 4. In Hoofdstuk 3 werd de motivatie voor bodempikken experimenteel gevariëerd in zes weken oude hennetjes die op een strooiselbodem werden gehouden. Dezelfde experimentele procedure die

het bodempikken van deze dieren stimuleerde, bleek bij vergelijkbare dieren, gehouden op een roostervloer, verenpikken te stimuleren. Dit resultaat ondersteunt de hypothese dat de causale faktoren voor bodempikken en verenpikken dezelfde zijn. In het experiment beschreven in Hoofdstuk 4 wordt de hypothese op een andere wijze getoetst. Ook hier werden weer zes weken oude henkuikens gebruikt. In dit experiment werd de bodem, die voor de helft bestond uit rooster en voor de helft uit strooisel, plotseling veranderd in een volledige roostervloer. Het feit dat hierdoor bodempikken afnam en verenpikken toenam ondersteunt wederom de bovenstaande hypothese.

In Hoofdstuk 4 en 5 wordt het omrichten van bodempikken beschreven in termen van "incentive motivation". In dit concept van motivatie spelen externe stimuli, zogenaamde "incentives", een belangrijke rol bij het induceren van motivatie en bij het richting geven van gedrag (namelijk gericht op de incentive). Specifieke eigenschappen van strooisel, een roostervloer of veren kunnen bepalend zijn voor de stimulerende waarde ("incentive value") ervan. Een aantal van deze eigenschappen worden bediscussiëerd. Zo kunnen visuele, tactile of gustative terugkoppelings signalen mogelijk een rol spelen, terwijl ook positieve lange termijn effekten van consumptie en vertering een rol zouden kunnen spelen. Bovendien zou een substraat louter omdat het de mogelijkheid biedt tot het uitvoeren van specifiek gedrag kunnen worden gewaardeerd als incentive. In dit verband werd de suggestie gedaan dat de mogelijkheid tot het uitvoeren van scharrelkrabben in combinatie met pikken zou kunnen bijdragen tot de positieve terugkoppeling. De waardering van stimuli als incentives baseert een dier op ervaringen met dergelijke stimuli in zijn omgeving.

In het experiment beschreven in Hoofdstuk 5 worden de effekten van een vroege ervaring met strooisel onderzocht. Er werden hennen opgefokt op strooisel (20 groepen) en op draadrooster (20 groepen), tot een leeftijd van 17 weken. Vervolgens werden alle groepen overgeplaatst naar hokken met half-strooisel, half-rooster vloer. Verenpikken bleek minder voor te komen in de op strooisel opgefokte groepen, vergeleken met de op rooster opgefokte groepen. Het verenpak was ook het minst beschadigd in de groepen die op strooisel waren opgefokt. De conclusie werd getrokken dat ervaringen tijdens de opfok effekt hebben op de

richtingspreferentie van het pikken tijdens de legperiode.
In het zelfde experiment werd ook het effekt van snavelkappen bestudeerd. Het ligt voor de hand te veronderstellen dat snavelkappen de sensorische capaciteit van de snavel verminderd doordat aanwezige receptoren worden beschadigd. Dit zou wel eens het vermogen voor tactile discriminatie kunnen beperken en daarmee het vermogen om een substraat juist te waarderen als een incentive voor pikken. De gesnavelkapte dieren vertoonden tijdens de opfok minder bodempikken en ook minder verenpikken, zowel op rooster als op strooisel. Tijdens de leg vertoonden alle groepen gelijke niveau's van bodempikken, onafhankelijk van snavelkappen of bodemtype. Het snavelkappen had alleen een effekt op het verenpikken tijdens de leg in de op roosters opgefokte groepen. De gesnavelkapte groepen vertoonden namelijk een zeer hoog niveau van verenpikken, hoewel de schade aan het verenpak van de dieren beperkt bleef. De conclusie was dat snavelkappen geen effekt heeft op de richtingspreferentie van het pikken en dat het de frequentie van het pikken niet verlaagt. Verder bleek snavelkappen een effektieve methode om schade aan het verenpak te beperken.
De resultaten van het experiment beschreven in Hoofdstuk 6 laten zien dat een hogere bezettingsdichtheid bij jonge hennen een vermindering van bodempikken en scharrelkrabben teweeg brengt. Hoewel in dit experiment geen grote mate van verenpikken optrad wordt toch verondersteld dat een hoge bezettingsdichtheid het omrichten van bodempikken stimuleert, hetgeen kan resulteren in verenpikken.
In de algemene discussie (Hoofdstuk 7) wordt een regelkringmodel van bodempikken gepresenteerd, waarin incentives een rol spelen. De motivatie van pikken wordt bediscussieerd en de conclusie is dat het een aantal uiteenlopende functies kan hebben zoals energie voorziening of het verzamelen van informatie, of dat het wordt uitgevoerd vanwege de positieve stimulatie die louter van de uitvoering het gevolg is. Het model van bodempikken wordt vervolgens aangepast, waarbij deze functies in het model worden opgenomen. Voor wat betreft toekomstig onderzoek wordt de nadruk gelegd op de analyse van de faktoren die een rol spelen bij de waardering van stimuli als incentive en daarmee gepaard gaand onderzoek naar de onderscheiden funkties van pikken.
De risico's van een aantal houderijfaktoren met betrekking tot veren-

pikken worden besproken in een laatste paragraaf in Hoofdstuk 7. In relatie tot voer lijken deficiënties, hoog energie niveau, struktuur en pelleteren extra risico's in te houden. Het zelfde geldt voor een hoge bezettingsdichtheid en een slechte kwaliteit strooisel. Maatregelen om risico's van verenpikken te verminderen dienen ook reeds in de opfok te worden genomen. Zonder dat in die periode werkelijk verenpikken optreedt kan door verkeerde omstandigheden het risico voor verenpikken in de legperiode toch worden vergroot.

CURRICULUM VITAE

Hendrik Jacob Blokhuis werd geboren op 9 februari 1955 te Woudenberg. Na het lager onderwijs bezocht hij het Corderius College te Amersfoort, waar hij in 1972 het diploma H.B.S.-B behaalde. In datzelfde jaar werd de studie zoötechniek aan de Landbouwhogeschool te Wageningen aangevangen. In 1979 werd het doctoraal examen behaald (cum laude), bestaande uit de hoofdvakken gezondheids- en ziekteleer der huisdieren en fysiologie van de huisdieren en als bijvak erfelijkheidsleer. In aansluiting hierop volgde een aanstelling als onderzoeker ethologie bij het Instituut voor Pluimveeonderzoek "Het Spelderholt" te Beekbergen. Sinds 1 januari 1989 is hij tevens hoofd van de afdeling Primaire Produktie van "Het Spelderholt".
De verschillende experimenten die hebben geleid tot dit proefschrift werden uitgevoerd op "Het Spelderholt" in de periode van 1982 tot 1988.