Animal welfare and genetics in organic farming of layers: the example of cannibalism

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Introduction and summary
During the last 40 years, breeding programmes were directed at intensive husbandry systems and changed markedly the genotypes of the animals involved. Apart from the question whether these animals have been adapted adequately to these intensive systems, the question arises as to how far the potential to adapt to extensive systems was maintained. Should animals be selected anew for these extensive systems, or can we just go on with the strains available now?

Cannibalism frequently occurs in organic poultry farming. Literature shows that a wealth of factors - ontogenetical, environmental and genetical - might play a. role in the development of cannibalism. However, none of these factors stands out as the main cause of the observed problems. A survey in the Netherlands among 11 farms in 1995 showed the severity of the problem. In this paper, new data are presented from a. survey in 1997, using a questionnaire, an animal welfare index (Animal Needs Index), behavioural observations and plumage scores. Results obtained by factor analysis show that still no clear cause for the occurrence of cannibalism is found. Differences between organic poultry farms with roosters and farms without roosters, together with some experimental data, indicate the possible importance of roosters on poultry farms. Furthermore, changes in the use of different breeds between 1995 and 1997 by farmers show the effects, especially on mortality due to cannibalism. Thus, one of the most promising ways to reach a solution seems to be to adapt the animal to its ecological environment by genetic selection.

Heritability estimates of cannibalism are lacking; the only one available indicates high heritability. Based on this single estimate, genetic selection against cannibalism appears feasible. A tentative model of the process of genetic selection for organically farmed poultry is given, emphasising genotype-environment interactions. Because of the latter, basic genetic studies have to be followed by measurement in the practice of farming. This will then adapt the environment to the animal and the animal to the environment. Furthermore, it is noted that the molecular genetic analysis together with ethological analysis can show the genetic background, i.e. markers or even genes that are responsible for the cannibalism. With such information a Darwinian 'natural selection', using genetic information of layers that are good producers and survivors, appears to be within the reach of organic poultry farming.

Aim of the study

In this paper, the status concerning breeds and management in relation to cannibalism in organic poultry farming in the Netherlands is explored. Furthermore, the objective of the study is to determine the best way to diminish feather pecking and cannibalism in organic poultry farming by adapting the bird to the ecological environment. In 1995, a survey was done, of which data are published elsewhere (Koene, 1997a). New data concerning cannibalism and management variables from the survey in organic poultry farming in 1997 are presented. In this survey four methods of measuring farm parameters are used, i.e. a questionnaire, an animal welfare index (AN-index), behavioural observations and a plumage index. Using factor analysis main factors distilled by each method are extracted, and factor scores are correlated to reveal their relationships. Subsequently, a model of genetic selection is presented, that integrates classic selection procedures and new molecular genetic methods to integrate selection in practice with selection on the level of off-line breeding. Different breeding and selection strategies will be presented dependent on welfare criteria, rather than on production criteria alone.

Intensive layers in extensive systems

Part of the goal of extensifying farming is to improve the housing conditions of animals with respect to their welfare. During the last 40 years, breeding programs were directed at intensive farming systems and changed markedly the genotypes of the animals involved. Apart from the question whether these animals have been adapted adequately to these intensive systems, the question arises whether the potential to adapt to extensive systems was maintained. If we return to these extensive systems should animals be selected anew or can we just go on with the strains available now? If the question is whether we adapt the animal to the environment or the environment to the animal (Faure, 1980), it is obvious that the process of selection is guided by animal-environment interaction, i.e. differences between animals can be attributed to genetic and environmental differences.

There are *a priori* no convincing arguments either pro or against selection of domestic animals for more extensive systems (Koene, 1997a). However, problem behaviour may appear in more extensive systems differently from that observed in intensive systems. For instance, in alternative systems for laying hens with larger groups and more space, more animals have the possibility to interact and thus increase the possible number of interactions and decrease the controllability of behaviour from the farmer's point of view. Selection for egg production in intensive systems seems to have caused a loss of genes for social interaction, causing increased cannibalism in floor systems (Sorensen and Christensen, 1997). Because of production loss some other authors state that non-genetic solutions should be pursued whenever possible (for instance, Hocking, 1994). Problems that occur are aggression, feather pecking and cannibalism, which still may necessitate beak trimming. Of these the most serious and damaging is cannibalism, which is the primary subject of this paper.

Cannibalism: cause and cure

The causes of cannibalism are not well understood, but the onset of cannibalism has been attributed to a number of causes that are outlined below. Generally, in cannibalistic species most incidences of cannibalism are related to feeding behaviour (Dong and Polis, 1992). The main theories of causation of cannibalism in chicken concentrate on an early phase during ontogeny of pecking behaviour. Blokhuis (1986) proposed the theory that feather pecking was redirected ground pecking and thus a part of the feeding behaviour system. Recently the relationship between dustbathing and feather pecking was explored and partly substantiated (Vestergaard, 1994). Vestergaard and Lisborg (1993) showed that the results concerning dustbathing are not in contradiction with Blokhuis' theory. Feather pecking is redirected pecking but according to Vestergaard as part of the dustbathing behaviour system.

However, Koene (1998) showed that the relation between feather pecking and cannibalism is unclear. For instance, evidence showed that vent pecking often starts after the start of laying and is an indication that cannibalism is influenced by changes in the hormonal system (Hughes, 1973). Furthermore, due to genetic selection, layers have a strong motivation to peck (Sorensen and Christensen, 1997). The pecking objects will be determined by the level of motivation and probably a learning process that acts especially during the early days (imprinting) but can also operate during later life. As an example, the quality of laying nests may be of essential influence in the development of cannibalism. Thus, the motivational and learning components need more attention in future research (and is currently under investigation in the Ethology group in Wageningen). In summary, cannibalism can have different causes, e.g. feather pecking and vent pecking.

Management and cannibalism

Cannibalism itself has not been the subject of much research. Part of the relevant information is available through experience, for instance by scientific experiments stopped by cannibalism. The practical experience is to be found in handbooks, in which presumed causes, consequences and solutions are mentioned. Suggested causes in a selection of 12 handbooks (table 1) are food composition (11), bright light (9), stocking density (6), too much corn meal (3), climate (3), distraction (2), feeding too late (1) and floor eggs (1). Solutions suggested are red light (5), removal of cannibals (3), tar on the wounds (3), oats (2), salt (2), music (1), and removal of sick hens (1). More suggestions are given in the scientific literature (Hughes and Duncan, 1972). But results are mainly very diverse and often contradictory. More information from practice is needed, and therefore surveys were done in the Netherlands in organic poultry farming.

Table 1. Causes of and cures for cannibalism in poultry husbandry as extracted from A. selection of handbooks on poultry keeping. Items are separated in causes and cures and sorted in descending order according to their occurrence in the total of twelve books.

	Item Book	1	2	3	4	5	6	7	8	9	10	11	12	Total
cause	food composition	*	*	*	*	*	*	*		*	*	*	*	11
cause	bright light			*	*	*		*	*	*	*	*	*	9
cause	density			*		*		*		*	*		*	6
cause	too much corn meal		*			*	*							3
cause	methionine/arginine	*				*								2
cause	red cloaca										*		*	2
cause	too few distraction					*							*	2
cause	feed too late								*					1
cause	floor eggs										*			1
cause	pellets											*		1
cure	red light				*	*		*	*	*				5
cure	selection/removal					*	*						*	3
cure	stable climate							*		*		*		3
cure	tar					*	*						*	3
cure	pickout									*			*	2
cure	reduction by oats					*				*				2
cure	salt		*										*	2
cure	music				*									1
cure	remove sick hens							*						1

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Cannibalism in the Netherlands: some new data

Introduction

In 1995, a survey was done in the Netherlands concerning the existing problems of the cannibalism related to the conditions of housing and management in organically farmed poultry. Results are presented in a Dutch report (Van de Wouw and Koene, 1995). However, results of this short survey must be interpreted with care because of the small sample size. Impressions (Koene, 1997a) are that more cannibalism is found on large farms, in large groups, keeping Hisex layers, and keeping hens only recently and with a high percentage of floor eggs. Factors that seem to be of less importance are BD (with a rooster) or EKO (without a rooster) farming, wheat availability, age at arrival on the farm, and fine or pelleted food. The survey showed that mortality due to cannibalism is sometimes very high (the range was 0-30%). On the question of how the pecking started one farmer responded ‘by extreme feather pecking’, one ‘by extreme pecking between cloaca and legs’, and nine ‘by cloaca pecking’.

The problems for the 'animal friendly' egg market were thus very serious. In 1996, the problem seemed to be not any smaller. Main results of the survey are presented elsewhere (Koene, 1997a). Furthermore, the problem seemed to be widespread in Denmark, Germany and the Netherlands (Koene, 1997b). The cause of cannibalism in reported cases was not revealed, but genetic factors, experience of the farmer, and the quality of laying nests seemed to be important. The investigation was repeated in 1997, combining several methods of estimating conditions for the chicken on the farms, including behaviour research.

Materials and methods

a) Housing

In 1997, some 50.000 layers were kept under organic conditions in the Netherlands. In the Netherlands, the Skal Foundation controls the quality of organic poultry farming. Hence, the housing of laying hens in the survey is comparable on some controlled and regulated points. However, large differences occurred concerning surface, substrate and laying nest. Part of the organically kept layers consisted of so-called BD (Biological Dynamical) layers and another part consisted of the EKO layers (labelled Ecological). The main difference between the two is that BD layers are kept together with roosters (at least 1 per 40 hens). In both housing conditions the layers' beaks are not trimmed.

b) Subjects

The number of laying hens per farm varied between 100 and 8500. In this survey, three strains were found, i.e. Lohmann Brown (Lohmann), ISA Brown (ISA) and Bovans Nera (Hendrix). In all BD farms, roosters were present in a rooster/hen ratio of generally 1 to 30.

c) Methods

Questionnaire

First, questionnaires were sent to 42 farms with questions and especially a question, whether behavioural observations of the layers indoor and outdoor were allowed. In 15 the answer was positive (response rate is thus very low, 36%) and 13 of these were visited. The items in the questionnaire ranged between question for opinions, yes/no answers, and estimations. The numeric questions involved the quantities of the number of (#) layers, percentage cannibalism in the last complete laying round, percentage of current cannibalism, farmers' experience in # years, surface inside in m2, surface for scratching in m2, surface outside in m2, # times/day grain was given, # cm feed/layer, # cm water/layer, # nests/layer, and % floor eggs. It is pointed out that these figures were farmer's estimates, not exact measurements.

AN-index

The German Tiergerechtheits index (Animal Needs Index; Bartussek, 1999; here called AN-index) is an animal welfare index based on a point system for relevant parts of the farming. There are separate indexes for different species; Striezel (1994) describes the AN-index for layers.

Table 2. Example of one of the categories (Locomotion) of the ANI-200. Columns a-g are the sub-categories ranging from space per hen to the structure of the area. Under the table the columns relevant for the system are indicated. Also, a short explanation of each item is given.

column	a	b	c	d	e	f	g
points	aviary # / m2	floor # / m2	perches in diff. heights	green outdoor m2 / hen	green outdoor duration of usage	ratio outdoor layers / m2	structure of the outdoor area
6	< 10						
5	< 11			> 10		< 8	
4	< 12	< 4	present	> 7,5		< 11	shadow givers, feed and water
3	< 13	< 5		> 5	total vegetation period	< 15	feed and water
2	< 14	< 6		> 2,5	> 2 / 3 part veg. period	< 18	feed or water
1	< 15	< 7			> 1 / 3 part veg. period		

Aviary	Column a
Strawyard	Column b
General	Column c
Green outdoor area	Columns d and e
Stone outdoor area	Column f
General	Column g
Column	Points
Column a	Different for each type aviary
Column b	Total available surface, including scratch area and wooden slats, excluding nesting area.
Column c	When the manure area is covered by the wooden slats and perches, then 'perches in different heights' will not be valued. The perches must use the space.
Column d	Green outdoor area is that surface that is covered mainly by grass. The total surface has to be estimated. In case no limits are found the maximum score is given.
Column e	Us E. data from the farmer. Limitations dependent on the kind of weather are possible.
Column f	The surface in the direct neighbourhood of the indoor facility, with substrate that enables ground scratching. This substrate must be sand, stones or other material, and must be available the whole year round. Limitations dependent on the kind of weather are possible. Daily outdoor availability is at least 4 hour.
Column g	Shadow givers are shrubs, trees, and penthouses as protection against bad weather and raptors. Feed and water reservoirs must be judged, when hens are not outdoors due to the weather.

The index is based on 8 categories in which possibilities of behaviour are recorded, i.e. (1) locomotion (max. score of 31 points on variables as outdoor structure), (2) feeding behaviour (max. score of 27 points on variables as trough width, and feeding times), (3) social behaviour (max. score of 31 points on variables as density, feather quality, and number of outdoor pop-holes), (4) resting behaviour (max. score of 25 points on variables as perch length, and light intensity), (5) comfort (max. score of 22 points on dustbath possibilities, and substrate), (6) nesting (max. score of 29 points concerning the laying nest, and floor eggs), (7) hygiene (max. score of 26 points on variables of substrate, water, smell, and outdoor use) and (8) care (max. score of 24 points concerning the facilities, feathers, cleanness, administration) and many more variables within categories. An example of one category is given (Table 2). The total sum of these values gives the index (maximum is 215 points). A relatively high index indicates a relatively good farm. The AN-index is determined for each farm during one morning after observer habituation to the specific farm.

Behaviour

In each farm, behaviour observations were done during 2 days for 5 hours a day. Scan sampling was done with 10-min intervals. The time budget of beak related behaviours is determined by scoring feeding, drinking, preening, object pecking, feather pecking and dustbathing indoor and outdoor (object pecking included ground pecking).

IBPW

The plumage quality of 10 randomly selected individuals indoor was determined according to the system of Herremans and Decuypere (1987) with some minor adaptations (IBPW = Index of body plumage wear). A high index indicates much wear and a bad plumage condition.

Analyses

Correlations between all variables from the questionnaire, the categories of the AN-indexes, the observed pecking behaviours and the IBPW-values are calculated. Factor analyses are done per method and correlations between within-method factors are presented (varimax rotated factor analysis; SAS, 1996). Factors extracted are based on a criterion of an Eigenvalue above 1. Significant factor loadings (>0.57, $p<0.05$) are printed bold in the tables (3-7). Factor names are given based on best professional judgement. Differences between BD (n=7) and EKO (n=6) farms are calculated using the GLM procedure (SAS, 1996).

Rooster presence

In an indoor experiment the effect of the presence of a rooster on pecking behaviour and cannibalism is investigated. In short, ISA Brown layers arrived at 18 weeks and were at random subdivided in groups of 10 of which 3 groups with a rooster and 3 without one. The cages measured 1.5x1.5m, and had a wooden floor, two laying nests with artificial grass, two perches, three drinking places, and a feeding trough. The temperature varied between 15 and 20 degrees. A 16-hour light period was given from 500h to 2100h through 6x40w TL bulbs. Observations using behaviour sampling were done during 5 weeks, 5 days a week, twice a day and lasted 25 minutes per cage. Behaviour elements were based on the pecking categories of Savory (1995). Furthermore, the pecking goal was recorded; the peck was hard, medium or soft and pecking was intensive or extensive in frequency. Only results of cloaca pecking will be presented here. Analysis was done by GLM (SAS, 1996) based on 2 conditions and three replications.

Results

Questionnaire

According to the farmers' estimate, the percentage cannibalism in the former complete laying round ranged from zero % (8 farms), 2% (BD; Bovans Nera), 4% (EKO; Bovans Nera), 5% (EKO; Lohmann Brown), 8% (EKO; ISA Brown) and 10% (EKO; ISA Brown). This was much less than in 1995 ($F_{1, 20}=11.02$, $p=0.003$; in 1995 cannibalism was in BD farms 11% and in EKO 9.7%; in 1997 it was in BD farms 0.4% and in EKO 4.5%). In 1995 especially the Hisex strain showed high percentages of cannibalism. Factor analysis using the numeric variables of the questionnaire revealed four factors with Eigenvalue larger than one (Table 3), explaining a total of 83% of the variance. Factor 1 explained the majority of variance (43%) and had significant loadings of surface inside, surface to scratch, number of cm feed trough per layer and number of nests per layer. This factor is tentatively named *density*. The second factor shows significant loadings of cannibalism in the last and present laying cycle, surface to scratch, cm water per hen. This factor is named *cannibalism*. The relatively high loadings of surface and water indicate a relationship between cannibalism and those variables. The third factor had significant loadings of surface outside and # grain/day and indicates the *ecological* aspects of the housing. The fourth factor has a significant loading of number of years the farmer is keeping laying hens, and is consequently named *experience*.

Table 3. Factor analysis of questionnaire data.

Q'nnaire	Factor	1	2	3	4
Variable					
1	# layers	0.53	0.35	-0.33	-0.35
2	last cannibalism	0.31	**0.78**	-0.09	-0.11
3	current cannibalism	0.05	**0.89**	0.17	-0.30
4	experience	-0.10	-0.08	0.00	**0.89**
5	surface indoor	**0.81**	0.28	0.05	0.30
6	surface scratch	**0.70**	**0.65**	0.07	-0.08
7	surface outdoor	0.12	0.04	**0.92**	0.14
8	# grain/day	-0.02	0.19	**0.67**	-0.48
9	# cm feed/layer	**0.74**	0.45	-0.12	0.02
10	# cm water/layer	0.19	**0.92**	0.11	0.18
11	# nests/layer	**0.89**	0.17	0.09	-0.20
12	% floor eggs	**-0.79**	0.24	-0.34	0.39
	Expl. Var. %	43	15	13	11
	Cum. Var. %	43	58	72	83
	Eigen value	5.19	1.82	1.61	1.33
	Label	densit.	cannib.	Ecol.	Exper.

AN-index

Factor analysis revealed three factors with an Eigenvalue larger than 1, explaining 77% of the variation (Table 4). The first factor explains 40% of the variation and has significant loadings of locomotion, feed, social and rest scores. It seems mainly related to the behavioural activities and is named *activity*. The second factor has significant loadings of comfort, hygiene and care scores, and is named *body care*. The last factor has a significant loading of only the nest score and is named *nesting*.

Table 4. Factor analysis of AN-index data.

TG-index	Factor	1	2	3
Variable				
1	locomotion	**0.64**	0.20	-0.18
2	feed	**0.68**	0.26	0.53
3	social	**0.71**	0.31	0.15
4	rest	**0.91**	-0.25	0.00
5	comfort	0.45	**0.85**	0.11
6	nest	-0.05	-0.01	**0.94**
7	hygiene	0.14	**0.70**	0.37
8	care	-0.10	**0.90**	-0.25
	% Expl. Var.	40.00	21.00	16.00
	% Cum. Var.	40.00	61.00	77.00
	Eigenvalue	4.17	1.69	1.28
	Label	activity	body care	nesting

Behaviour

Factor analysis of the 6 pecking behaviours sampled reveals three factors explaining a total of 74% of the variation (Table 5). The first factor explaining 33% of the variation has significant factor loadings of feed pecking and dustbath pecking and negative loading of object pecking (mainly ground pecking), it is named *normal* pecking. The second factor explaining 23% of the variation has a significant positive loading of feather pecking and a significant negative loading of preening, the factor is named *FP,* related to feather pecks. The third factor has a significant positive loading of drink pecking and a negative loading on object pecking (mainly ground pecking), it is named *drinking*.

IBPW

Factor analysis of the body parts with plumage coverage revealed only one factor explaining 90% of the variation (table 6); the factor is named *Fibpw*, i.e. different from the calculated IBPW.

Table 5. Factor analysis of pecking behaviour data.

Pecks	Factor	1	2	3
Variables				
1	feed	**0.79**	-0.02	-0.07
2	drink	-0.32	-0.10	**0.89**
3	preen	-0.18	**-0.78**	-0.11
4	object	**-0.59**	-0.08	**-0.67**
5	feather	-0.06	**0.82**	-0.16
6	dustbath	**0.86**	0.17	-0.08
	% Expl. Var.	33	23	19
	% Cum. Var.	33	56	74
	Eigenvalue	2.27	1.94	1.08
	Label	normal	FP	drinking

Table 6. Factor analysis of plumage data.

IBPW	Factor	1
Variable		
1	head	**0.85**
2	breast	**0.94**
3	vent	**0.94**
4	thigh	**0.99**
5	back	**0.97**
6	wing	**0.98**
7	tailbone	**0.95**
8	tail	**0.97**
	% Expl. Var.	90
	% Cum. Var.	90
	Eigenvalue	8.23
	Label	Fibpw

Correlations between factors

The four methods of observing characteristics of organic poultry farms revealed several significant factors distinguishing those farms. To find relationships between variables correlations are calculated, but often high correlations between measurements obtained through the same method hamper interpretation, for instance #cm feed per hen is highly correlate with #cm water per hen in the questionnaire. Thus, the correlations of factor scores of each farm on factors with Eigen value larger than 1 are calculated (Table 7). Factors from the questionnaire (4), from the AN-index (3), from the pecking behaviour observations (3) and the IBPW (1: Fibpw) are correlated with the factors that best measure the targets issues, i.e. the factor *cannibalism* from the questionnaire, the factor *FP* from the behaviour measurements, and the factor *Fibpw* from the index of body plumage wear (IBPW). Furthermore, factors are correlated with the calculated AN-index and the calculated IBPW scores. Correlations above 0.57 are significant (P<0.05). Concerning *cannibalism* only a highly significant negative loading of *nesting* in the AN-index is found (Table 6), together with a negative relationship, with the overall AN-index. Concerning *FP* pecking only a significant correlation with the *IBPW* and the *Fibpw* is found; indicating that on farms showing more feather pecking birds more body plumage wear is found. Last but not least, the factor *Fibpw* is significantly negative correlated with *body care* and with the overall AN-index.

Table 7. Correlation of extracted factor with three selected factors and the calculated IBPW index and AN-index.

Correlations	Factors	cannibalism	FP	Fibpw
Questionnaire	density	0.00	0.20	0.14
	cannibalism	.	0.09	0.33
	ecological	0.00	-0.09	-0.20
	experience	0.00	-0.03	-0.48
TG-index	activity	-0.40	-0.23	-0.31
	body care	-0.11	-0.51	**-0.82**
	nesting	**-0.78**	0.17	-0.03
Pecks	normal	0.45	0.00	0.16
	FP	0.09	.	0.68
	drinking	0.45	0.00	0.33
Plumage	Fibpw	0.33	**0.68**	.
Calculated	IBPW	0.32	**0.68**	1.00
	TG-index	**-0.62**	-0.40	**-0.71**

Rooster presence

The mean AN-index for BD was 115 points and for EKO 97 points (not significantly different). In the AN-index a rooster in a layer group is valued 4 points; consequently a difference between BD and EKO of 14 points is to be explained. Significant differences between the BD and EKO farms were found for the factor scores on *body care* (0.50 vs. –0.58, $F_{1,11}$=5.06, p=0.045), *FP* (-0.56 vs. 0.66, $F_{1,11}$=7.39, p=0.020) and *IBPW* (-0.53 vs. 0.61, $F_{1,11}$=5.94, p=0.033). On BD farms *body care* was higher, *FP* was less and *IBPW* was lower than on EKO farms. All these differences are in favour of the BD systems.

In the indoor experiment the amount of vent pecking was significant lower in the first week in groups with a rooster (0.05 vs. 0.34 pecks per 15 min., $F_{1,4}=17.56$, $p=0.014$), associated with the start of egg laying. During the whole 5-week period the difference was only marginal significant (0.09 vs. 0.33 pecks per 15 min., $F_{1,4}=5.20$, $p=0.085$). In conclusion, the presence of the rooster may be the causal difference between BD and EKO ecological poultry farms.

Discussion

The survey

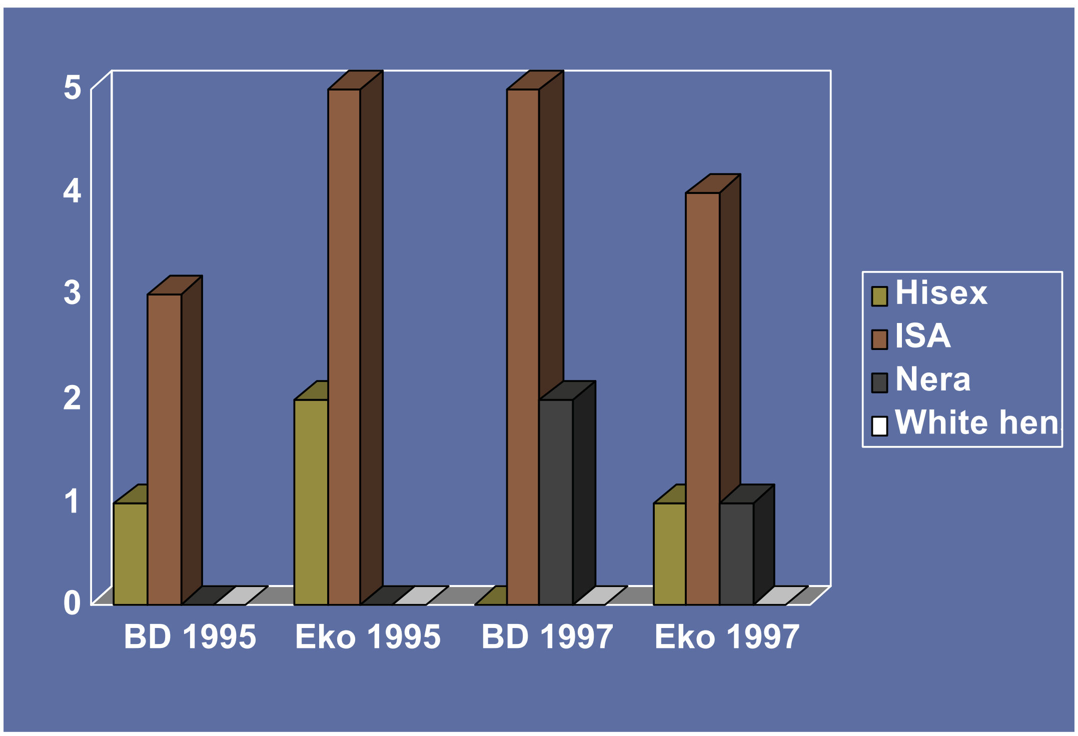
Factor analysis of the questionnaire data revealed four factors. Some interesting relationships are suggested by the rotated factor patterns found. The percentage floor eggs loads negatively on the density factor, suggesting that if the density factor increases, the percentage floor eggs decreases. The *cannibalism* factor suggests a relation between the occurrence of cannibalism and water availability per hen and the surface for scratching, so suggesting more cannibalism with an increase in scratch area, which could not be explained yet. The factor analysis of the AN-index suggests that the categories locomotion, feeding, social and rest measure the same variation, and are different from the other four factors. Care for the hens' body, for hygiene and for the facilities loads on the same factor, while nesting loads on a separate factor. This suggest the importance of behavioural possibilities for comfort behaviour and nesting facilities apart from each other, and apart from other activities; probably the different factors did not receive the same attention of the farmers.

The factor analysis of the pecking behaviour shows the relationships between feed, dustbath and ground pecking, and partly unite the feather pecking theories of Blokhuis and Vestergaard, mentioned in the introduction. A negative relationship between food pecking and ground pecking, but also a negative one between dustbath pecking and ground pecking is suggested. Probably both ground pecking and dust bath pecking are part of the feeding system; in this case both not related to the FP factor. The opposite loadings of preen and feather pecking suggest that less comfort pecking is found when much feather pecking is found. Determination of parasite load will give additional information on the cause of preening. Drinking pecks are negatively related to ground pecking. It suggests that water availability is important as is also suggested by the relationship with the factor *cannibalism*.

The correlation between the factor scores of the farms show that good farms have less cannibalism, and that good farms have probably better nesting facilities for the laying hens. This is in agreement with the suggestion that cannibalism often starts with vent pecking and often in the context of egg laying, when the cloaca is visible and glistening, probably attracting pecking behaviour. *FP*, although not the prime subject of this study is not related to *cannibalism*, which fits with earlier remarks concerning this point. It logically is related with worse body plumage (*Fibpw*) as a result of the pecking. Last correlation is between the *Fibpw* and the factor *body care*, suggesting that bad feather plumage probably has to do with the care of the environment and the care of the layers for their own body.

The above findings are corroborated by the data based on farmer experience of the, 1995 survey; vent pecking is often the start of cannibalism, not feather pecking. Apart from the importance of the resting facilities for the layers, also a change in the strains used in, 1995 and, 1997 is apparent (Figure 1). The farmers seem to have done a good job; i.e. the percentage death due to cannibalism is reduced from 10% to 2.5%. The Hisex breed is found only once in this survey, maybe due to farmers' experience of extreme cannibalism or due to our, 1995 report (Wouw van de and Koene, 1995). The Bovans Nera strain is new in the field and seems to perform reasonably well. A remark can be made concerning the use of white layers in organic poultry farming. Although it is found that white layers may perform better in organic conditions concerning feather pecking (Van Rooijen, 1997) and cannibalism (Koene, 1997b), such strains are not used in the Netherlands. This is due to the marketing facts: the consumer learns that brown eggs are laid in animal-friendly strawyard systems, and that white eggs come from battery cages! So the choice of strain is for marketing/consumers, not for the layers welfare! In conclusion, farmer's initiatives change already the breeds used in organic poultry farming by trial and error. Developing the tools for breeding an even better adapted layer may accelerate this process.

Figure 1. Number of poultry farms with different breeds of layers in the survey of 1995 and in 1997.



Rooster presence

All investigated organic farms were BD or EKO farms. In BD farms roosters are present, which subjectively seems to increase rest in the indoor stable. This is conform the literature, in which a third party, i.e. another hen or rooster in a conflict seems to have a reducing effect on pecking behaviour (Bshary and Lamprecht, 1994; Ylander and

Craig, 1980), in particular the rooster (Bhagwat and Craig, 1978). In contrast, some BD farmers in the past have necessarily changed to EKO farming due to severe cannibalism of roosters (probably too young roosters, which were harassed and eaten by the hens). Part of the difference between BD and EKO farms is due to a somewhat different attitude towards farming of the farmers, i.e. BD farmers seem to have more attention for their hens (see rooster effect). Still, the most probable reason is the presence of roosters. Within a natural way of farming laying hens the presence of roosters fits very well. From the indoor experiment the influence of the rooster on vent pecking is significant although no specific behaviour is found as an explanation of these differences. In contrast, the presence of roosters is not mentioned in the handbooks in Table 1 as a cure for cannibalism.

Welfare

Cannibalism in poultry husbandry indicates a welfare problem; certainly for the cannibalised birds, and maybe also for the cannibals themselves, dependent on what causes their behaviour. Different causes are mentioned earlier, but most probably strains of layers can have a predisposition of intense pecking behaviour that can expresses itself in cannibalism. When cannibalism occurs some actions can be taken, as reducing light intensity, red light, providing more distraction and so on. However, data show that despite such steps the problems still are not solved (Blokhuis and Wiepkema, 1998). As it appears that chicken lines used in organic poultry farming are not the best suited, and may be better adapted to the environment, especially to a social environment with non-beak trimmed conspecifics.

Siegel (1989) already suggested to use genetic selection to change laying hens and broilers. In his Gordon memorial lecture concerning 'The genetic-behaviour interface and well-being of poultry' he stated that 'arousal is needed for meat stocks and calming for egg-stocks'. Whether that is true is still dependent on the way selection programmes are designed in the near future. In extensive organic farming in addition the animal should be a strong animal with a high survival, high fitness and adaptability. Webster (1994) stated that, 'The welfare of an animal must be defined not only by how it feels within a spectrum that ranges from suffering to pleasure but also by its ability to sustain physical and mental fitness and so preserve not only its future quality of life but also the survival of its genes'. In a short definition of welfare 'The welfare of an animal is determined by its capacity to (1) avoid suffering and (2) sustain fitness' (Webster, 1994). But how to measure welfare in organic poultry farming?

Behavioural measurement

Laying hens in organic farming have some explicit advantages compared to hens in intensive husbandry. Positive aspects of their welfare are, however, difficult to quantify. For instance, freedom is probably one of the positive aspects to the welfare of free-living and free-range animals. In quantifying harm to welfare of free-living animals Kirkwood (1994) assessed the scale and severity of harm to welfare by considering (1) the number of animals affected, (2) the cause and nature of the harm, (3) the duration of the harm and (4) the capacity of the animal to suffer. Kirkwoods approach gives some indications for determining and quantifying the positive welfare aspects of freedom or free-living (i.e. the lifespan of an animal without harm to welfare). However, as long as we are dealing with obvious negative welfare aspects, it is needed first to diminish abnormal behaviours, such as cannibalism and feather pecking.

For adaptation to the environment outdoor laying hens need behavioural flexibility to react on internal and external stimuli that threatens homeostasis. Detection of the important defensive mechanisms and associated behaviours are important for creating means for genetic selection. We need to know behavioural parameters associated with the cannibalistic pecking behaviour for starting a selection programme. The feather peck device of Bessei *et al*. (1997) could be of great help as a direct measure of the abnormal pecking behaviour. Animals - when challenged by changes in the environment - show first behavioural reactions or adaptations (McBride, 1980). Such first reactions can be described as acute stress reactions or emotional expressions (Wiepkema *et al.*, 1992). Siegel (1989) stated that 'poultry farmers routinely use sound to judge flock well-being', i.e. vocalisations are practical tools to judge well-being (Huber and Foelsch, 1978; Koene, 1991; Zimmerman and Koene, 1998a, 1998b, 2000a, 2000b).

So, emotional expressions like vocalisations may be clues to estimate welfare in laying hen houses. For instance, birds thwarted in getting food often vocalise (gakel-call). Thus sound could be a behavioural parameter related to the occurrence of a welfare problem (e.g. hunger). Heritabilities of traits and genetic correlations with other traits are estimated rather easily, but they are dependent on the particular environment. One hypothesis is that behavioural or rather emotional expressions of the animal are related to experiences of the animal in its environment (Wiepkema et al., 1993). In this context, it is appropriate to mention that the uttering of positive emotional expressions may be a better indicator of well-being, although difficult to make operational as a tool in selection for optimal welfare of in- or extensively kept animals. For instance, Huber and Foelsch (1978) found more Ku-calls (the 'friendly contact call'), indicating more positive social contact in strawyard systems compared to battery cages. Behavioural parameters such as vocalisations, which show explicit strain differences (Zimmerman and Koene, 1998b) can provide the target for genetic selection.

Genetics

The relationship between feather pecking and cannibalism remains unclear (see Koene, 1998 and the, 1995 survey, in which farmers mention mostly vent pecking as the cause and start of cannibalism). Line differences in cannibalism are often found (Hughes and Duncan, 1972), but the precise genetics are unclear. The only reported heritability, directly related to cannibalism is obtained by selection on beak inflicted injuries in laying hens, showing a high realised heritability of 0.65 (Craig and Muir, 1993).

It is promising that breeder companies are now becoming aware and active in the field of alternative laying hen farming as is shown in the following citations of Preisinger (1998), 'Especially in Europe consumers are more and more concerned about animal welfare issues. Well-known management tools like beak trimming or reducing light intensity may not be accepted in the future to manage the birds adequately. Under alternative housing systems birds are challenged with problems unknown in cages. With increasing demand for eggs out of alternative housing systems and increasing welfare regulations more and more egg producers are asking for a different type of hen, specifically adapted to 'animal friendly' production systems. Up to now, the major sources of information related to strain differences is based on cage testing. If there are significant genotype x environment interactions, different strain combinations may be required for alternative housing systems than they are for cage; and based on specific line-crosses, special attention will be required in specific programmes to develop a bird for alternative housing systems. Major breeding targets will include low prevalence of cannibalism and feather pecking without beak trimming. Selection against aberrant behaviour has become more important to meet market requirements and to improve overall productivity.

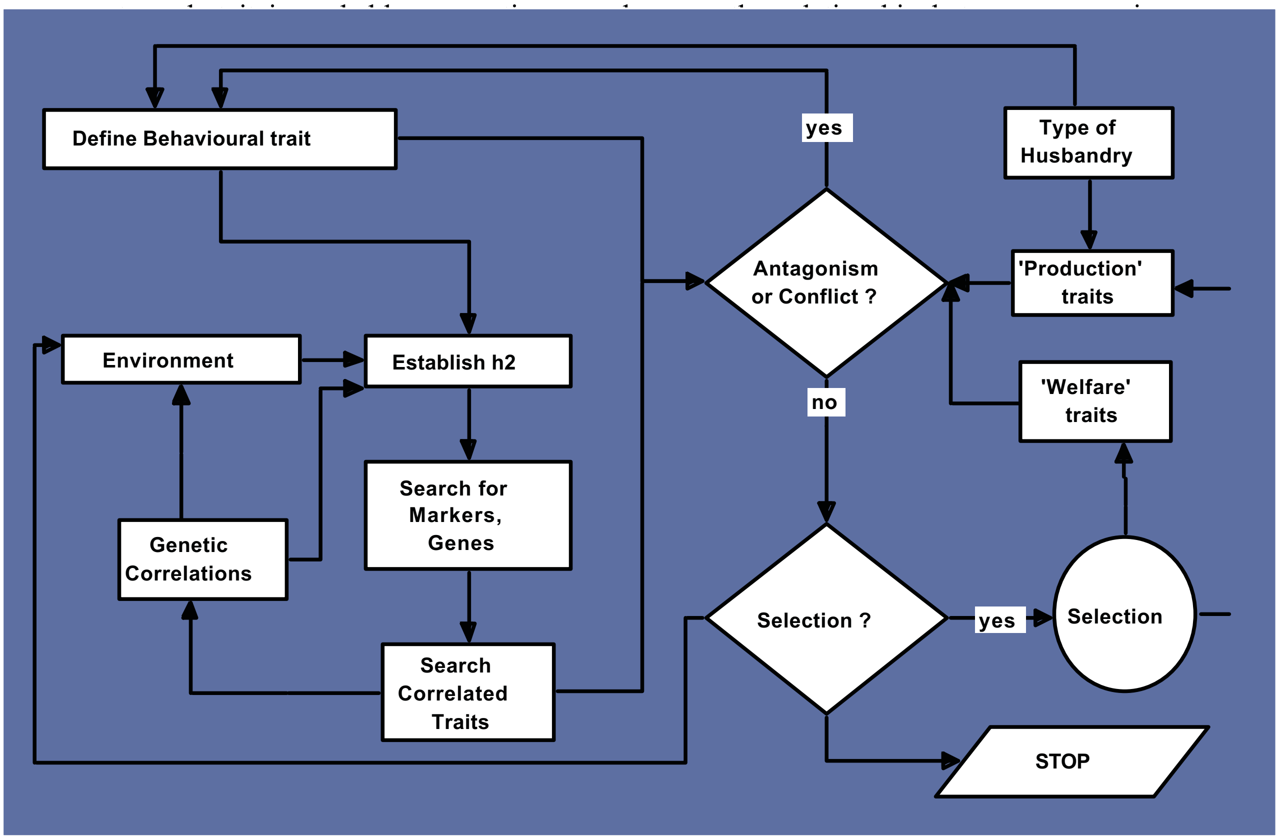
The ontogenetical aspects of the causation of cannibalism are unclear in the case of vent pecking as a precursor to cannibalism. In the case of feather pecking as the precursor to cannibalism, the theories concerning the causation of feather pecking concentrate on the ontogenetical aspects, but also here for practical purposes solutions are also sought for in genetics. The so-called high (HF) and low (LF) feather pecking lines show significant differences in amount of feather pecking, but also significant differences in physiology (Korte *et al.,* 1997) and in behaviour and vocalisations (Jones et al., 1995; Rodenburg and Koene, 2000). Both behavioural parameters have potential as target for genetic selection.

Genetic selection

A flow-chart model or strategy for selection for behavioural traits in animal farming was partly given elsewhere (Koene, 1992; cf. Newman, 1994). The strategy for breeding for welfare traits is dependent on the type of farming which is the starting point of the model that determines the environment in which the selection has to take place. Such a selection strategy can be done in 7 steps (Figure 2).

Quantitative genetics show that selection probably can be done better on group or family level than on individual level (Griffin, 1967). In multi-bird cages it is shown that adaptability and well-being of layers were improved by group selection (Muir, 1996). Improvement of well-being, nesting, viability and egg production can be achieved by selecting families on the parameters of (1) days of survival, (2) willingness to lay eggs in nests and (3) egg production over two laying cycles (Liljedahl, 1999). However, such a selection method seems to be not (yet) feasible in the practice of organic poultry farming.

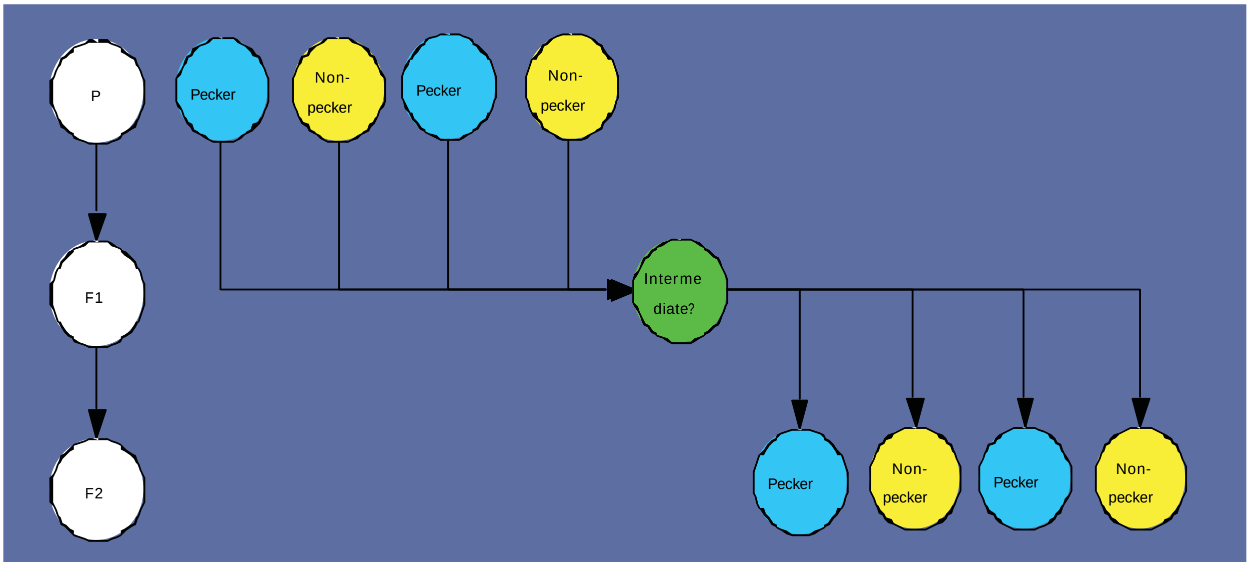
Genotype by environment interactions will be a limitation in all interpretations of heritabilities and genetic correlations. Therefore the environment has a pronounced place in the model. Future behaviour genetic research has to be aimed at (1) emotional expressions as welfare parameters (negative and positive), (2) unravelling the heritability of behavioural (welfare) traits and their phenotypic and genetic correlations with production traits (sustainability), (3) the dichotomy in behavioural traits (types of animals) (Korte *et al*., 1997) (4) the use inbred strains and/or of twins in fundamental research. Selection against cannibalism in laying hens may be successful. Especially genotype-environment interactions (effect of light intensity and group size) are important and must be included in the selection procedure. The best strategy seems to select a specific breed without cannibalism. The genetic correlation of cannibalism with production is not clear. It is thus difficult to estimate the effects on production in this



<u>Molecular genetics and pecking</u>

Molecular genetic techniques and behaviour research (Newman, 1994) allow for genetic identification of cannibals. With a set of high polymorphic microsatellite markers a total genome scan procedure can be done. Segregation for behavioural parameters may reveal chromosomal regions that are basic to cannibalism or related traits by identification through ‘linkage analysis’. Such markers are guides for characterising the responsible genes (Crooijmans *et al.,* 1996). From a genetic point of view cannibalism is not very predictable, but seems to be often associated with vent pecking which is more predictable, and associated with nesting quality. Molecular genetic techniques can probably identify gene-complexes responsible for cannibalism, following the global procedure in figure 3 which is now investigated in Wageningen (Buitenhuis and Van der Poel, Animal Breeding and Genetics, Wageningen, and Rodenburg and Koene, Ethology, Wageningen).

Figure 3. In a F1 generation of genetically different lines - the best is divergently selected lines - concerning cannibalism, i.e. cannibals and/or non-cannibals are determined by behavioural research. By pooling samples of many individuals



Time phase	Phase 1	Phase 1	Phase 1	Phase 1	Phase 2	Phase 3	Phase 3	Phase 3	Phase 3
Individual	1	2	3	4		1	2	3	4
Marker 1									
Marker 2									
Marker 3									

In summary, the possible future strategies to solve the cannibalism problem in organically farmed laying hens could be:

- Keep beak-trimming layers. However, this is not allowed in BD and EKO layers in the Netherlands. Only symptoms of the pecking problem are removed, causing pain in the animals (Gentle, 1997).
- Use regular commercial strains and keep trying to adapt the environment to animal. Better management, human-animal relationship, ontogenetic conditions are needed.
- Use regular commercial strains and wait until breeders deliver animals according to welfare standards enforced by legislation.
- Choose a commercial breed composed of non-pecking parent lines and accept the possibly correlated lower egg production. Don't forget breeds used in other countries like for instance the Australorps.
- Breed and select your own animals or family group of animals. Biological dynamic farming pay special attention to welfare and an ecological approach. A Darwinian approach in which the fitness of an individual can be determined by its reproduction and survival is really ecological! Roosters and a brooder (or broody layers) are essential. Such a strategy is possible in BD systems in the Netherlands.

- Select the animals that are the best under practical conditions and determine their genetic make-up by molecular genetic techniques. In this way breeders may compose the hybrid with the best traits for organically farmed farming.
- Select the animals that are the cannibals under practical conditions and determine their genetic make-up by molecular genetic techniques. In this way breeders may select against cannibalism. This technique is currently used concerning feather pecking in laying hens.
- Use the above mentioned selection model and try to balance welfare and production traits in making a new organically farmed hen strain ('Freehen' or 'Biohen').

Although it is commercially probably the most attractive option to sit and wait for the perfect hen, it is better for the welfare of the hen to start asking for a new type of laying hen without the vice of cannibalism. In the Netherlands and Germany there is a market for a 'biokip' or 'Biohuhn'. The best strategy seems to select for a specific cannibalism-free breed. The search for such breeds has started already. In England the Colombian Blacktail is claimed to show no cannibalism. In the Netherlands the brown Hisex layers showed more cannibalism than ISA hybrids (Koene, 1997a). Hisex birds are not found anymore in organic poultry farming after 1997. White (LSL) breeds are preferred in Germany for showing less cannibalism (Koene, 1997b)! However, they produce white eggs, which could not be marketed as welfare-friendly eggs in the Netherlands.

For health and welfare reasons, composition of new races of laying hens with a large adaptation ability for changing environments is preferred above using animals of current battery cage breeds. Information of individual animals about health, welfare and production must define the features and traits for selection in future. Natural selection should determine the genetic basis of the future production animals in organic farming. Animal variation in health, welfare and production must identify the optimal combination of genetic characteristics in relation to environmental characteristics. Thus leading to identification of the necessary characteristics of future animal friendly, natural, ecological, biological housing systems. The limits of selection are still difficult to determine if we adapt the animal to its environment. The example of blind hens (Ali and Cheng, 1985) that produce better than sighted birds, show no damaging pecking and have probably less stress is a challenging subject for an ethical discussion concerning welfare. Although this example is beyond ethical limits, it seems the best way forward to adapt the hen to a new extensive environment within a framework using the natural variation within the species (Simm *et al.*, 1996).

Conclusions

Composition of new races of laying hens with a large adaptation ability for changing environments without too much loss of production has a number of advantages for the producers and for the animals' welfare above just releasing animals of current battery cage breeds, that share a high propensity for cannibalism. As outlined in the introduction, the aim was to find a solution for severe cannibalism with special emphasis on a genetic solution. Surveys in practice provided ways of improving welfare in laying hens, i.e. experience and probably training of the farmer, changing laying nests and most important adapting a non-cannibalistic hen to the organic farming environment.

The eco-ethological approach (natural behaviour in a natural environment) complemented with a molecular genetic approach seems to be the most promising. If successful, and beak trimming is no longer necessary, also billions of intensively kept hen may benefit from such an effort.

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