Rearing hens in furnished cages

Maïka Cox
Kris De Baere
Johan Zoons

Poultry nr. 42

Introduction

At the Provincial Centre for Practical Applied Poultry Research of the province of Antwerp enriched cages are used in real circumstances and in accordance with European guidelines.

During the experiments production, quality and health of the animals are evaluated as well as behaviour.

In this research two types of cages are used, those provided with feed troughs and those with feeding pans. All cages have a laying nest, perches, scratching materials and dust bathing facilities.

During three laying periods different aspects of the cages were examined and compared:

- During the first laying period (June 2001 until June 2002) the influence of two different feeding systems is examined as well as different nesting and scratching materials.
- During the second period (October 2002 until October 2003) feeding systems, genetic strains, nesting and scratching materials were compared and in addition research was conducted on dust bathing behaviour in a litter box and on a scratching mat.
- In the third laying period (December 2003 until December 2004) once again two feeding systems and two genetic strains were examined as well as different scratching materials and the dust bathing behaviour of the birds. Also the use of different perches and environmental enrichments were evaluated.

Proefbedrijf voor de Veehouderij

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Abstract

Cannibalism occurred in the enriched cages but is constrained to a few cages. Once started, the mortality rates rose quickly and not much could be done to change it. A technical problem can develop stress in the group which can cause cannibalism.
The technical results showed there are great differences between the different laying periods. Different influences from the environment such as management play a role.
Regarding the used strains, no clear conclusions could be made since the results from the different laying periods differed strongly.
The use of laying materials in the nests improved the egg quality since less eggs were bruised or dented. Also the percentage of eggs laid outside the nests was reduced with the use of nesting materials.
All scratching materials used kept the nails of the brown hens shorter than those in cages with no scratching facilities. The level of the nail reduction depended on the material used. Some materials though seemed to wear down the nails too much which can injure the animals.
The results showed that more dust baths are taken on the scratching mat but these dust baths take less time than those acted out in litter boxes.
The birds preferred the higher perches. Concerning the material used, there seemed to be a slight preference for wood, the plastic perches were also used more often. The plumage condition seemed to be lower in cages with metal and plastic perches.
The materials used as environmental enrichment didn't seem to be effective in reducing feather pecking since no clear effects on plumage condition were noticed. When the materials were introduced to the birds, they showed great interest in them but this wore off quickly.

Contents

1 MATERIALS AND METHODS

1.1 Birds

Between June 2001 and December 2004 three batches each of 4,920 laying hens were studied.
Each flock consisted of two strains; during the first two laying periods Hisex Brown and Bovans Goldline (brown) were compared while in the last period the latter was compared with Isa Brown. The hens had been commercially reared in battery cages without perches and the three flocks were beak-trimmed respectively at the age of 14, 18 and 10 days. The pullets were transferred to the experimental buildings at 16 weeks of age. Data collection started at 18 weeks and continued until the hens were 70 weeks old.

1.2 Housing (Buildings and cages)

At Geel, Belgium, the Provincial Centre for Practical Applied Poultry Research of the province of Antwerp, had two houses for laying hens at its disposal. The two buildings were identically built and orientated and each contained two separate compartments. The birds used in this research were housed in the two compartments of the houses facing east (ground plan of the two buildings see Figure 1), called A and C.
Both compartments had equal environment and lighting schemes and their own temperature regulation. In the top of the roof, four fans were placed, two with adjustable valves and two with 'butterfly' valves. These fans were placed in sequence and those with adjustable fans could be used at variable speeds while the other two could only be used at 100 % capacity.
Ventilation was monitored closely with climate computer and measurement fans. Ventilation flow was regulated, based on average house temperature and relative humidity. Temperature was measured by two probes and relative humidity was determined based on the principle of wet and dry bulb temperature. Air input consisted of a classic valve. After consultation with the flock owner, the optimum temperature was set at 22 degrees Celsius.

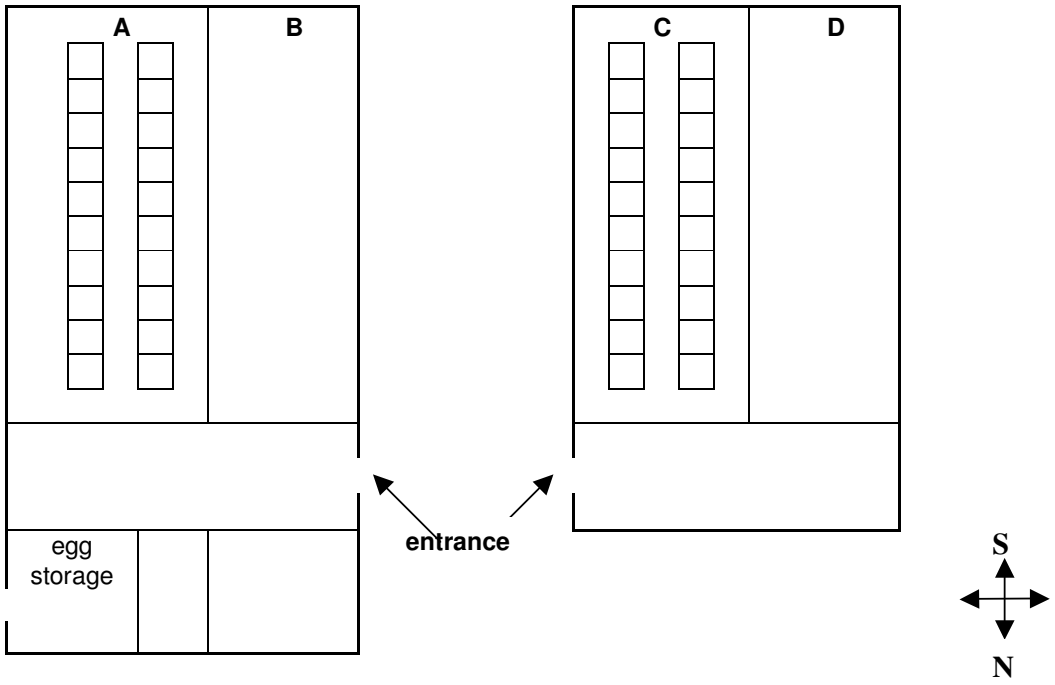

Figure 1: Ground plan of the two houses and compartments used

Cages were divided into two models of enriched cages according to the feeding system used; cages provided with a feed trough (FT) and cages with two round feeding cups or pans (FP).
Each of the two compartments (Figure 2) contained two rows of three tiers, each tier consisting of ten cages. Each row was provided with another feeding system (FT or FP) and each tier was stocked alternately with both breeds.
Cages (FT and FP) respectively measured 2,4 m (w) x 1,1 m (d) x 0,54 m (h) and 2,4 m (w) x 1,2 m (d) x 0,54 m (h), nest sections respectively 0,6 m (w) x 0,55 m (d) x 0,54 m (h) and 0,6 m (w) x 0,6 m (d) x 0,54 m (h). In the cage with linear feeders (FT) 39 birds were housed; since the cages with pans (FP) were slightly wider they contained 43 birds.
All cages were provided with litter boxes attached to one side of the cage in order to provide dust bathing facilities. The dust baths measured approximately 60 cm (w) x 25 cm (d) and were raised about 20 cm above the bottom of the cage. In front of the dust baths a perch of 60 cm in length was placed to facilitate access. Each bath was provided with a time-controlled mechanism for opening and closing (by pulling up the bottom).
Each cage had 620 cm perch length; this was provided by two wooden perches of 200 and 160 cm, the ventilation pipe of 200 cm (space under litter box was not counted) and the perch of 60 cm in front of the litter box. In Table 1 the available area, perching length and feeding length are lined out per type of cage and per hen housed.

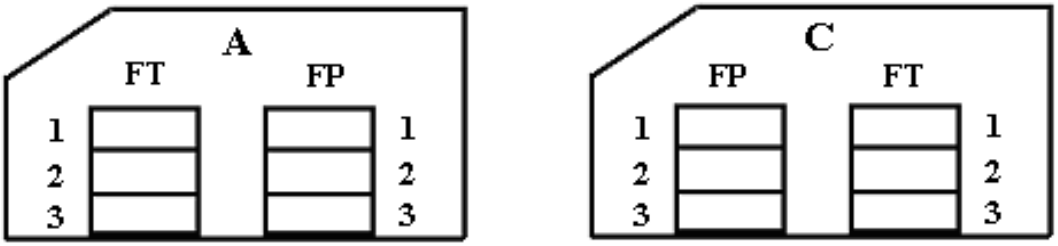

Figure 2: Cross sectional diagram of the two compartments; FT: cages with feed trough, FP: cages with feeding pans

Table 1:Characteristics of housing systems used

		feeding pans (FP)
total hens housed in cage	39	43
total cage area	29700 cm²	32400 cm²
total cage area per hen	761,5 cm²	753,5 cm²
nesting area	3300 cm²	3600 cm²
total usable area per hen	635,4 cm²	591,4 cm²
feeding length per hen	12,3 cm	4,9 cm
perch length per hen	15,9 cm	14,4 cm

1.3 Management

A standard commercial diet was provided *ad libitum* as was water trough nipple drinkers. Feeding facilities and water cups were checked twice a day. Both water and food consumption were recorded per tier.
The birds were inspected twice a day and sick or dead birds were removed. The cause of death was determined by autopsies.
The light period was gradually built up from week 17 to reach a maximum of 16 hours at 22 weeks. There was a slight difference in building up this light period between the three flocks (see Figures 3, 4 and 5 for lighting schemes).
Manure was removed once a week using an automatic system consisting of manure belts under each tier.
To avoid eggs being laid in the litter boxes, they were only opened from 13.30h until 18.00h. At 14.00h litter was provided in the dust baths under the form of fine white sawdust, approximately 2g per hen.

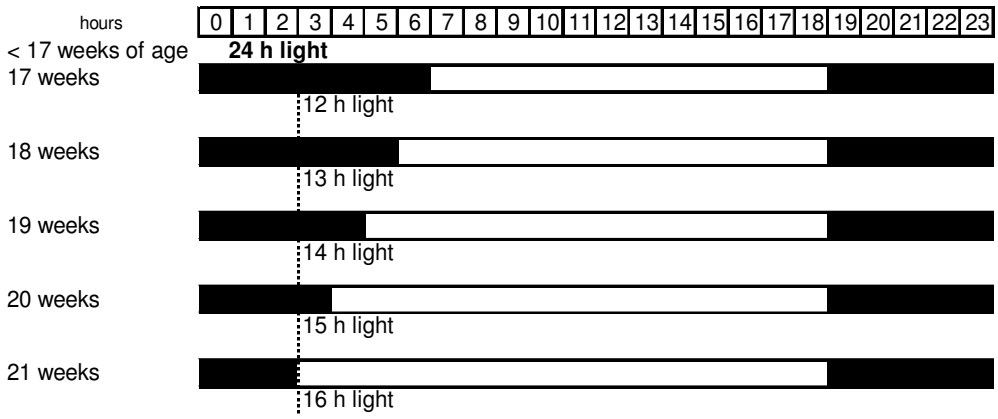

Figure 3: Lightning scheme first laying period

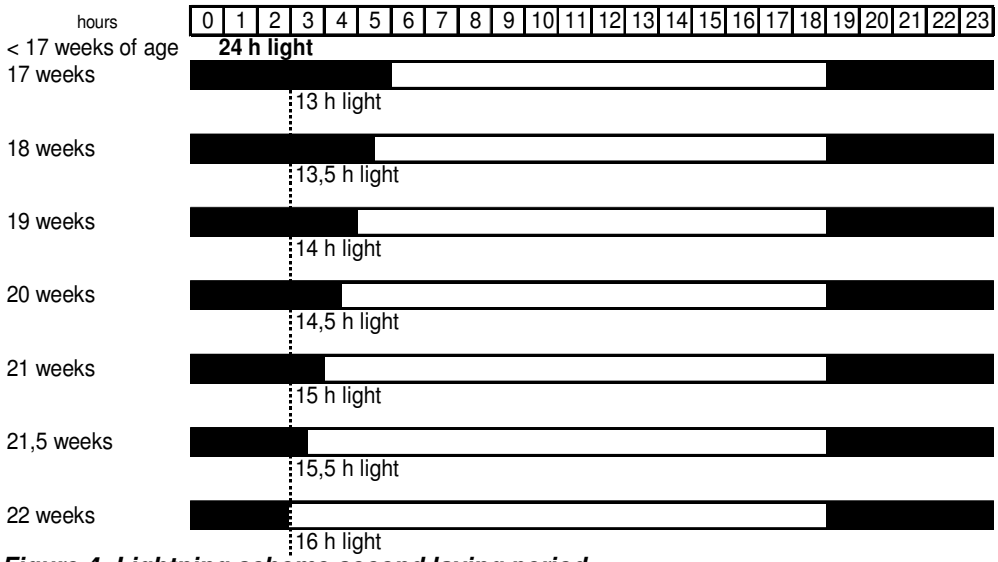

Figure 4: Lightning scheme second laying period

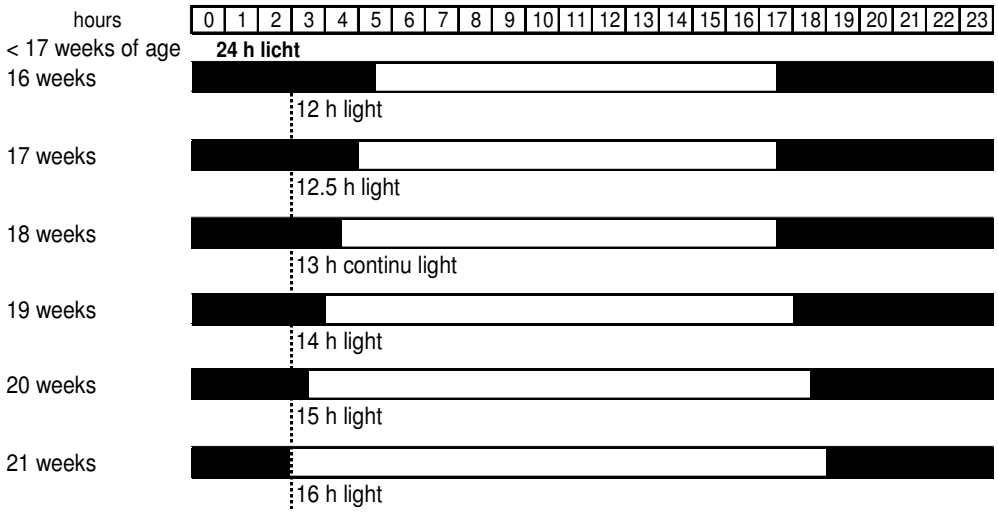

Figure 5: Lightning scheme third laying period

2 EXPERIMENTS / TREATMENTS

2.1 Strains

During every period two strains of laying hens were used and compared; Hisex Brown frequently used in batteries and cages and on the other hand Bovans Goldline, a strain known to be less aggressive and mostly used in alternative systems. Due to the AI crisis the strain Hisex Brown wasn't available for the third laying period. It was then decided to use the Isa Brown strain in comparison with Bovans Goldline.

2.2 Cage types

Two types of feeding were used during this experiment. Cages were either provided with linear feed troughs or with two feeding pans or cups.

2.3 Nesting materials

In the nesting area, different nesting materials were compared according to production, quality of eggs and percentage of eggs laid outside the nests.
During flock I artificial turf (Astroturf® XPNP long) and a standard coated wire mesh were compared on each upper tier. On the lower tiers 3 types of artificial turf (Astroturf® XPNP long, Astroturf® XPNP short and Astroturf® HPNP) were evaluated. During the second flock Astroturf® XPNP long, Astroturf® XPNP short and a standard coated wire mesh were evaluated on the lower tiers.
In Table 2 the different types of nest pads used, are briefly described.

Table 2: Description of different nest pads used in experiment

HPNP	High Performance Nest Pad (older model) Bristles are of different lengths and on average 19-20 mm long, bristle tops are not rounded off and bottom is perforated to allow dirt to fall through the material.
XPNP	Extra Performance Nest Pad (recent model): holes in bottom of mat are slightly larger compared to HPNP - long: bristles are all of the same length, namely 19-20 mm and the tops are rounded off - short: bristles have different lengths and on average 14 mm long, tops are also rounded off.

2.4 Abrasives

Different scratching devices were placed in the cages and by measuring the length of the claws, their effectiveness and endurance was compared with cages where no scratching materials were used (reference).
During all flocks these abrasives were tested on the second tiers and in the cages with feed troughs (FT) they were fitted on the egg baffles so that during feeding the birds scratched the materials. In cages with circular feeding pans (FP) the abrasives were fitted onto the ventilation pipe (situated in the middle of the cage, under the feeding pans) or onto a self-made construction which was placed under the feeders.
In the cages with feed troughs, the scratching materials were replaced or new materials were used at the start of the second batch. During the third laying period these materials were not changed or replaced in order to assess their endurance.
The scratching devices used in cages with feeding pans were never renewed during the three batches.
Table 3 gives an overview of all materials used as claw shorteners.

Table 3: Different abrasives used during consecutive laying periods; FT: Feed Trough, FP: Feeding Pans

Type of abrasive	Number of abrasives used	used in
Norton ceramic plates	- 10 per cage (**N10)** - 6 per cage (**N6)** - 4 pasted onto a wooden construction (**Nwc)** - 4 per cage (**N4)**	flock 1, 2, 3; FT + FP flock 1, 2, 3; FT flock 1, 2, 3; FP flock 2, 3; FT
3M abrasive strips	- rough, 3 strips (2,5 cm * 49 cm) per cage (**3Mr)** - fine, 3 strips (2,5 cm * 49 cm) per cage (**3Mf)**	flock 1, 2, 3; FT + FP flock 1, 2, 3; FT + FP
Perforated egg baffles	- 5 short rows of small holes (**P2)** - 3 longer rows of small holes (**P1)**	flock 2, 3; FT flock 2, 3; FT

2.5 Dust bathing

During the second and third batch half the litter boxes on one tier were replaced with scratching mats which were also provided with sawdust. Dust bathing behaviour on these two facilities were analysed through observations. During the third batch half of the observed scratching mats and litter boxes were provided with a mixture of sawdust and feed in order to examine the influence on the dust bathing behaviour.

2.6 Use of different kinds of perches

In the third laying period the cages on the upper tiers were provided with different kinds of perches. Perches differed in material and height, each cage contained one type of perch. In Table 4 an overview of the different perches used, is given.

Table 4: Overview of different perch materials and heights

Material	Profile	Height
metal	circular, 27 mm diameter	7 cm 15 cm
wood	rectangular, 5 cm * 2,5 cm	7 cm 15 cm
plastic	mushroom, 4cm wide	7 cm

2.7 Environmental enrichment

During the final laying period cages on the lower tiers were provided with different sorts of enrichment devices. Materials used were a bundle of white cotton strands, a bundle of denim strips, cords to bundle straw and pieces of a pecking block.

2.8 Overview experiments

In Table 5 an overview of all experiments performed during the three laying periods is given.

Table 5: Overview experiments

Technical results	Two breeds	Flock I, II and III
	Two types of cages	Flock I, II and III
Nesting materials		Flock I and II
Abrasives		Flock I, II and III
Dust bathing behaviour		Flock II and III
Perching behaviour		Flock III
Environmental enrichment		Flock III

3 RECORDS / COLLECTION OF DATA

3.1 Production records

Recorded daily:

- mortality per cage
- water consumption per tier.
- egg production per tier was also recorded daily, including total number of eggs, total egg mass, number of first and second choice eggs (with annotation of dirty and dented eggs) as well as the number of broken and not commercial eggs.

Recorded weekly:

- food consumption per tier
- average weight of the birds per tier by weighing 30 birds per tier (10 birds of 3 randomly chosen cages), from age of 34 weeks average weight was determined every two weeks

Three times during laying period

- intensive egg quality research; interior as well as exterior quality is measured and defined. Therefore 60 eggs per tier are collected, totalling 720 eggs, and weighed. The following shell parameters were noted: dirt, cracks, pinholes. The thickness of the shell was also measured on three places (middle, sharp end and blunt end). The interior quality was assessed by the thickness of the egg-white and the presence of blood spots. Colour of the egg yolk was also determined using the Yolk Colour Fan from Roche®. This intensive quality research took place on 28, 40 and 60 weeks of age during the first flock; on 31, 41and 60 weeks during the second flock. During the third flock, the birds were 29, 40 and 61 weeks old.

Recorded several times during laying period, according to experiment:

- eggs were collected per cage and sorted out in the same way as when collected on a daily basis (first class, second class (dirty, dented), broken). In addition, these eggs were inspected with a candling lamp and further differentiation was made (type of dirt, positions of dents).

3.2 Feather condition and claw length

In order to compare the feather condition, plumage of ten birds per cage was evaluated according to the method of Tauson et al. (1984).
Five body areas (neck, breast, back, wings and tail) were scored from 4 to 1, where 4 meant very good plumage and 1 very poor plumage with almost naked areas.
Together with the plumage condition, the length of the claws of the middle front digits (right and left, average length was then determined), measured along the curve.
During the first laying period these measurements were carried out on the second tiers (totalling 400 birds) and at 27, 42 and 67 weeks of age. During the second flock the same tiers were measured at 21, 36, 51 and 66 weeks. During the third laying period claw lengths were measured on the second tiers where as feather scores were assessed for every tier (totalling 4,800 birds). This took place at 21, 37, 51 and 67 weeks of age.

3.3 Dust bathing behaviour

During the second and the third laying period half of the litter boxes on one tier were replaced by scratching mats. In order to compare dust bathing in the litter box and on the scratching mat, direct observations were carried out by two observers who each viewed a number of (the same) cages.
At about 13.45h the observer took position in front of the cage so he or she could have a good view of the bathing facility and waited for about fifteen minutes to allow the birds to settle. After the scratching material was provided at 14.00h, during one hour and a half every dust bath taken by a hen was recorded as well as its duration and reason for ending. During the last hour the occupation (number of hens present) of the scratching facility was registered every five minutes as well as the number of birds dust bathing at that time.
During the second period every observer looked at twelve cages once, during the third period every observer watched sixteen cages and this was repeated twice during the period (total of 32 observations per observer). Before the start of the third laying period the perches in front of the litter boxes were removed in order to avoid eggs being laid in the boxes and in order to diminish manure droppings in the boxes.

3.4 Perching behaviour

During the third laying period the use of different perches was analysed. Therefore observations took place approximately one hour after dimming the lights. The number of birds on the perches was counted, as well as the number of birds in the nests and dust bathing facilities. Taking into account the mortality in the cages, the percentage of hens present on perches, in nests or litter boxes was calculated.

3.5 Health records

All dead and culled birds were autopsied to find the cause of death. Possible remarks are the following:
deformation of sternum, tarsal fracture, bruised ribs, E. Coli, liver corrosion, infection of oviducts, cannibalism, very skinny birds and other unknown indications.

4 STATISTICS

Statistical analyses were performed using the General Linear Models of statistical analysis program SPSS 12.0 (Lead Technologies Inc.) for Windows. In order to find possible differences variance analyses (α = 0,005) and Duncan's post hoc difference test was used.

5 RESULTS

5.1 Production and technical results

5.1.1 Mortality

In Tables 6 to 8, mortality rate is given per flock and per tier and strain.

1. First laying period

During the first period mortality was the highest on the second tier, especially in the cages with feeding pans. In Figure 6 the number of dead birds is given per cage and it is clear that there were large differences between the cages. In some cages none or just one or two birds died while in other cages more than half of the birds died. These cages with high mortality were mostly situated on the second tier. These high rates were due to cannibalism as the cages on the second tiers received a lot of direct light.
Due to these findings an adjustment of the lighting became necessary in order to optimise the light distribution.

Table 6: Mortality rate during flock I given per tier, feeding system and strain

	FT			FP		
	Bovans Goldline	Hisex Brown	Average rate	Bovans Goldline	Hisex Brown	Average rate
upper tier	11,8 %	6,7 %	9,2 %	12,8 %	7,2 %	10,0 %
middle tier	13,8 %	4,9 %	9,4 %	23,7 %	12,6 %	18,1 %
lower tier	10,0 %	6,4 %	8,2 %	5,8 %	7,7 %	6,7 %
average rate	11,9 %	6,0 %	8,9 %	14,1 %	9,1 %	11,6 %

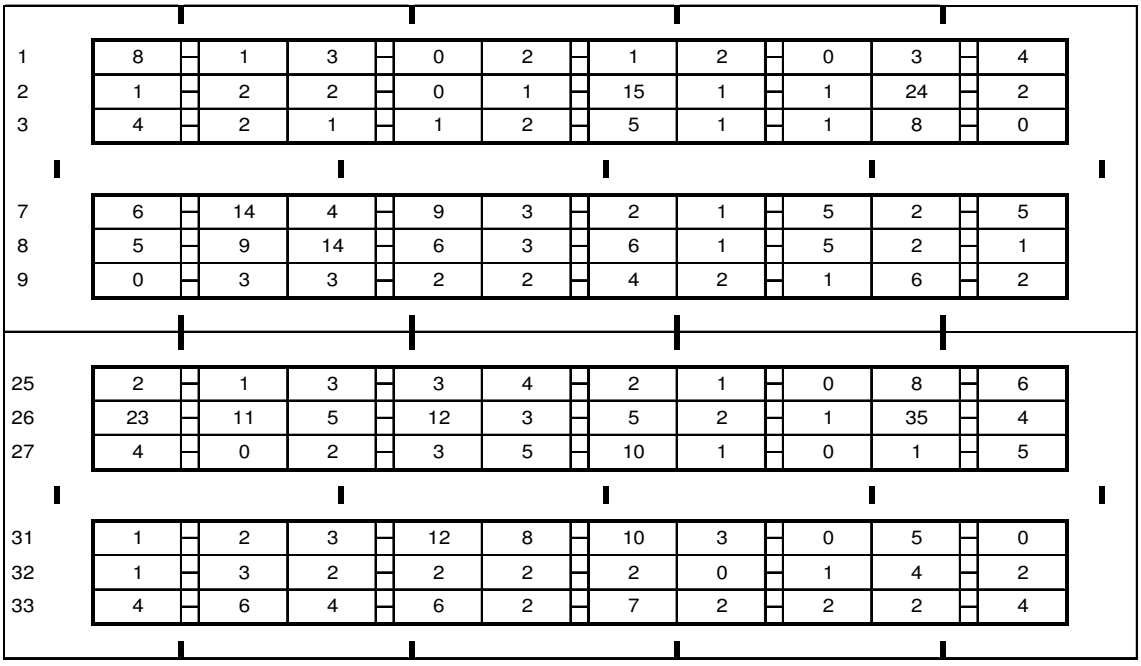

Figure 6: Number of dead hens per cage at the end of first laying period

2. Second laying period

By adjusting the light in the compartments, mortality rate on the second tier was highly reduced during the second flock (Table 7). As shown in Figure 7 mortality was particularly high in four cages which were all cages provided with feeding pans and Hisex Brown hens. This high rate was due to some technical problems with water and feed supply on the tiers concerned.
Most likely this provoked stress in some cages and with that cannibalism started, in the other cages mortality rate was limited to a few birds.

Table 7: Mortality rate during flock II given per tier, feeding system and strain

	FT			FP		
	Bovans Goldline	Hisex Brown	Average rate	Bovans Goldline	Hisex Brown	Average rate
upper tier	4,6 %	6,2 %	5,4 %	4,4 %	16,5 %	10,5 %
middle tier	2,1 %	3,6 %	2,8 %	5,6 %	12,6 %	9,1 %
lower tier	2,3 %	2,3 %	2,3 %	4,2 %	6,5 %	5,4 %
average rate	3,0 %	4,0 %	3,5 %	4,7 %	11,9 %	8,3 %

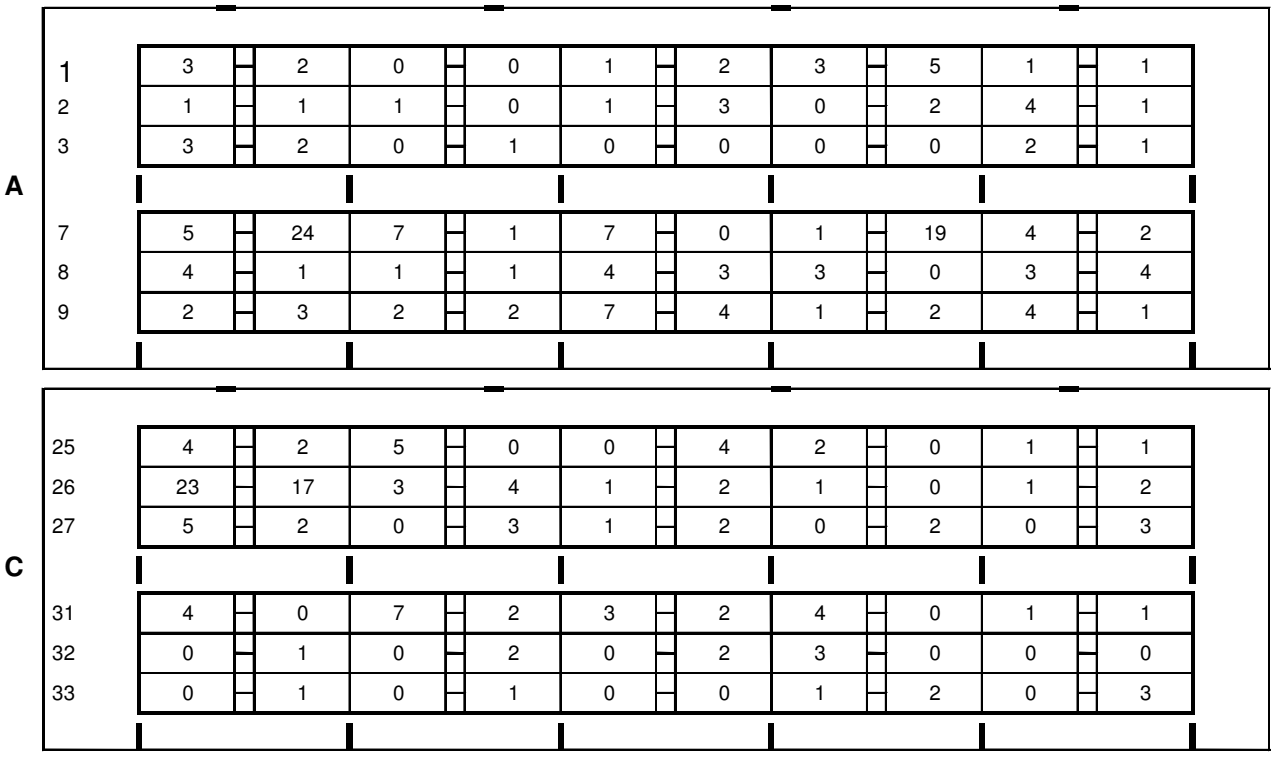

Figure 7: Total number of dead hens per cage at end second laying period

3. Third laying period

During the third laying period, cages with high mortality were mostly situated on the highest tiers (as shown in Table 8 and Figure 8). Cannibalism was once again partially responsible for the mortality rates. Probably this was induced due to the stronger invasion of direct light on the higher levels.
After autopsy of the dead birds it was also discovered that a lot of birds suffered liver corrosion.

Table 8: Mortality rate during flock III, given per tier, feeding system and strain

	FT			FP		
	Bovans Goldline	Isa Brown	Average rate	Bovans Goldline	Isa Brown	Average rate
upper tier	16,7 %	20,3 %	18,5 %	18,8 %	16,5 %	17,7 %
middle tier	6,9 %	5,9 %	6,4 %	5,1 %	5,1 %	5,1 %
lower tier	3,6 %	5,1 %	4,4 %	3,0 %	11,6 %	7,3 %
average rate	9,1 %	10,4 %	9,75 %	9,0 %	11,1 %	8,3 %

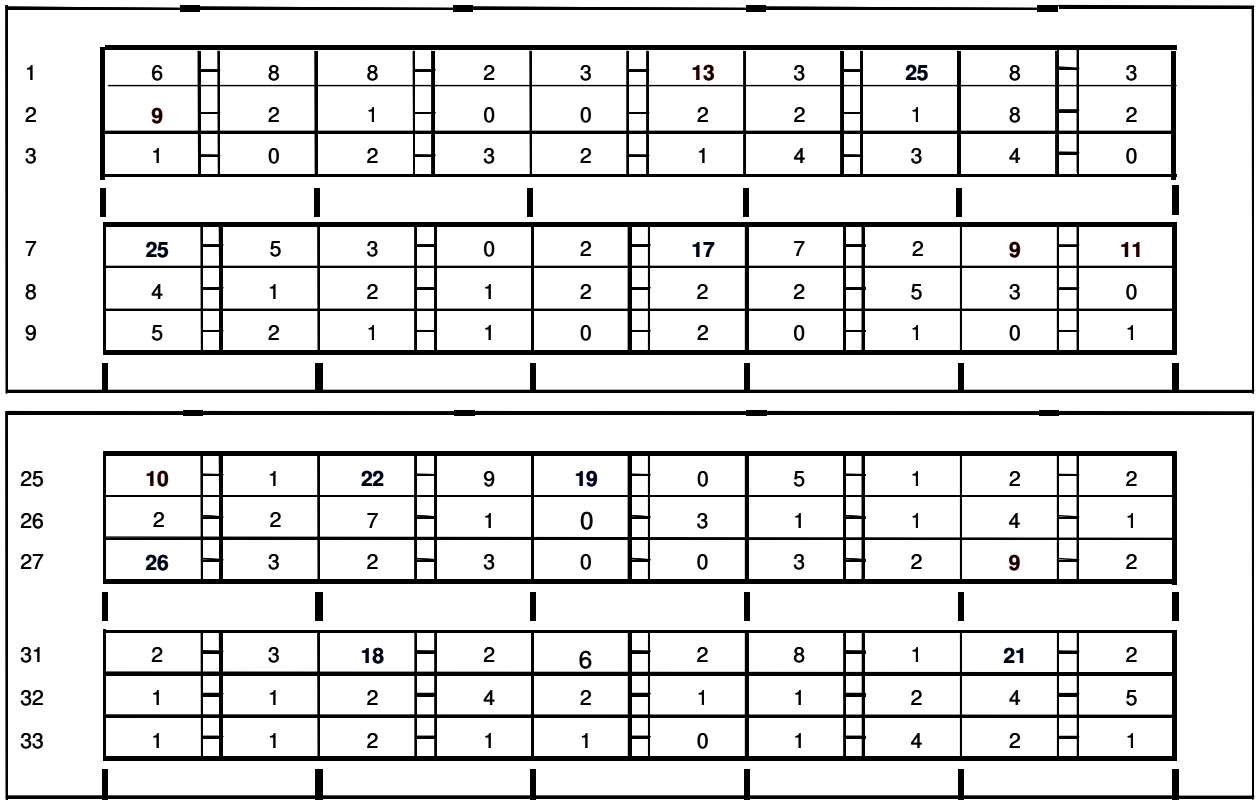

Figure 8: Total number of dead hens per cage at end of third laying period

5.1.2 Technical results

5.1.2.1 Comparing two strains of hen

1. First laying period

In Table 9 the technical results are given for both strains used. Only feed consumption was significantly different, Bovans Goldline consumed significantly more food than Hisex Brown.
Furthermore there was a tendency to a higher water consumption by Bovans Goldline and because of that, water / feed proportion was higher for Bovans Goldline.

Table 9: Technical results (week 18-70) for the strains used in first laying period

	Bovans Goldline	Hisex Brown	Significance
total mortality	13,4	7,8	0,421
% 2nd grade eggs	8,6	8,2	0,635
% broken eggs	2,9	2,5	0,754
% dirty eggs	6,1	5,9	0,578
laying % per hen present	85,3	86,9	0,538
egg weight (g)	62,4	62,2	0,846
egg mass (kg per hen present)	19,49	19,82	0,416
live weight (g)	1968	1998	0,533
water consumption (ml per hen present per day)	212,0	204,1	0,054
feed consumption (g per hen present per day)	121,1	120,4	**0,027**
water / feed proportion	1,75	1,70	0,074
feed conversion	2,24	2,18	0,324

2. Second laying period

During the second laying period more differences between the used strains were noticed. Due to the high mortality in four cages which were all stocked with the strain Hisex Brown, as mentioned above, mortality rate was significantly higher for this strain. In order to make a better comparison, the mortality rate was calculated by leaving out those four cages. Those results did not show a significant difference between both strains used.
Average egg weight was higher for the Bovans Goldline strain as well as feed and water intake.

Table 10: Technical results(week 18-70) for the strains used in second laying period

	Bovans Goldline	Hisex Brown	Significance
total mortality	3,9	8,0	**0,034**
corrected mortality (*)	4,7	3,8	0,321
% 2nd grade eggs	6,6	7,0	0,618
% broken eggs	2,1	1,7	0,540
% dirty eggs	4,7	5,3	0,122
laying % per hen present	84,8	85,5	0,500
egg weight (g)	62,8	61,3	**0,007**
egg mass (kg per hen present)	19,59	19,32	0,249
live weight (g)	1994	1975	0,736
water consumption (ml per hen present per day)	203,4	189,2	**0,010**
feed consumption (g per hen present per day)	114,6	111,9	**0,010**
water / feed proportion	1,78	1,69	**0,010**
feed conversion	2,10	2,07	0,119

* mortality rate without the four cages with extreme mortality

3. Third laying period

During the third laying period birds from the strain Hisex Brown were not available and thus the Isa Brown strain was used and compared with Bovans Goldline.
Regarding the mortality rate no difference was noticed between the two strains used. Also no significant differences were noted for the other technical results.
A mild trend was noticed towards a lower laying percentage and a lower egg mass for the Isa Brown strain in comparison with Bovans Goldline.

Table 11: Technical results (week 18-70) for both strains used in third laying period

	Bovans Goldline	Isa Brown	Significance
total mortality	8,3	9,4	0,818
% 2nd grade eggs	6,1	6,3	0,704
% broken eggs	2,2	2,3	0,699
% dirty eggs	4,1	3,5	0,175
laying % per hen present	87,3	84,4	0,241
egg weight (g)	63,0	62,5	0,180
egg mass (kg per hen present)	20,58	19,72	0,215
live weight (g)	1932,1	1966,2	0,277
water consumption (ml per hen present per day)	212,2	210,5	0,694
feed consumption (g per hen present per day)	120,0	118,5	0,194
water / feed proportion	1,77	1,78	0,800
feed conversion	2,09	2,13	0,380

5.1.2.2 Comparing two types of cages

1. First laying period

In the beginning of the first laying period there were some problems with the correct distribution of the feed in the feeding pans. This meant that not every pan received the same amount of food. By some adjustments to the feeding system the distribution was improved but these problems had their influence on the technical results of this type of cage. Furthermore it was established that birds scratching in the feeding pans caused food to spill onto the manure belt. Trough more accurate directing of the feed amounts, an attempt was made to reduce this spillage but feed intake still remained higher in cages with feeding pans. Therefore feed conversion was significantly higher in these cages than in the cages provided with a feed trough.
During the first period a higher percentage of dirty eggs in cages with feeding pans was noted. Furthermore there was a trend to a higher percentage of second grade eggs in these cages.

Table 12: Technical results from week 18-70 for the two feeding systems used, first laying period

	Feed trough (FT)	Feeding pans (FP)	Significance
total mortality	8,7	12,5	0,554
% 2nd grade eggs	7,8	9,0	0,071
% broken eggs	2,6	2,7	0,555
% dirty eggs	5,4	6,7	**0,005**
laying % per hen present	87,2	85,0	0,869
egg weight (g)	62,2	62,3	0,647
egg mass (kg per hen present)	53,65	52,31	0,297
live weight (g)	1958	2009	0,199
water consumption (ml per hen present per day)	212,2	203,9	0,136
feed consumption (g per hen present per day)	117,9	123,7	0,109
water / feed proportion	1,80	1,65	0,127
feed conversion	2,13	2,29	**0,042**

2. Second laying period

During the second laying period there was a significant difference in mortality between both cage types. This was due to the four cages with extreme mortality rates which all happened to be cages with feeding pans and this influenced the final results. In order to make a better comparison, the mortality rate was again calculated by leaving those cages out. These results did not show a significant difference in mortality rate between both cage types.
The trend to a higher percentage of second grade eggs in cages with feeding pans was confirmed in the second period. This time the difference in percentage of dirty eggs was not significant but a similar trend was noticeable.
Furthermore it seemed that the birds still spilled quite some food on the manure belt. This caused a significant higher feed intake in the cages with feeding pans. The water / feed proportion was lower and the feed conversion was higher, though not significant, than in cages with feeding troughs.

Table 13: Technical results from week 18-70 for feeding systems, second laying period

	Feed trough (FT)	Feeding pans (FP)	Significance
total mortality (%)	3,3	8,5	**0,017**
corrected mortality (%)*	3,3	5,2	0,244
% 2nd grade eggs	6,7	6,9	**0,016**
% broken eggs	2,0	1,8	0,173
% dirty eggs	4,8	5,2	0,073
laying % per hen present	86,8	83,6	0,218
egg weight (g)	61,6	62,6	0,191
egg mass (kg per hen present)	19,64	19,27	0,257
live weight (g)	1995	1974	0,352
water consumption (ml per hen present per day)	198,6	194,0	0,164
feed consumption (g per hen present per day)	111,9	114,7	**0,016**
water / feed proportion	1,78	1,69	0,072
feed conversion	2,05	2,12	0,168

* mortality rate without the four cages with extreme mortality

3. Third laying period

In order to get a better feed distribution, the decision was made to provide cages with feeding pans with a circulating feeding system instead of a single current system using end pans. These adjustments were carried out before the start of the third laying period.
The results of that period show very little significant differences between both feeding systems except for the laying percentage, which was higher in the cages provided with feed troughs.
Like the previous laying periods there was a tendency to a higher feed intake in cages with feeding pans. Despite different attempts to diminish the spilling of feed, this spilling continued however in less amounts.
Regarding second grade and dirty eggs no remarkable differences or trends were noticed between both feeding systems.

Table 14: Technical results from week 18-70 for feeding systems, third laying period

	Feed trough (FT)	Feeding pans (FP)	significance
total mortality	8,9	8,8	0,961
% 2nd grade eggs	6,2	6,2	0,990
% broken eggs	2,3	2,2	0,713
% dirty eggs	3,7	3,8	0,717
laying % per hen present	86,9	84,8	**0,025**
egg weight (g)	62,6	62,9	0,551
egg mass (kg per hen present)	20,35	19,96	0,159
live weight (g)	1926,3	1972,0	0,162
water consumption (ml per hen present per day)	213,9	208,8	0,494
feed consumption (g per hen present per day)	118,3	120,2	0,239
water / feed proportion	1,81	1,74	0,412
feed conversion	2,08	2,14	0,310

5.2 Experimental results

5.2.1 Comparison of nesting materials

5.2.1.1 Comparing XPNP® long and a standard mesh wire

During the first flock an artificial nest pad with long bristles was compared with a standard wire mesh in the nests of the upper tiers. This comparison was made by candling the eggs laid in the nests as well as those laid outside the nests, in the cage. In Table 15 the results of the first recording at 23 weeks is given, there was no specification on the kind of dirt on the eggs.

Table 15: Comparing an artificial nest pad with wire mesh, first recording

23 weeks of age	XPNP® long	Wire mesh	significance
Sorting at collection of eggs			
% 1st grade	92,15	85,85	0,129
% dirty eggs	5,31	7,62	0,133
% dented eggs	1,05	5,21	0,089
% broken eggs	0,72	0,55	0,802
Sorting by candling the eggs			
% dirty eggs	24,54	24,41	0,936
% broken eggs	0,74	0,45	0,691
% dented eggs	2,56	7,39	0,068
% eggs with line cracks	1,37	3,24	**0,003**
% eggs with star cracks	0,69	0,74	0,884

Though there is only a significant difference between the nesting materials with regard to the percentage of eggs with hair cracks, some trends are visible. Wire mesh as a nesting material tends to give more dented eggs which was noticed at sorting as well as at candling the eggs. Because of the high numbers of dirty eggs, the decision was made to specify the kind of dirt during following candling.
In Table 16 the results from 5 measurements (at week 35, 42, 49, 57, 65 weeks of age) are given, again all eggs were candled and this time there was a distinction made between several kinds of dirt.

Table 16: Comparison of an artificial nest pad and wire mesh, second recording

35-65 weeks of age	XPNP® long	Wire mesh	significance
Sorting at collection of eggs			
% 1st grade	90,41	88,58	0,413
% dirty eggs	5,59	5,60	0,991
% dented eggs	1,80	4,00	0,133
% broken eggs	1,08	1,29	0,563
Sorting by candling the eggs			
% eggs with droppings or blood	10,52	10,14	0,808
% eggs with egg white or yolk	2,42	4,78	**0,038**
% eggs with dust	1,44	2,96	0,118
% eggs with feathers	8,27	3,96	0,061
% broken eggs	1,29	1,31	0,973
% dented eggs	2,53	5,76	0,061
% eggs with line cracks	4,65	5,33	0,394
% eggs with star cracks	2,34	2,75	0,560

The percentage of eggs contaminated with egg white or yolk is significantly higher in the cages with wire which could be explained by the slightly higher (though not significantly) number of broken eggs.
A trend to a higher percentage of dented eggs when using a mesh wire is also noticed. A possible explanation is the fact that these eggs roll away towards the egg belt at a higher speed, which makes the chance of cracking higher.
Due to the fact that small feathers easily get stuck in the nesting pad, the number of eggs with feathers tends to be higher in the nests with XPNP® long.

Table 17: Percentage of eggs laid outside the nests

XPNP long	Wire mesh	significance
10,32 %	28,80 %	0,097

Table 18: Percentage of eggs laid outside the nests, specified per cage type

	XPNP long	Wire mesh	significance
Feed trough (FT)	11,41	30,29	**0,000**
Feeding pans (FP)	9,22	27,30	**0,000**
	0,426	0,901	

Table 19: Percentage of eggs laid outside the nests, specified per strain used

	XPNP long	Wire mesh	significance
Bovans Goldline	9,45	19,28	**0,000**
Hisex Brown	11,18	38,31	**0,000**
	0,104	**0,000**	

Tables 17 to 19 represent the percentage of eggs laid outside the nesting areas and indicates the preference of the hens for the nesting materials used. A comparison between cages with feeding trough and feeding pans was made as well as a comparison of the strains used.
The number of eggs laid in the cage (thus on the wire mesh bottom) was higher in the cages with wire mesh in the nests though turned out to be not significant. Birds seemed to prefer the nesting pad to lay their eggs on.
A difference between the two breeds was noticed in the cages with only a wire in the nests. There it seemed that the Hisex Brown had an higher intention of laying on the cage floor and not in the nests.

5.2.1.2 Comparing three artificial nest pads

On the lower tiers three different nesting pads were used during the first flock. All three materials were produced by Astroturf®.
There were not many differences observed between the three materials used. The new XPNP models also had a significantly higher number of eggs with hair cracks but a possible reason for this is not known.
The number of eggs with feathers tends to be higher in the cages provided with HPNP mats, since the feathers got stuck very easy.

Table 20: Comparison of three artificial nest pads

	HPNP	XPNP long	XPNP short	significance
Sorting at collection of eggs				
% 1st grade	92,62	89,42	92,12	0,319
% dirty eggs	4,11	6,60	4,59	0,294
% dented eggs	1,31	1,42	1,63	0,758
% broken eggs	1,08	1,53	1,06	0,465
Sorting by candling the eggs				
% eggs with droppings or blood	7,09	9,93	8,66	0,265
% eggs with egg white or yolk	4,01	4,69	1,95	0,514
% eggs with dust	4,95	4,26	3,65	0,236
% eggs with feathers	9,30 b	6,85 a	5,69 a	0,056
% broken eggs	1,26	1,43	1,05	0,649
% dented eggs	2,44	3,43	2,90	0,108
% eggs with line cracks	3,74 a	6,04 b	4,77 a,b	**0,043**
% eggs with star cracks	1,34	2,18	1,60	0,318

Table 21: percentage off eggs laid outside the nests

HPNP	XPNP long	XPNP short	significance
7,64 %	7,74 %	9,57 %	0,106

Table 22: percentage of eggs laid outside the nests, specified per cage type

	HPNP	XPNP long	XPNP short	significance
Feed trough (FT)	9,70	10,54	12,25	0,055
Feeding pans (FP)	5,59 a,b	4,94 a	6,88 b	**0,020**
	0,000	**0,000**	**0,000**	

Table 23: percentage of eggs laid outside the nests, specified per strain used

	HPNP	XPNP long	XPNP short	significance
Bovans Goldline	5,59 a	6,43 a,b	8,40 b	**0,013**
Hisex Brown	9,70	9,05	10,73	0,128
	0,000	**0,011**	**0,020**	

Tables 21 to 23 represent the percentages of cage eggs, comparing nesting materials, cage design and breeds.
It appeared that the hens preferred the mats with longer bristles (HPNP, XPNP long) as the number of cage eggs was slightly higher in the cages with XPNP short, while the other materials showed similar results.
The cages with linear feed troughs had a substantially higher number of eggs outside the nests and again Hisex Brown had the tendency to lay more eggs outside the nests in comparison with Bovans Goldline.

5.2.1.3 Comparing two models of nesting pads and a mesh wire

During the second flock the two new XPNP models were tested and compared with a standard wire mesh in the nests. In Table 24 the results of collecting and candling the eggs are given.
A significant difference was noticed concerning the eggs with feathers. As expected the number with feathers is highest in cages with XPNP long since feathers got more easily stuck in long bristles. The number of eggs with feathers is substantially lower in cages with XPNP short and even less in cages with wire-floor nests.
The trend for higher number of eggs contaminated with manure or blood can also be explained by the longer bristles which hold excretions more easily.
There was a tendency to a higher number of dented eggs in the cages with wire-floor nests, again probably explainable by the higher speed of the eggs when rolling towards the egg belt.

Table 24: Comparison of two artificial nest pads and a wire mesh

	XPNP long	XPNP short	Wire mesh	significance
Sorting at collection of eggs				
% 1st grade	93,08	92,88	89,54	0,330
% dirty eggs	3,83	3,54	4,79	0,117
% dented eggs	1,01	0,77	3,40	0,112
% broken eggs	0,54	0,70	1,34	0,368
Sorting by candling the eggs				
% eggs with droppings or blood	8,14	6,17	6,91	0,074
% eggs with egg white or yolk	1,68	0,53	1,30	0,233
% eggs with dust	1,23	1,33	1,74	0,202
% eggs with feathers	8,29 c	5,66 b	1,70 a	**0,027**
% broken eggs	0,61	0,64	1,11	0,346
% dented eggs	1,18	0,83	6,30	0,054
% eggs with line cracks	2,43	2,02	3,78	0,196
% eggs with star cracks	0,83	1,50	2,00	0,256

Table 25: Percentage of eggs laid outside the nest, per nesting material

XPNP long	XPNP short	Wire mesh	significance
4,63 % a	7,82 % a	23,32 % b	**0,010**

Table 26: Percentage of eggs laid outside the nests, specified per cage type

	XPNP long	XPNP short	Wire mesh	significance
feed trough (FT)	4,55 a	6,80 a	22,21 b	**0,000**
feeding pans (FP)	4,71 a	8,84 b	24,44 c	**0,000**
	0,887	0,345	0,412	

Table 27: Percentage of eggs laid outside the nests, specified per strain used

	XPNP long	XPNP short	Wire mesh	significance
Bovans Goldline	4,06 a	3,83 a	16,66 b	**0,020**
Hisex Brown	5,20 a	11,80 b	29,99 c	**0,025**
	0,318	**0,000**	**0,000**	

As shown in Tables 25 to 27, the percentage of eggs laid outside the nests was the highest in cages provided with a standard wire mesh as nesting material. There was also a tendency towards more cage eggs when nests were provided with short bristle nesting pads, although this was not significant.
No significant differences were noticed when comparing the two cage models used.
The number of mislaid eggs however, was significantly higher for the breed Hisex Brown with exception to the cages provided with a long bristle nesting pad. Hisex Brown seemed to be more selective about the nesting material, since there was not only a significant difference between wire mesh and nesting pads, but they obviously also preferred to lay their eggs on the XPNP model with the longest bristles.

5.2.2 Abrasives

1. First laying period

The claw lengths measured during the first flock are given in Table 28 for the cages with feed trough (FT) and in Table 29 for cages with feeding pans (FP). Significant differences between the abrasives used are given horizontally by a, b, c, d; significant changes with age are given vertically by w, x, y, z.
At every age, claws of hens were significantly shorter ($p < 0.05$) in cages provided with abrasives.
In cages with FT and at 67 weeks of age, the claws were reduced the most with 3M fine tape (12,1 mm) and rough (11,8 mm). The lowest reduction in claw length was still 5,3 mm when using 6 Norton ceramic plates. It was also noticed that the effect of age was not significant in the cages provided with abrasives, thus length of claws did not change with age.
In cages provided with FP the highest reduction at 67 weeks was provided by 3M fine tape (11,4 mm) and rough (11,1 mm), followed by Norton plates on a wooden construction (10,9 mm) and 10 Norton ceramic plates (still a reduction of 8,2 mm). Except for the cages with 10 ceramic plates, claw length was significantly different with age, moreover a significant decrease in claw length over time was noticed for most abrasives used.

Table 28: Claw length at different ages in cages with feed trough, first flock

cage type FT	age in weeks	reference	3Mf	3Mr	N10	N6	significance
claw length (mm)	27 w	21,0 d,x	13,0 a	13,2 a	17,5 b	18,8 c	**0,000**
	42 w	25,0 d,y	12,6 a	13,6 a	17,2 b	19,5 c	**0,000**
	67 w	25,0 d,y	12,9 a	13,2 a	17,0 b	19,7 c	**0,000**
	significance	**0,000**	0,444	0,645	0,733	0,441	

Table 29: Claw length at different ages in cages with feeding pans, first flock

cage type FP	age in weeks	reference	3Mf	3Mr	N10	Nwc	significance
claw length (mm)	27 w	20,8 d,x	13,8 a,x,y	15,5 b,y	18,5 c		**0,000**
	42 w	24,3 d,y	13,3 a,x	13,7 a,x	18,5 b	18,9 b,y	**0,000**
	67 w	25,9 d,y	14,5 a,y	14,8 a,y	17,7 b	15,0 a,x	**0,000**
	significance	**0,000**	**0,004**	**0,001**	0,454	**0,000**	

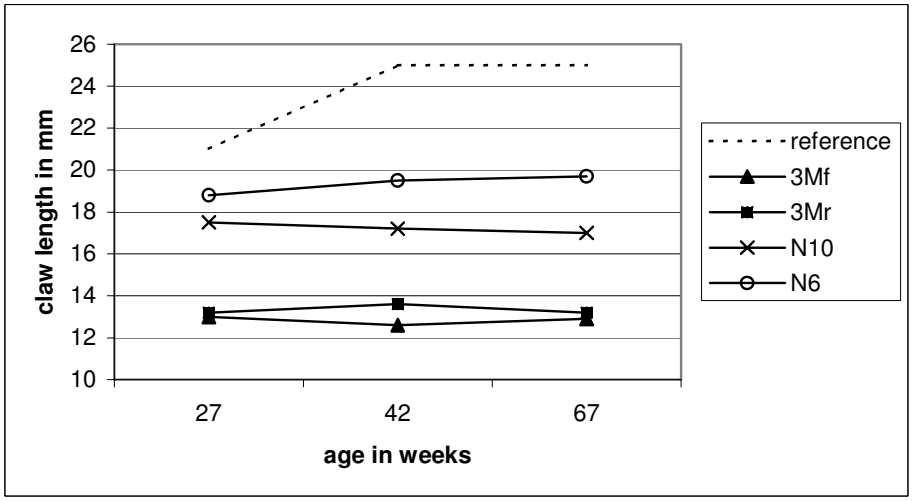

Figure 9: Mean claw length per age for cages with FT, first flock

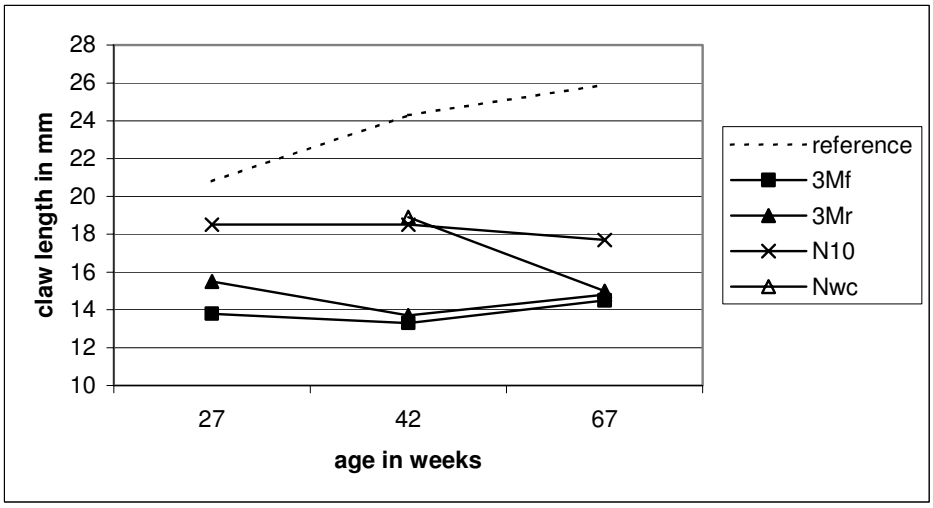

Figure 10: Mean claw length per age for cages with FP, first flock

2. Second laying period

In the second flock abrasives were changed in FT cages but in order to examine durability, they were not replaced in cages with FP. Results are shown in Tables 30 and 31.
In cages with FT the claws were significantly shorter from 36 weeks of age in cages with abrasives. The highest reduction (13,6 mm) was achieved with 3M rough tape, followed by the perforated egg baffles (5,7 mm for P2 and 4,7 mm for P1) and 4 Norton plates (3,1 mm). Age effect was significant for every abrasive used and claws increased significantly with time. When comparing to the results of the first flock, it seems that the new materials used are less effective since the claw length at the end was obviously longer.
In cages with FP, claws were significantly shorter at every age. Best results were obtained with 3M fine (11,2 mm) and Norton plates on a wooden construction (10,9 mm). Compared with the first laying period, claws of hens were longer overall. The abrasives still kept the claws shorter than in reference cages. 3M rough tape though seemed to wear down faster than the other materials used.

Table 30: Claw length at different ages in cages with feed trough, second flock

cage type FT	age in weeks	reference	3Mr	N4	P1	P2	significance
claw length (mm)	21 w	18,0 c,w	13,3 a,x	17,8 c,w	15,8 b,w	15,4 b,w	**0,000**
	36 w	21,5 d,x	12,7 a,w	19,3 c,x	17,3 b,x	16,6 b,w	**0,000**
	51 w	25,2 d,y	12,8 a,w	21,9 c,y	19,3 b,y	18,7 b,x	**0,000**
	66 w	27,4 d,z	13,8 a,y	24,3 c,z	22,7 b,z	21,7 b,y	**0,000**
	significance	**0,000**	**0,000**	**0,000**	**0,000**	**0,000**	

Table 31: Claw lengths at different ages in cages with feeding pans, second flock

cage type FP	age in weeks	reference	3Mf	3Mr	N10	Nwc	significance
claw length (mm)	21 w	19,2 d,w	15,4 a,x	17,8 b,c,x	18,3 c,x	17,3 b,x	**0,000**
	36 w	23,5 d,x	15,1 a,x	17,0 b,x	19,5 c,x,y	16,6 b,x	**0,000**
	51 w	25,9 d,y	16,9 a,b,y	18,8 b,c,x	20,2 c,x,y	16,3 a,x	**0,000**
	66 w	29,9 c,z	18,7 a,z	21,1 b,y	20,6 a,b,y	19,0 a,b,y	**0,000**
	significance	**0,000**	**0,000**	**0,000**	0,101	**0,001**	

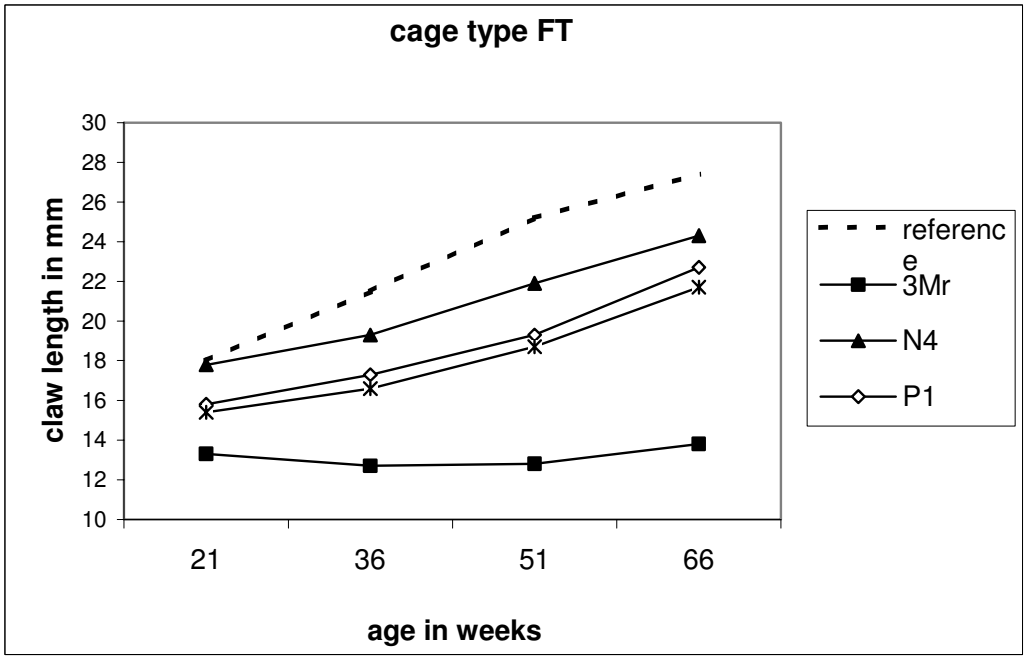

Figure 11: Mean claw length per age for cages with FT, second flock

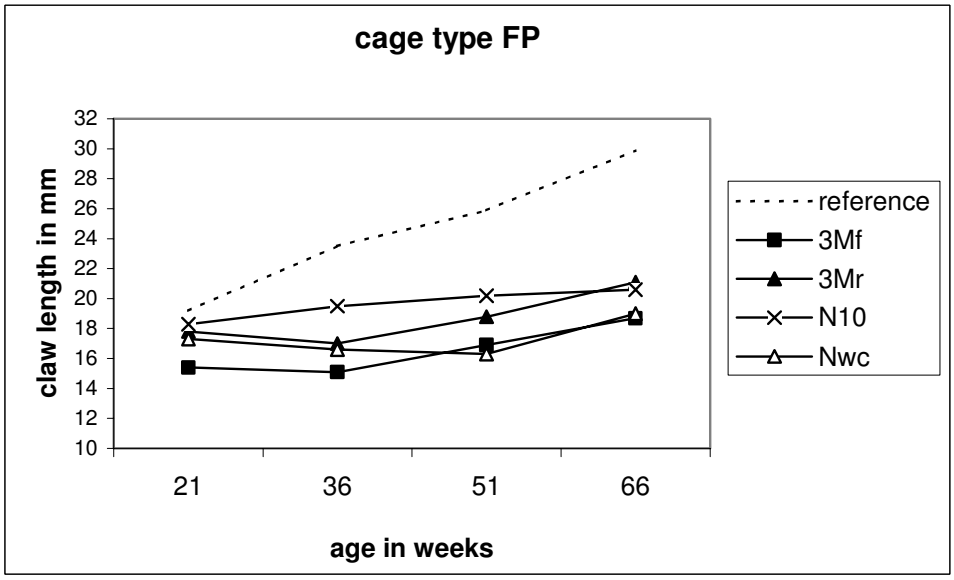

Figure 12: Mean claw length per age for cages with FP, second flock

3. Third laying period

The scratching materials used in the third laying period were the same as those used in the second laying period. No replacements were carried out in order to judge the durability of the materials. In the cages with FP, the wooden construction was left out because of sanitary reasons (contained a lot of manure). Results are given in Tables 32 and 33.
In cages with FT the claws were all significantly shorter in cages with abrasives from 37 weeks of age. The highest reduction in claw length was noticed in the cages with 3M rough tape (13 mm). The cages with 4 Norton plates showed a reduction of 4,1 mm while in cages with perforated egg baffles the results were comparable (3,9 mm for P2 and 3,6 mm for P1). When compared with the results of the previous laying period, the materials seem to be as effective since the claw lengths at the end are comparable.
In the cages with FP the claws also were shorter in cages with abrasives as from an age of 37 weeks. The highest reduction was measured in cages with 10 Norton plates (6,6 mm), followed by the cages provided with 3M tape rough and fine (3,9 mm and 3,6 mm respectively). When the results are compared to those of the second flock it seems that the 3M tape fine was less effective during this third flock. After three batches all materials still keep the claws shorter than those from animals in cages with no abrasives.

Table 32: Claw length at different ages in cages with feed trough, third flock

cage type FT	age in weeks	reference	3Mr	N4	P1	P2	significance
	21 w	18,1 d,x	14,4 a,y	17,6 d,x	16,2 c,x	15,3 b,x	**0,000**
claw length	37 w	22,6 d,y	13,4 a,x	20,9 c,y	18,0 b,y	17,4 b,y	**0,000**
(mm)	51 w	26,7 c,z	13,8 a,x,y	22,4 b,y	21,5 b,z	21,0 b,z	**0,000**
	67 w	26,3 c,z	13,3 a,x	22,1 b,y	22,7 b,z	22,4 b,z	**0,000**
	significance	**0,000**	**0,000**	**0,000**	**0,000**	**0,000**	

Table 33: Claw lengths at different ages in cages with feeding pans, third flock

cage type FP	age in weeks	reference	3Mf	3Mr	N10	significance
	21 w	18,2 x	17,2 x	17,7 x	17,7 x	**0,137**
claw length	37 w	22,9 c,y	17,8 a,x	20,3 b,y	18,7 a,x	**0,000**
(mm)	51 w	25,2 b,z	20,5 a,y	21,3 a,y	20,9 a,y	**0,000**
	67 w	25,5 c,z	21,6 b,y	21,9 b,y	18,9 a,x	**0,000**
	significance	**0,000**	**0,000**	**0,000**	0,101	

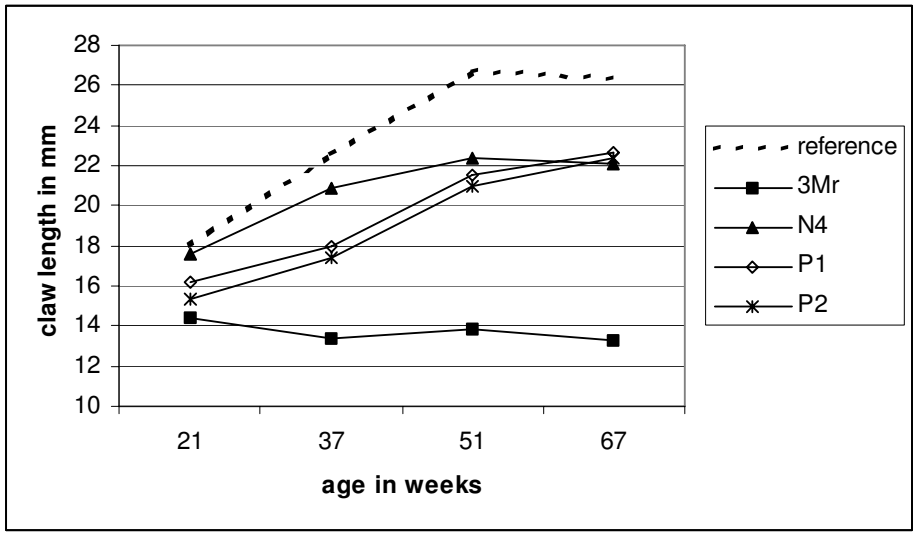

Figure 13: Mean claw length per age for cages with FT, third flock

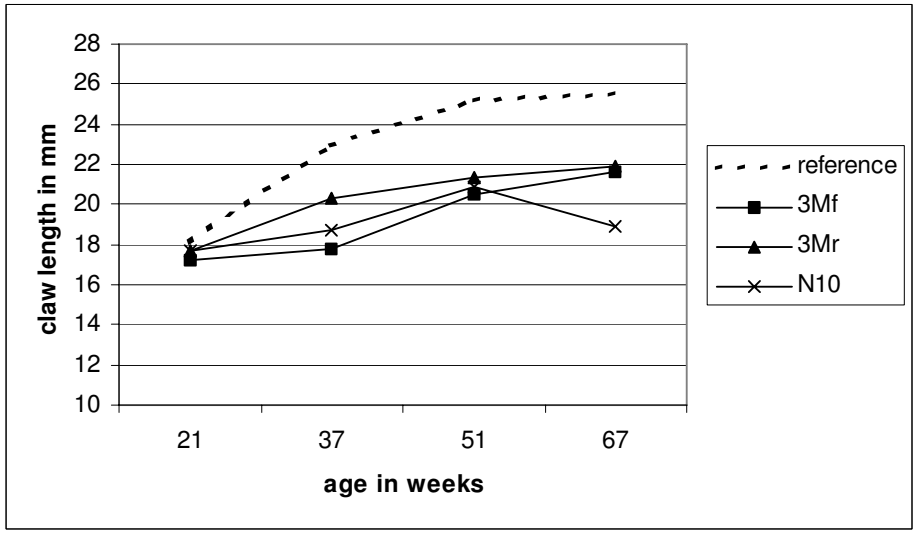

Figure 14: Mean claw length per age for cages with FP, third flock

5.2.3 Plumage condition

A comparison in plumage condition was made between the two strains used, as well as between both cage types.

1. First laying period

In Table 34 the overall feather condition (sum of scores different body parts) of the two types of cages is compared. It seems that feeding pans start a little better than feed troughs but at 67 weeks of age, hens in cages with feed troughs have significantly better plumage condition.

Table 34: Overall feather score, comparing cage types, first flock

	age	feed trough	feeding pans	significance
overall	27 w	18,8	18,9	0,151
feather	42 w	11,7	11,7	1,000
score	67 w	8,3	7,2	**0,000**
	significance	**0,000**	**0,000**	

In order to check the influence of the strain on the plumage condition, the results for cages with FT are given in Table 35, the results for cages with FP in Table 36.
In cages with FT Hisex Brown started off with a significantly better plumage condition but from 42 weeks of age, Bovans Goldline has a smaller plumage deterioration. In cages with FP the opposite tendency is noticeable. Here Bovans Goldline had a better plumage condition at 27 weeks but afterwards it decreased faster than the plumage condition of Hisex Brown. At 67 weeks the difference between Bovans and Hisex is no longer significant.

Table 35: Overall feather score of hens in cages with FT, first flock

Cage type FT	age	Bovans goldline	Hisex brown	significance
overall	27 w	18,7	18,9	**0,042**
feather	42 w	12,0	11,3	**0,000**
score	67 w	9,2	7,4	**0,000**
	significance	**0,000**	**0,000**	

Table 36: Overall feather score of hens in cages with FP, first flock

Cage type FP	age	Bovans goldline	Hisex brown	significance
overall	27 w	19,2	18,6	**0,000**
feather	42 w	11,4	11,9	**0,004**
score	67 w	7,0	7,5	0,109
	significance	**0,000**	**0,000**	

2. Second laying period

The feather scores measured during the second flock are given in Tables 37 and 38. In cages with feed troughs no difference in plumage condition was noticed between the two strains used. In the cages with the feeding pans the feather scores are lower for the strain Hisex Brown. This could suggest the strain had more problems with feather pecking.

Table 37: Overall feather score of hens in cages with FT, second flock

Cage type FT	age	Bovans goldline	Hisex brown	significance
overall feather score	21 w	20,0	20,0	1,000
	36 w	19,6	19,4	0,305
	51 w	12,8	12,0	0,101
	66 w	9,8	9,7	0,738
	significance	**0,000**	**0,000**	

Table 38: Overall feather score of hens in cages with FP, second flock

Cage type FP	age	Bovans goldline	Hisex brown	significance
overall feather score	21 w	20,0	20,0	1,000
	36 w	19,5	18,1	**0,000**
	51 w	15,0	8,6	**0,000**
	66 w	11,2	7,0	**0,000**
	significance	**0,000**	**0,000**	

3. Third laying period

During the third laying period the strain Hisex Brown was replaced with Isa Brown due to difficulties of ordering the animals.
In Table 39 the results from the cages with feed troughs are given. The strain Isa brown had better scoring than the strain Bovans Goldline. In cages with feeding pans the same results showed (Table 40) and Isa Brown had better plumage condition throughout the laying period.

Table 39: Overall feather score of hens in cages with FT, third flock

Cage type FT	age	Bovans goldline	Isa brown	significance
overall feather score	21 w	20,0	20,0	0,157
	37 w	15,1	18,6	**0,000**
	51 w	10,4	12,3	**0,000**
	67 w	7,1	8,1	**0,009**
	significance	**0,000**	**0,000**	

Table 40: Overall feather score of hens in cages with FP, third flock

Cage type FP	age	Bovans goldline	Isa brown	significance
overall feather score	21 w	20,0	20,0	1,000
	37 w	16,4	18,4	**0,000**
	51 w	9,7	13,6	**0,000**
	67 w	6,4	9,8	**0,000**
	significance	**0,000**	**0,000**	

These results show that the plumage condition deteriorates significantly with age during each laying period. There are also differences noted between the batches, for example during the second laying period the strain Bovans Goldline had much better results than during the last laying period.

5.3 Behavioural study

5.3.1 Dust bathing behaviour

1. Second laying period

During the second laying period a total of 12 cages housing Hisex Brown hens were observed by two different observers. In this way 12 cages with feeding pans, of which 6 with litter boxes and 6 with scratching mats, and 12 cages with linear feed troughs, half with boxes, half with mats, were analysed regarding dust bathing behaviour.
In Figure 15 the number of dust baths per cage, registered during the one hour and a half observations, was used and the average duration of a dust bath in that cage was calculated. When considering the results from cages with litter boxes and mats as two groups, it shows that dust baths on a mat were more numerous but did not take that long. While dust bathing in the litter boxes occurred less frequently, the duration of these dust baths were longer.
The recordings are compared statistically in Table 41 and 42. Since the litter boxes were only accessible from the front side and once a hen started to dust bathe in it, it was more difficult for another hen to get in and start also. The mats were open and therefore more easily to access and in doing so, disturbing a dust bathing hen.

Table 41: Average duration in seconds of dust baths taken in a litter box and on a scratching mat during second laying period

	litter box	scratching mat	significance
Average duration of dust bath	517 s	318 s	**0,025**

Table 42: Average number of observed dust baths in cages with litter box and cages with scratching mat during third laying period

	litter box	scratching mat	significance
Average number of dust baths per observation	8	13	**0,017**

From Figure 16 it seemed that approximately 67 % of the dust baths observed on the scratching mat took less than 5 minutes. In the dust boxes, the dust bathing took more time and therefore the percentages of observed dust baths with longer duration are higher than in cages with scratching mats.

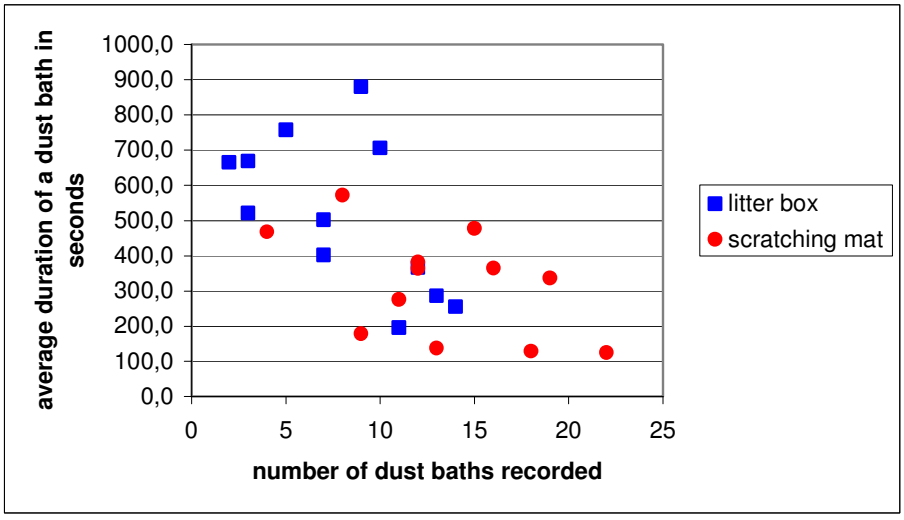

Figure 15: Number of recorded dust baths in relation to their average duration during second laying period

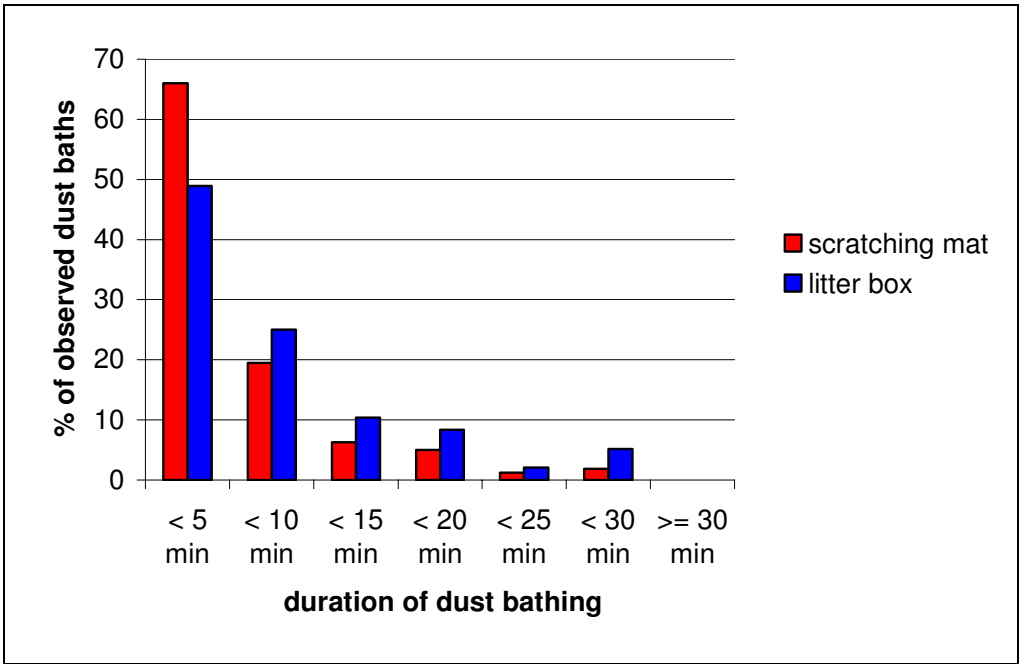

Figure 16: Percentage of observed dust baths laid out by duration of dust bathing during second laying period

Together with the duration of each dust bath, the reason why the bird stopped dust bathing was also recorded. In Table 43 a comparison is made between dust baths taken in the litter boxes and those taken on the mats by giving the percentage of all recorded baths on that facility which ended for that specific reason.

Table 43: Percentage of total dust baths per facility terminated for that particular reason during second laying period

Assumed reason for ending the dust bath	litter box	scratching mat
the bird stops for no obvious reason, gets up	43,1	45,6
the bird pecks other birds	2,0	1,2
the bird is scared by something in- or outside the cage	2,0	3,0
the bird falls asleep	10,8	3,6
the bird is being jumped on	1,0	10,1
the bird is pecked	5,9	4,7
the bird is disturbed	13,7	14,8
the bird gets chased away by others	1,0	4,1
the bird gets trampled on	2,0	4,7
too many birds in dust bathing facility	14,7	3,6
the bird goes drinking/eating	3,9	4,7
the food chain is running	0,0	0,0

These results show that birds on the scratching mat are more often jumped on or chased away by other hens, while in the litter boxes there are often too many birds present or the birds fall asleep (lie still) more frequently.

2. Third laying period

During the third laying period a total of 16 cages was observed twice by different observers.
During this period not only the type of dust bathing facility was compared but also the type of litter used. In half of the cages regular sawdust was used while in the other half a mixture of sawdust and feed was used.
The results showed that the average number of recorded dust baths was significantly higher in the cages provided with scratching mats (Table 44). Again the average duration of the observed dust baths was longer in the cages with litter boxes (Table 45).

Table 44: Average duration in seconds of dust baths taken in a litter box and on a scratching mat during third laying period

	litter box	scratching mat	significance
Average duration of dust bath	690 s	321 s	**0,000**

***Table 45*: Average number of observed dust baths in cages with litter box and cages with scratching mat during third laying period**

	litter box	scratching mat	significance
Average number of dust baths per observation	5	16	**0,000**

In Figures 17 and 18, these results were represented graphically.

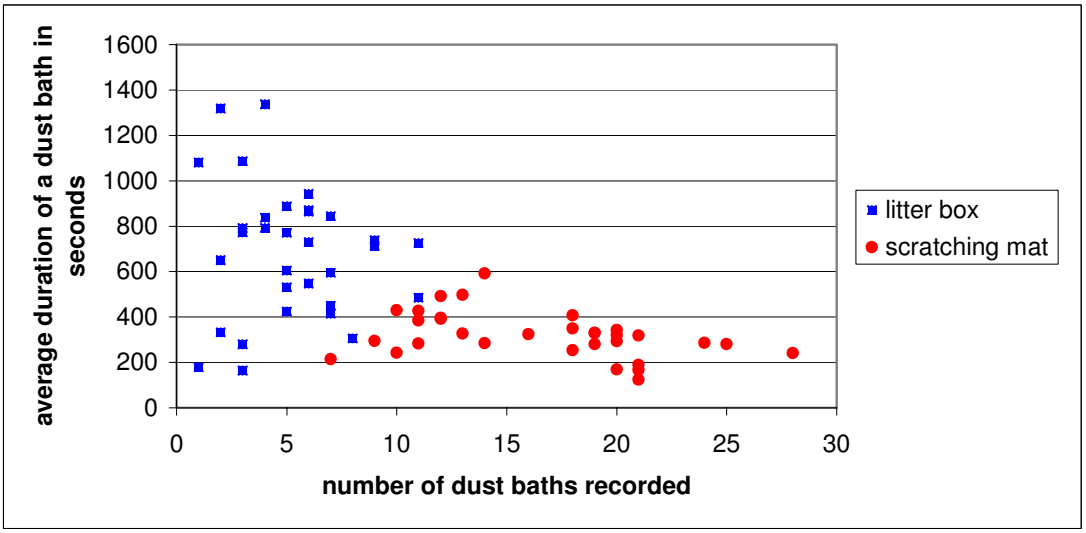

Figure 17: Number of recorded dust baths in relation to their average duration during third laying period

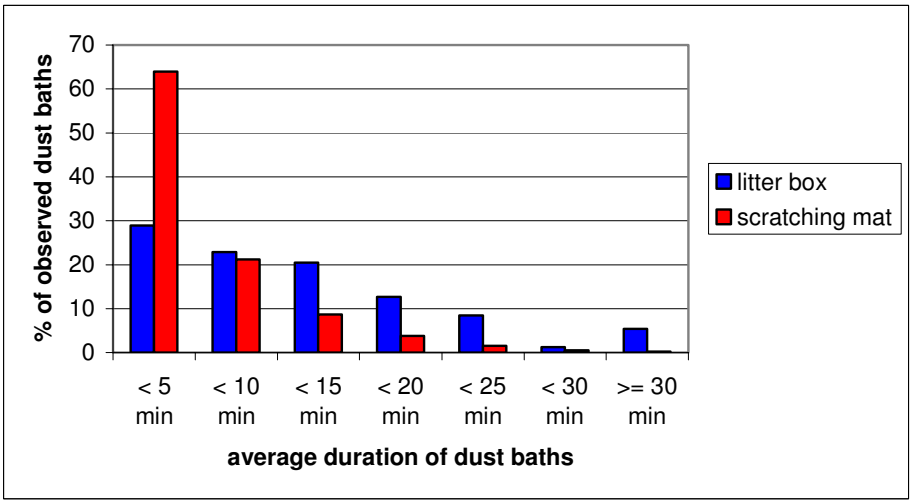

Figure 18: Percentage of observed dust baths laid out by duration of dust bathing during third laying round

When the average number of dust baths recorded per cage was studied, this number was significantly higher in cages where the litter consisted of a mix of sawdust and feed (Table 46).

Table 46: Average number of observed dust baths in cages with sawdust and cages with a mix of sawdust and feed during third laying period

	sawdust	sawdust and feed	significance
Average number of dust baths per observation	10	12	**0,015**

Together with the number of dust baths and the duration of each dust bath, the reason why the bird stopped dust bathing was also recorded. In Table 47 the results are given by percentages of all recorded dust baths per dust bathing facility. As noticed during the second laying period, the birds were more often chased away on the scratching mats while they more easily fell asleep in the litter boxes. Due to the removal of the perch in front of the boxes it seemed that the birds had more difficult access to the litter box when there were already birds dust bathing. While during the second laying round birds would often go in the box even when that the box was already overcrowded, it seemed that during the third laying period the boxes weren't that often overcrowded.

Table 47: Percentage of total dust baths per facility terminated for that particular reason during second laying period

Assumed reason for ending the dust bath	litter box	scratching mat
the bird stops for no obvious reason, gets up	56 %	39 %
the bird falls asleep	25 %	7 %
the bird pecks other birds	5 %	1 %
the bird goes drinking/eating	5 %	6 %
the bird is disturbed	4 %	4 %
too many birds in dust bathing facility	2 %	26 %
the bird gets chased away by others	1 %	3 %
the bird gets trampled on	1 %	9 %
the bird is being jumped on	1 %	1 %
the bird is pecked	1 %	2 %
the bird is scared by something in- or outside the cage	1 %	2 %

5.3.2 Perching behaviour

In Table 48 the percentage of birds sitting on the perches during the time of observation is given. It seemed that for the wooden and metal perches, the number of birds on the perches was the highest for perches of 15 cm height. Nevertheless, these higher perches were obstacles in the cages and diminished the freedom of movement of the birds.
When both heights were looked at separately, it seemed that the metal perches were less used on the higher as well as on the lower perches. The reason could be that the material wasn't suitable but also that the dimensions used weren't ideal. Maybe with the use of perches with a greater diameter the usage would be increased. The plastic perches were well used by the birds and the results were comparable to those of the wooden perches at 7 cm height.
The results also showed that the percentage of birds who used a perch increased with age. The birds were raised in battery cages and had no experience with perches.

Table 48: Percentage of birds sitting on the perches (significant differences between the perches used are indicated horizontally by a, b, c…; differences concerning the age of the birds are indicated vertically by w, x, y, z)

	metal 7 cm	metal 15 cm	wood 7 cm	wood 15 cm	plastic 7 cm	significance
34 weeks	28,1 a x	48,2 c w	47,2 c x	60,1 d x,y	41,5 b x	0,000
39 weeks	32,3 a x,y	47,5 b w	48,2 b x,y	57,2 c x	44,9 b x,y	0,000
45 weeks	36,3 a y	54,5 c x	52,6 b,c y	63,4 d y,z	48,3 b y	0,000
50 weeks	34,0 a x,y	59,5 c x,y	52,8 b y	64,2 c y,z	50,2 b y	0,000
58 weeks	47,5 a z	63,1 b,c y,z	59,0 b z	68,5 c z	57,5 b z	0,000
62 weeks	45,7 a z	64,9 c z	57,9 b z	69,2 c z	58,6 b z	0,000
significance	0,000	0,000	0,000	0,000	0,000	

As the results from Tables 49, 50 show, the type of perch or the age of the birds did not have a significant influence on the number of birds observed sitting in the litter boxes or in the nests.

Table 49: Percentage of birds observed in litter boxes (significant differences between the perches used are indicated horizontally by a, b, c…; differences concerning the age of the birds are indicated vertically by w, x, y, z)

	metal 7 cm	metal 15 cm	wood 7 cm	wood 15 cm	plastic 7 cm	significance
34 weeks	5,8	5,1	4,5	4,8	5,2	0,586
39 weeks	4,1	5,3	5,3	4,6	4,7	0,732
45 weeks	4,6	4,1	5,1	4,8	5,0	0,847
50 weeks	4,8	4,9	5,9	4,8	3,9	0,476
58 weeks	4,5	5,8	5,7	5,1	5,0	0,551
62 weeks	5,6	6,0	6,8	5,9	6,7	0,809
significance	0,639	0,304	0,297	0,766	0,069	

Table 50: Percentage of birds observed in the nests (significant differences between the perches used are indicated horizontally by a, b, c…; differences concerning the age of the birds are indicated vertically by w, x, y, z)

	metal 7 cm	metal 15 cm	wood 7 cm	wood 15 cm	plastic 7 cm	significance
34 weeks	0,5 x	0,9	1,5	0,8	1,4	0,289
39 weeks	3,1 y	2,5	3,7	1,5	2,4	0,312
45 weeks	1,2 x	0,6	1,3	0,7	1,5	0,637
50 weeks	0,9 x	0,7	1,2	0,9	1,3	0,834
58 weeks	1,6 x,y	0,8	2,0	0,7	1,6	0,299
62 weeks	1,4 x	1,2	2,2	0,7	1,6	0,542
significance	0,028	0,092	0,108	0,645	0,765	

The feather condition of the birds was also assessed in order to look at the influence of the different perches used. The results are given in Table 51 and no clear effect of perch height was seen on the feather score of the birds. When the materials of the perches were compared, it turned out that the wooden perches (as well the low as high perches) had a lower feather score than the metal perches. The feather condition in cages with plastic perches was better than in cages with wooden perches and comparable to the results with the metal perches.

Table 51: Average feather score per type of perch used

	metal 7 cm	metal 15 cm	wood 7 cm	wood 15 cm	plastic 7 cm	significance
21 weeks	20,0	20,0	20,0	20,0	20,0	1,000
37 weeks	17,7 c	17,1 b,c	16,1 a	16,9 b	17,4 b,c	0,000
51 weeks	12,9 c	12,2 b,c	10,2 a	11,9 b	12,4 b,c	0,000
67 weeks	9,1 c	9,0 c	7,4 a	8,1 a,b	8,5 b,c	0,000

5.3.3 Environmental enrichment

The materials which were placed in the cages were being pecked at quite eagerly in the beginning. However, the interest of the birds in the materials decreased very fast and the materials lost their attractiveness. In some cages the materials were pulled off rapidly by the birds, fell on the manure belt and disappeared.
In order to look at the influence of the environmental enrichment, the feather condition of the birds was assessed. There was no difference noticed between cages with and cages without enrichments.

6 Summary

Cannibalism occurred in the enriched cages but is constrained to a few cages. Once started, the mortality rates rose quickly and not much could be done to change it. A technical problem can develop stress in the group which can cause cannibalism.
The technical results showed there are great differences between the different laying periods. Different influences form the environment such as management play a role.
Regarding the used strains, no clear conclusions could be made since the results from the different laying periods differed strongly.
The use of laying materials in the nests improved the egg quality since less eggs were bruised or dented. Also the percentage of eggs laid outside the nests was reduced with the use of nesting materials.
All scratching materials used kept the nails of the brown hens shorter than those in cages with no scratching facilities. The level of the nail reduction depended on the material used. Some materials though seemed to wear down the nails too much which can injure the animals.
The results showed that more dust baths are taken on the scratching mat but these dust baths take less time than those acted out in litter boxes.
The birds preferred the higher perches. Concerning the material used, there seemed to be a slight preference for wood, the plastic perches were also used more often. The plumage condition seemed to be lower in cages with metal and plastic perches.
The materials used as environmental enrichment didn't seem to be effective in reducing feather pecking since no clear effects on plumage condition were noticed. When the materials were introduced to the birds, they showed great interest in them but this wore off quickly.

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Departement Economie, Plattelandsbeleid en Internationale Samenwerking
Proefbedrijf voor de Veehouderij
Poiel 77 | 2440 Geel | België | T 003214 56 28 70 | F 003214 56 28 71 |
info@proefbedrijf.provant.be

Directie: Projectingenieur Johan Zoons