# WELFARE ASSESSMENT IN LAYING HENS

**R.M. de Mol*, W.G.P. Schouten, E. Evers, H. Drost, H.W.J. Houwers & A.C. Smits**

* corresponding author: Agrotechnology & Food Innovations, Wageningen UR, P.O. Box 17, NL-6700 AA Wageningen, The Netherlands
rudi.demol@wur.nl

## Abstract

A computer-based decision support system for welfare assessment in laying hens was constructed. This system FOWEL (Fowl Welfare) uses a description of a husbandry system as input and produces a welfare score (on a scale from 0 to 10) as output. A formalized procedure based on Bracke (2001) was applied to assess the welfare status of housing and management systems based on scientific knowledge. The user of FOWEL has to describe a husbandry system by 25 attributes (like: space per hen, beak trimming, free range); the level of each attribute should be given. Each attribute has two or more levels defining the characteristics of a husbandry system. The weighting factor of an attribute is based on the available scientific knowledge of the effects of attribute levels on the welfare aspects. The most important attributes are feeding level, space per hen, perches, water availability and nests. The attribute free range (open-air run) is of minor importance. The resulting welfare score of a husbandry system is based on the attribute levels combined with the weighting factors of these attributes. FOWEL includes a description of 22 husbandry systems. The welfare score of cage systems is low, the welfare score of barn and aviary systems is medium, and the welfare score of organic systems is high. The presence of a free range gives only a small improvement in the welfare score. FOWEL was validated using expert opinion in that there is a substantial agreement between laying hens experts and the model about the ranking of housing systems and about the weighting of attributes of housing systems.

keywords: model, welfare, laying hens

## 1 Introduction

The welfare of farm animals has become an important issue in the last decennia. It is recognized that animals are sentient beings. Welfare had become a problem in intensive husbandry systems. New legislation was imposed to guarantee minimum welfare levels.

Welfare has many aspects and that makes it difficult to compare husbandry systems. Bracke (2001) describes a formalized procedure to 'objectively' assess the overall welfare status of farm animals in relation to the housing and management system based on available scientific knowledge. This procedure is elaborated by Bracke for pregnant sows and implemented in the decision support system SOWEL (sow welfare model) and validated by expert opinions. Here, a similar decision support system for laying hens is described. This computer model, named FOWEL (Fowl Welfare), assigns welfare scores to husbandry systems for laying hens based on scientific knowledge. This makes it possible to compare husbandry systems on welfare status. Also FOWEL is validated by expert opinions.

## 2 Materials and Methods

### 2.1 Outline of FOWEL

The decision support system FOWEL (Fowl Welfare) is based on a calculation model for the welfare score of a husbandry system on the basis of available scientific knowledge. This model is similar to the model SOWEL (Sows Welfare) that calculates the welfare score of housing systems for pregnant sows; see Bracke (2001), or Bracke et al. (2002), for details. The description of FOWEL is analogous to the description of SOWEL in Bracke (2001) and Bracke et al. (2002).

The input of FOWEL is a description of a housing system for laying hens and the output is a welfare score for this housing system (see Figure 1). A husbandry system is the combination of a housing and a management system, it contains the buildings, the farmer and the hens in the system. The description of a housing system is based on attributes. The user must specify the level for each attribute. Attributes are descriptors of husbandry systems, like 'space per hen' and 'free range'. There is an integer number of levels for each attribute, for example the attribute 'free range' has three levels: 'free range with cover', 'free range without cover' and 'no free range'. The levels are disjoint and the all levels encompass the whole range for the attribute.

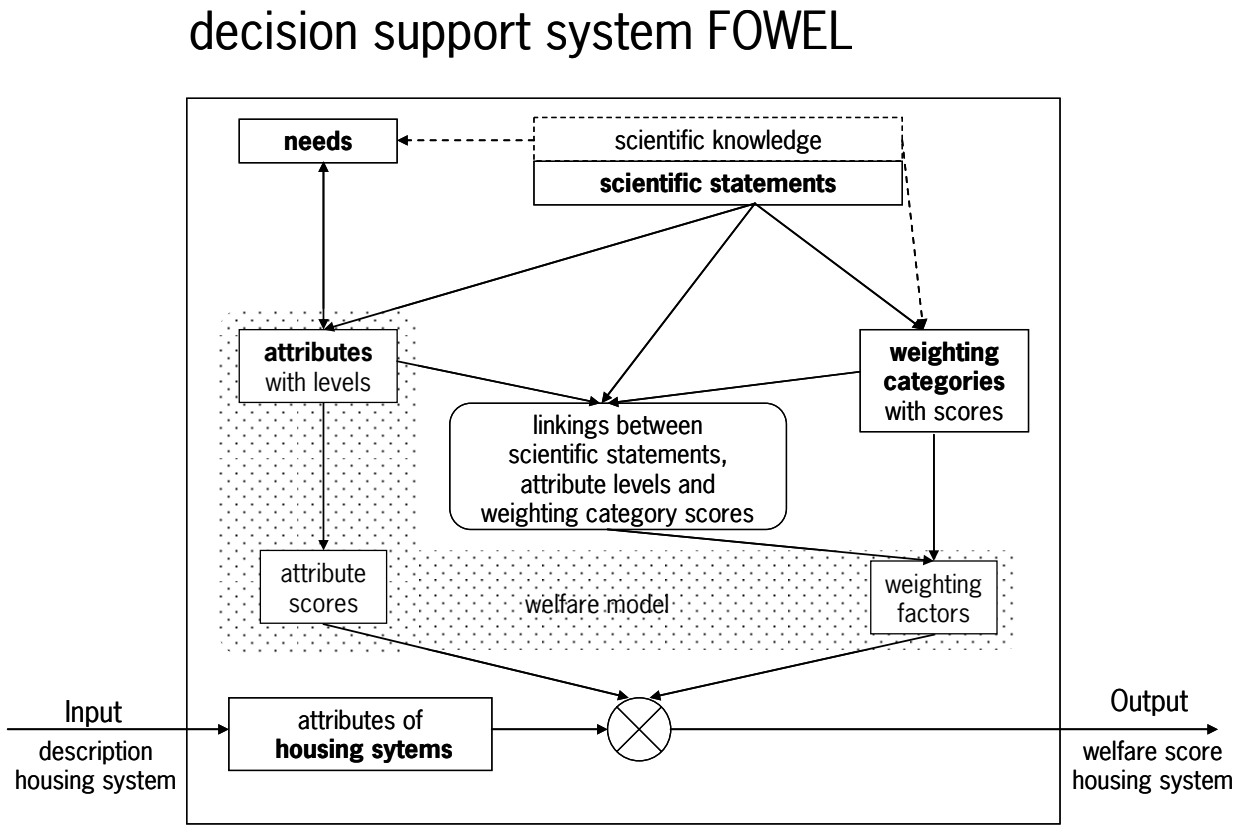


Figure 1 Structure of the decision support system for welfare assessment, implemented as a database with linked tables; the names of the most important tables are printed in bold (figure after Bracke, 2001; 73).

FOWEL contains descriptions of twenty Dutch husbandry systems, as well as two husbandry systems that were developed in the project Laying Hen Husbandry ('Houden van Hennen'): the Roundel and the Plantation (Wageningen UR project team, 2004). It is possible to add new systems in FOWEL. The 22 currently contained systems are:

1. cage system
2. cage system, lesser density
3. enriched cage system
4. barn system, no free range
5. barn system, semi-intensive eggs with free range
6. barn system, semi-intensive eggs with covered free range
7. barn system, semi-intensive eggs with covered and uncovered free range
8. barn system, free range eggs, intensive
9. barn system, free range eggs, extensive
10. aviary system, semi-intensive, no free range
11. aviary system, extensive, no free range
12. aviary system, semi-intensive eggs with free range
13. aviary system, free range eggs
14. aviary system, semi-intensive with covered free range
15. aviary system, extensive with covered free range
16. aviary system, semi-intensive with covered and uncovered free range
17. aviary system, free range eggs with covered and uncovered free range
18. organic production, barn or aviary system, with free range
19. twelve-hen system
20. uncultivated poultry (chicken, pheasants)
21. Plantation (Laying Hen Husbandry project)
22. Roundel (Laying Hen Husbandry project)

This list of 22 husbandry systems contains not only three cage systems, six variations on barn systems (some free range), eight variations on aviary systems (some free range), one organic production system and the two Laying Hen Husbandry project systems, but also two imaginary reference systems: a twelve-hen system where hens are kept in small group under perfect conditions and uncultivated poultry were hens live in free nature like their ancestors.

## 2.2 Implementation of FOWEL

FOWEL is implemented in Microsoft Access with tables, queries, forms and reports. The tables contain all relevant data, the tables are related (it is a relational database). For example, there is a table with attributes and a table with levels, these two tables are related to establish which levels are related to an attribute. Queries give a selection of data from one table or a combination of tables. Forms can be used to view and edit data in the tables. Reports give a survey of data in the tables.

A switchboard has been defined to help end-users navigating through the database. The main menu appears when the database is opened (see Figure 2), submenus with access to forms, reports or system information will appear when a switchboard item is selected. All relevant elements of the database can be accessed by the switchboard, so the database window (at the background of Figure 2) is hardly ever needed.

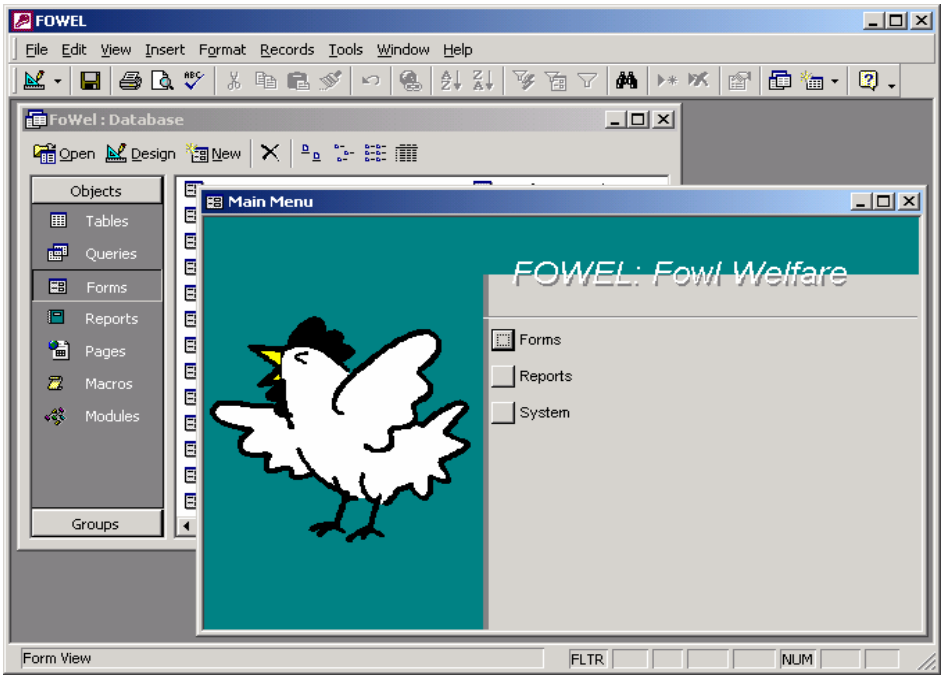

**Figure 2** Screen dump of the FOWEL implementation with the main menu.

The main tables (bold-printed in Figure 1) contain the scientific statements, the needs, the attributes, the weighting categories and the husbandry systems. The husbandry systems are defined by the levels of the attributes ('attribute scores'). The welfare model combines data from these tables: weighting factors are calculated, based on scientific statements and weighting categories. The weighting factors combined with the attribute scores of a husbandry system give the welfare score of a husbandry system. This procedure will be explained in detail in the next section.

### 2.3 Computations in FOWEL

The husbandry systems are defined by **attributes**; each attribute has two or more distinct **levels** that define the characteristics of a husbandry system. 25 Attributes are included in FOWEL, as given in Table 1. The weighting factor is the outcome of a calculation that is explained in this section.

**Table 1** List of attributes in FOWEL, sorted according to their weighting factor (WF) with the best level, the worst level and the number of levels (N).

| nr | attribute | best level | worst level | N | WF |
|---|---|---|---|---|---|
| 1 | feeding level | ad lib; enough eating places | restricted; limited eating places | 4 | 25 |
| 2 | space per hen | ≥ 2000 cm² | [450-600) cm² | 6 | 21 |
| 3 | perches | perches present (satisfying requirements) | perches absent | 3 | 18 |
| 4 | water availability | ad lib; enough drinking places | restricted; limited drinking places | 4 | 17 |
| 5 | nests | free to choose nest under shelter | no nests | 7 | 16 |
| 6 | beak trimming | beak trimming < day 8 | beak trimming ≥ day 8 | 3 | 15 |
| 7 | handling/disturbance | no sudden changes in environment | sudden long-lasting changes in environment | 3 | 15 |
| 8 | comfort behaviour | enough space for comfort behaviour (e.g. preening) | not enough space for comfort behaviour (e.g. preening) | 2 | 13 |
| 9 | dust bathing | ≥ 1 m²/100 hens, simultaneously | no dust bathing | 5 | 12 |
| 10 | pecking/scratching | scratching space < 8 hens/m²; litter depth ≥ 10 cm | no scratching room | 5 | 11 |
| 11 | foraging | feed in scratching room | no feed in scratching room | 2 | 10 |
| 12 | floor space | < 9 hens/$m^2$ | ≥ 16 hens/$m^2$ | 4 | 10 |
| 13 | novelty | variation in environment | no variation in environment | 3 | 8 |
| 14 | separation/visual contact | separation/fleeing possible | separation/fleeing not possible | 2 | 8 |
| 15 | cockerel | cockerel present (1/25 hens) | cockerel absent | 2 | 7 |
| 16 | palatability | high palatability | low palatability | 2 | 7 |
| 17 | hierarchical structure | ≤ 6 hens/group | > 3000 hens/group | 6 | 6 |
| 18 | light | light > 10 hr; > 60 lux | light ≤ 10 hr | 3 | 6 |
| 19 | free range | free range with shelter | no free range | 3 | 5 |
| 20 | predators | predators absent | predators present | 2 | 5 |
| 21 | air quality (gasses, dust) | within limits | outside limits | 2 | 4 |
| 22 | space per group | ≥ 500 m² | < 500 m² | 2 | 3 |
| 23 | climate | within limits | outside limits | 2 | 2 |
| 24 | litter handling | manure removal/drying > 1/week | no manure removal/drying | 3 | 2 |
| 25 | toe trimming | no toe trimming | toe trimming | 2 | 0 |

Each attribute is related to at least one **need** (see Figure 3). For example, attribute 'free range' is related to the needs 'Movement' and 'Exploration'. The need 'Movement' is not only related to 'free range', but also to the attribute 'space per group'. Twelve needs are defined in FOWEL that determine the welfare of laying hens:

1. Body care
2. Exploration
3. Health
4. Ingestion
5. Movement
6. Pre-laying and laying
7. Reproduction
8. Respiration
9. Rest
10. Safety
11. Social contact
12. Thermoregulation

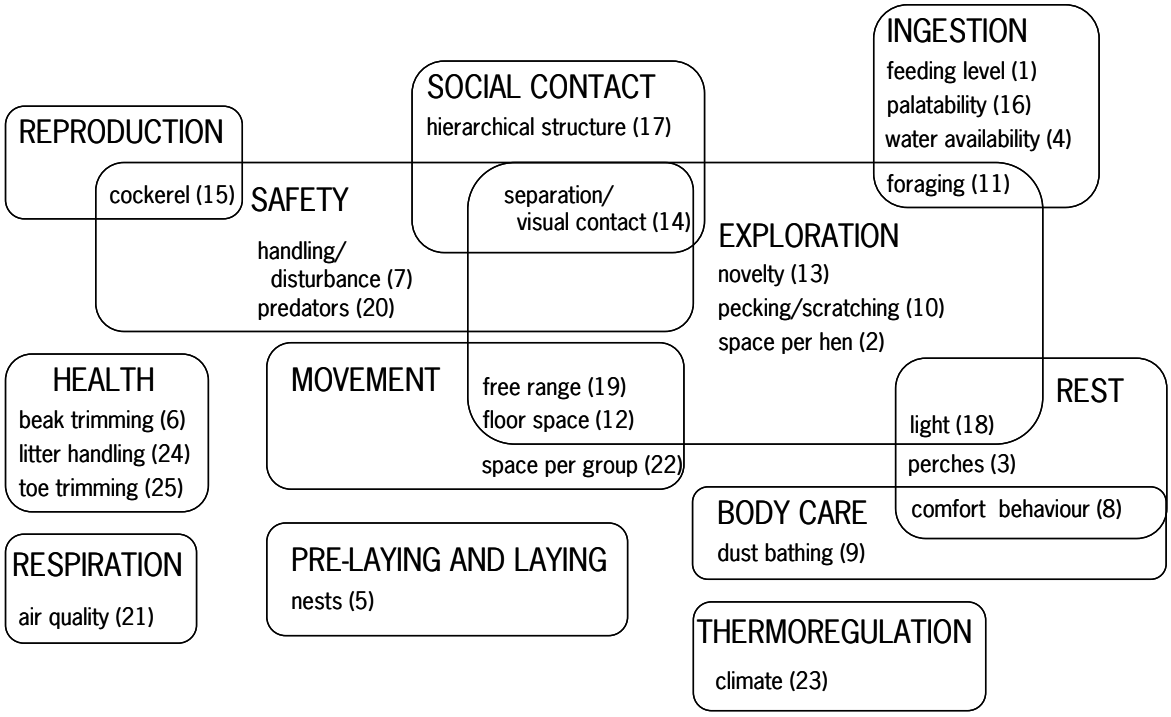


**Figure 3** Diagram showing how the attributes are linked to the needs, for each attribute the order is included between brackets.

The size of a frame in Figure 3 is not related to the importance of the need. The procedure for the definition of needs and attributed is described in Bracke (2001). As depicted in Figure 1, needs and attributes are used for the computation of weighting factors. The attributes represent welfare components, all attributes together represents the welfare. Each attribute has several levels (see Table 1), sorted from good to bad. This makes it possible to compute **attribute scores**. When an attribute has two levels, the best level gets attribute score 1 and the worst level gets attribute score 0. These scores are 1, ½ and 0 in case of three levels. With four levels these become 1, ⅔, ⅓ and 0. With even more levels, the scores are distributed evenly between 1 and 0 at the same way. The welfare score of a husbandry system is based on a combination of attribute scores and weighting factors per attribute (see Figure 1).

The weighting factors are based on scientific statements. A literature search has been done to get information on welfare of laying hens. Relevant **scientific statements** have been selected from this literature, telling something about the welfare of laying hens under specific conditions. For instance, the statement "For example a low stocking density decreases feather damage, and access to an outdoor run has a reducing effect." from Vestergaard & Johnsen (1998) says something about the effect of an outdoor run on feather pecking (that is, on abnormal behaviour). In general, a statement says something about the effects of a certain level of an attribute on a weighting category. The effect can be positive or negative. According to Bracke et al. (2002), the **weighting categories** classify welfare performance criteria, which have been measured in the various welfare disciplines, namely veterinary science (with the weighting categories 'pain' and 'illness'), evolutionary biology ('reduced survival', 'decreased fitness'), stress physiology (HPA, SAM), and ethology ('aggression', 'abnormal behaviour', 'frustration and avoidance', 'natural behaviour', 'preferences' and 'demand'); a survey is given in Table 2.

**Table 2** Weighting categories with a short description, the range of the weighting scores (all taken from Bracke et al., 2002) and the number of scientific statements in FOWEL linked to each weighting category.

| weighting category | description | range | number of statements |
|---|---|---|---|
| Pain | Evidence of pain including lameness and skin lesions, e.g. from aggression. | -1, -3, -5 | 6 |
| Illness | Evidence of health problems, including increased mortality, but excluding lameness, skin lesions, and specific survival aspects. | -1, -3, -5 | 2 |
| Reduced survival | Evidence of reduced survival related to physiological requirements (other than through specific health problems), e.g. longevity, minimum space requirements, deprivation of food or water, and a poor climate. | -1, -3, -5 | 10 |
| Decreased fitness | Evidence of decreased fitness (that is likely to indicate negative effect), including (re)production effects, but excluding specific survival aspects related to physiological necessities, HPA, and illness. | -1, -2, -3 | 5 |
| HPA | Evidence of activation of the HPA (hypothalamic-pituitary-adrenocortical) axis indicative of distress. | -1, -3, -5 | 3 |
| SAM | Evidence of SAM (sympathetic-adrenal-medullary) activation (indicative of negative effect), e.g. increased heart rate and (nor)adrenaline levels. | -1, -2, -3 | 0 |
| Aggression | Evidence of increased aggression excluding skin lesions (cf. pain). | -1, -2, -3 | 22 |
| Abnormal behaviour | Evidence of disturbed behaviour such as stereotypes, apathy, and disturbed sexual behaviour. | -1, -2, -3 | 42 |
| Frustration and avoidance | Evidence of blocked behaviour or deprivation including willingness to work to avoid a treatment. | -1, -2, -3 | 34 |
| Natural behaviour | Evidence of (potential positive reward from) behaviour as seen in (semi)natural conditions, including time budgets and species specificity of that behaviour. | +1, +2, +3 | 113 |
| Preferences | Evidence from preference tests and behaviour under other than natural circumstances, including rebound effects and anticipation. | +1, +2, +3 | 25 |
| Demand | Evidence that animals spend effort to obtain a commodity, especially using operant conditioning. | +1, +3, +5 | 12 |

The scientific statements relate the attribute levels with the weighting categories. When the database of FOWEL was filled, a score has been given for each relation, depending on the strength of a statement: a minimal, an average or a maximal effect. For weighting categories with a negative influence on welfare, this score is translated into a negative number: -1, -3 or -5 (for the main weighting categories) and -1, -2 and -3 (for the other weighting categories). For weighting categories with a positive influence on welfare this translation is: 1, 3 or 5 (for 'demand') and 1, 2 or 3 (for 'natural behaviour' and 'preferences'). If it can be concluded from a statement that there is no relation between an attribute level, than the score 0 may be given.

This procedure for relating statements with attribute levels and weighting categories was adopted from Bracke (2001). This procedure is elaborated further by Bracke by introducing types of a weighting category. This differentiation is not adapted here as it make the computation more complicated with only minor effects on the results.

**Attribute**

Level

| Weighting category | Score | | | | Statement |
|---|---|---|---|---|---|
| **8 foraging** | | | | | **(weighting factor = 10)** |
| 08,01 feed in scratching room | | | | | (weight = 6) |
| Aggression | 07,5 | no effects | 0 | 1813,2 | The results of the second experiment show that feeding on the floor alone, i.e. not in combination with environmental enrichment also reduces aggression, whereas is has no influence on social |
| Natural behaviour | 10,2 | average | 2 | 491,1 | These motivational factors determine a pattern of sampling behaviour that on the one hand ensures that chicks continue to ingest different types of particles, (...) |
| Natural behaviour | 10,2 | average | 2 | 399,1 | Feather pecking can be reduced by varying the supply of food and providing the opportunity for hens to seek their own food. |
| Natural behaviour | 10,2 | average | 2 | 316,1 | (..) feeding was the single most common activity (40% of all observations), but "comfort" behaviour (19%), standing or perching (14%), nesting (7%) and foraging (7%) also occupied appreciable proportions of time. |
| Natural behaviour | 10,2 | average | 2 | 1660,1 | The results support the idea that selection for high production results in modified behavioural strategies (.. such as extensive |
| Natural behaviour | 10,2 | average | 2 | 186,1 | Both the quality and the availability of the foraging materials had a significant effect on foraging behaviour and a significant but opposite effect on feather pecking. |
| Natural behaviour | 10,3 | maximal | 3 | 212,1 | but housing conditions that promote foraging behaviour help to reduce and prevent feather pecking. |
| Natural behaviour | 10,3 | maximal | 3 | 1813,1 | In both experiments, there was no difference in the amount of time feeding and also pecking and scratching even though food was not available in the litter in the unenriched situation. |
| Natural behaviour | 10,3 | maximal | 3 | 1341,1 | In order to reduce feather pecking and to increase foraging behaviour, it is recommended that laying hen chicks raised in aviary systems do get access to litter from day 1 on. |
| Natural behaviour | 10,3 | maximal | 3 | 131,1 | High rates of feather pecking and pronounced feather damage were only found in hens housed without access to straw and fed on |
| Natural behaviour | 10,3 | maximal | 3 | 1847,1 | Both breeds behaved in accordance to some qualitative predictions based on the optimal foraging theory, i.e. moved between patches, left patches before these were empty and stayed shorter time on successive visits to the same patch. |
| Preferences | 11,2 | average | 2 | 1834,1 | Wild-type hens react stronger on a predator attack then domestic hens. And they look better for cover. The average number of birds in the open area was higher in domestic birds than in wild-type |
| Preferences | 11,3 | maximal | 3 | 1267,1 | Food choice is determined by social facilitation in chicks. |
| 08,02 no feed in scratching room | | | | | (weight = -4) |
| Pain | 01,1 | minimal | -1 | 597,1 | Fayoumi hens spent about 11.5 min/h at the feeders, 2 min drinking and just over 4 min roosting and the rest of the time they seemed to be "merely moving around". |
| Abnormal behaviour | 08,2 | average | -2 | 1284,1 | It is concluded that some of these factors could inhibit foraging and dust-bathing behaviour and others may increase competition or frustration, both of these changes having been shown experimentally to initiate feather pecking behaviour. |
| Abnormal behaviour | 08,2 | average | -2 | 86,1 | The results suggest that feather pecking in laying hens is associated with stress. |
| Abnormal behaviour | 08,2 | average | -2 | 19,1 | Evidence suggests that cannibalism (...) is redirected foraging behaviour. This study provides the first experimental evidence that social learning can contribute to the spread of cannibalism (..) |
| Abnormal behaviour | 08,2 | average | -2 | 130,1 | Feather pecking in hens is associated with stress. Provision of foraging material (long-cut straw) and food form (mash instead of pellets) reduces feather pecking. |
| Abnormal behaviour | 08,2 | average | -2 | 110,1 | It is concluded that the results support the hypothesis put forward that genetic differences in foraging behaviour could be the basis for the genetic influence in the development of feather pecking. |
| Abnormal behaviour | 08,2 | average | -2 | 179,1 | It is concluded that hens should be provided with foraging material and high perches during the laying period to reduce feather pecking and feather damage. |
| Abnormal behaviour | 08,3 | maximal | -3 | 43,1 | This study suggests that litter quality is important to hens, and that a substrate must provide feedback for dustbathing and/or foraging to reduce the risk of severe feather pecking. |

**Figure 4** Part of a FOWEL report with a survey of statements per attribute and level, with the related weighting categories, the computed weight per level and the weight factor of the attribute.

The definition of attributes (and levels), the weighting categories (and scores) and scientific statements on welfare of laying hens, make it now possible to calculate the weighting factor per attribute. This is explained here with an example from FOWEL (a more formalized explanation can be found in Bracke, 2001). Figure 4 contains a part of a report from FOWEL with a survey of all statements for the attribute 8 'foraging' with related weighting categories and scores. There are two levels for the attribute foraging: level '08,01': 'feed in scratching room' and '08,01': 'no feed in scratching room'. Thirteen scientific statements have been found for level 08,01 (see Figure 4), related to the weighting categories Aggression (n = 1), Natural behaviour (n = 10) and Preferences (n = 2). Eight statements have been found for level 08,02, related to Pain (n = 1) and Abnormal behaviour (n = 7).

The 'weight' of a level is defined as the sum of the maximal scores per weighting category for statements related to this level. Thus, the weight for level 08,01 ' feed in scratching room ' is the sum of 0 (maximum score for Aggression), 3 (maximum score for Natural behaviour) and 3 (maximum score for Preferences) makes 6. Similarly, the weight for level 08,02 'no feed in scratching room' is the sum of -1 (maximum score for Pain) and -3 (maximum score for Abnormal behaviour) makes -4.

The weighting factor of an attribute is defined as the maximum difference between the weights of the levels of the attribute. So, the weighting factor for the attribute 'foraging' is the difference between the weight of the two levels, that is the difference between 6 and -4 is equal to 10 (see Figure 4).

This procedure for calculating the weighting factors has been applied for each attribute. The results are included in Table 1. As explained in Figure 1, the welfare score of a husbandry system is computed by combining the attribute scores with the weighting factors.

The absolute welfare score of husbandry system h is defined as the sum over all attributes a of the attribute score of husbandry system h and attribute a multiplied by the weighting factor of attribute a:

$$\text{absolute score}(h) = \sum_{a=1}^{25} \left( \text{attribuutscore}_a^h \cdot WF_a \right).$$

For example, for husbandry system 1, 'cage system' the absolute score is the sum of:

- de attribute score 1 for 'feeding level' multiplied by the weighting factor 25 is 25;
- de attribute score 0 for 'space per hen' multiplied by the weighting factor 19 is 0;
- ...
- ...
- de attribute score 1 for 'litter handling' multiplied by the weighting factor 2 is 2;
- de attribute score 1 for 'toe trimming' multiplied by the weighting factor 0 is 0.

Thus, the absolute score of husbandry system 1 is:

absolute score(1) = 25 + 0 + ... + 2 + 0 = 55.67.

Husbandry system 1 appears to be the husbandry system with the lowest absolute welfare score. Husbandry system 19 'twelve-hen system' is the husbandry system with the highest absolute score: 216.63. There is no existing husbandry system with all attributes at the highest level; the absolute welfare score for such a hypothetical husbandry system would be 246.

The absolute welfare scores of husbandry systems are transformed to relative welfare scores on a scale from 0 to 10. The relative welfare score 0 is assigned to the husbandry system with the lowest absolute welfare score and 10 to the husbandry system with the highest absolute score. Only the first 20 husbandry systems have been taken into account for setting the highest and lowest absolute welfare scores, the two husbandry systems from the Laying Hen Husbandry project were not included for this. An intermediate value proportional to the absolute value is assigned as the relative welfare score to all husbandry systems:

$$\text{relative score(h)} = \frac{(\text{absolute score(h)} - 55.67)}{(216.63 - 55.67)} \cdot 10 \,.$$

For example, the absolute score of husbandry system 4, 'barn system, no free range' is 150.43. Thus, the relative score is:

$$\text{relative score(4)} = \frac{(150.43 - 55.67)}{(216.63 - 55.67)} \cdot 10 = 5{,}9$$

The absolute and relative scores of the 22 included husbandry systems are presented in the next chapter.

## 3 Results

The database of the decision support system FOWEL has been filled with data: 12 needs, 25 attributes, 22 husbandry systems, 300 relevant scientific statements and 12 weighting categories (as in Table 2). The scientific statements have been related with weighting categories and scores. All this is combined with the attributes and their levels to compute the weighting factors per attribute (as described in the previous chapter). The resulting weighting factors as given in Table 1 are an important result from FOWEL. The attribute 'feeding level' has the highest weighting factor and is thus the most important attribute. Other important attribute are 'space per hen' and 'perches'. The attribute 'free range' is of minor importance with 5 as weighting factor and being the 19th attribute in a sorted list of 25 attributes.

The weighting factors per attribute and the attribute scores of husbandry systems have been combined to compute the welfare scores of the husbandry systems. The resulting relative welfare scores are given in Table 3 and depicted in Figure 5, the absolute scores are given in Table 3 and depicted in Figure 6.

**Table 3** Relative (on a scale from 0 to 10) and absolute welfare scores (based on attribute scores and weighting factors), computed by FOWEL for 22 husbandry systems, sorted by score.

| nr | husbandry system | relative score | absolute score |
|---|---|---|---|
| 1 | cage system | 0.0 | 55.67 |
| 2 | cage system, lesser density | 0.3 | 59.87 |
| 3 | enriched cage system | 2.3 | 92.82 |
| 10 | aviary system, semi-intensive, no free range | 5.8 | 149.77 |
| 4 | barn system, no free range | 5.9 | 150.43 |
| 11 | aviary system, extensive, no free range | 6.1 | 153.10 |
| 12 | aviary system, semi-intensive eggs with free range | 6.1 | 154.27 |
| 14 | aviary system, semi-intensive with covered free range | 6.3 | 156.77 |
| 16 | aviary system, semi-intensive with covered and uncovered free range | 6.3 | 156.77 |
| 5 | barn system, semi-intensive eggs with free range | 6.3 | 157.43 |
| 7 | barn system, semi-intensive eggs with covered and uncovered free range | 6.5 | 159.93 |
| 6 | barn system, semi-intensive eggs with covered free range | 6.6 | 162.18 |
| 13 | aviary system, free range eggs | 6.7 | 163.10 |
| 8 | barn system, free range eggs, intensive | 6.7 | 163.27 |
| 9 | barn system, free range eggs, extensive | 6.7 | 163.27 |
| 17 | aviary system, free range eggs with covered and uncovered free range | 6.8 | 165.60 |
| 15 | aviary system, extensive with covered free range | 7.0 | 167.85 |
| 18 | organic production, barn or aviary system, with free range | 7.8 | 181.37 |
| 20 | uncultivated poultry (chicken, pheasants) | 8.7 | 196.00 |
| 21 | Plantation (Laying Hen Husbandry project) | 9.2 | 204.17 |
| 22 | Roundel (Laying Hen Husbandry project) | 9.6 | 209.67 |
| 19 | twelve-hen system | 10.0 | 216.63 |

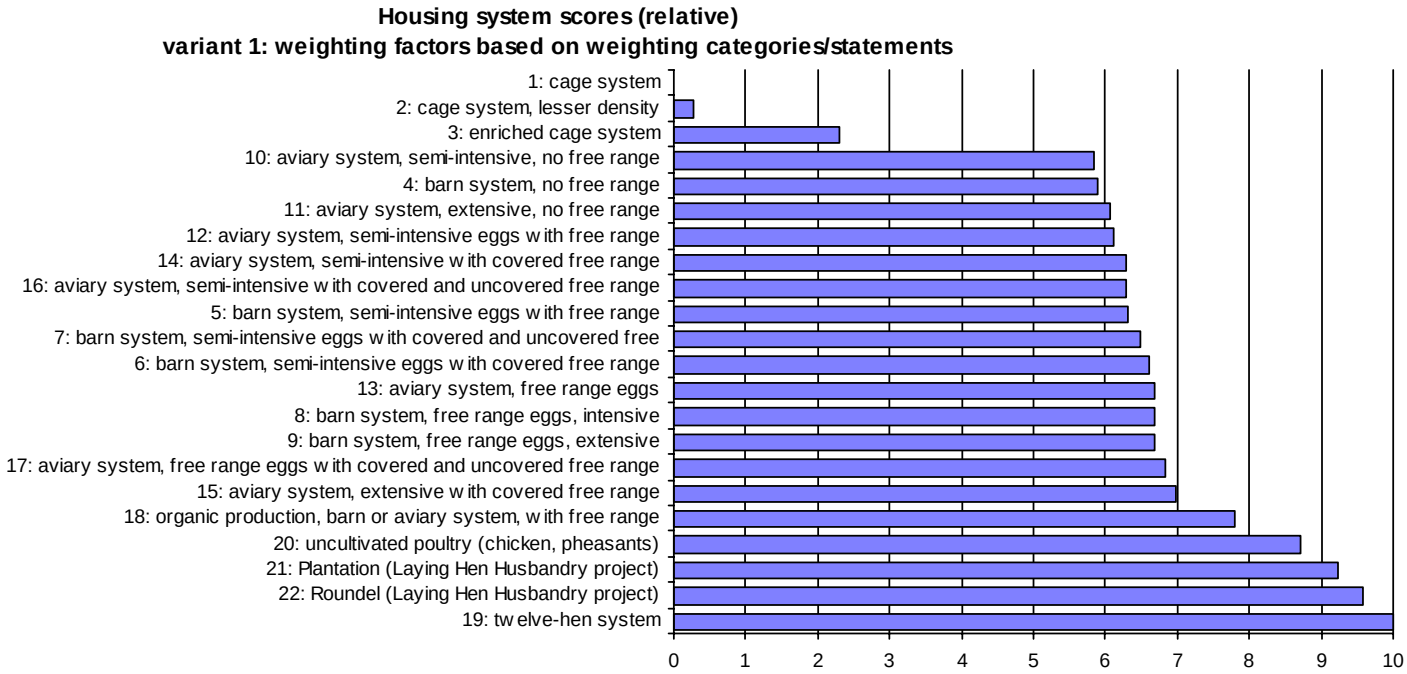


**Figure 5** Relative welfare scores on a 1-10 scale for 22 husbandry systems calculated with FOWEL.

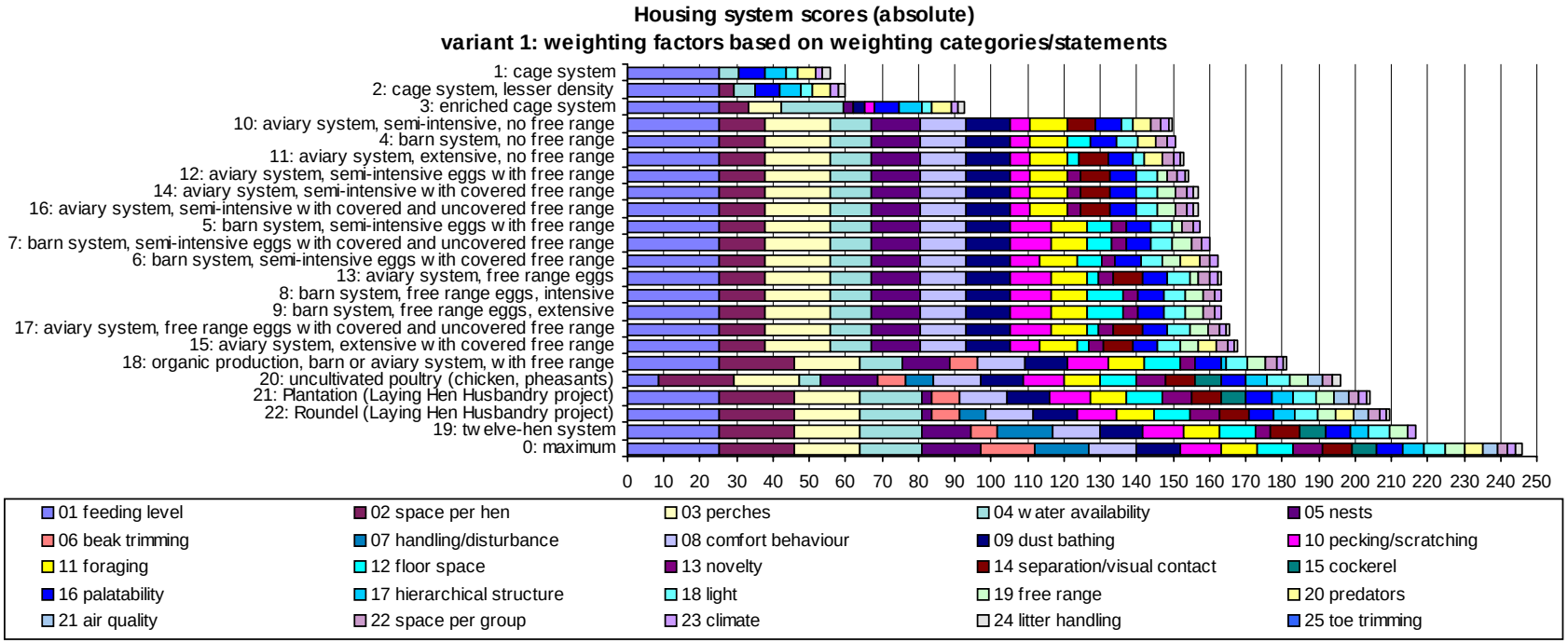


**Figure 6** Absolute welfare scores for 22 husbandry systems (and a hypothetical husbandry system 0 with all attribute levels at the maximum) calculated with FOWEL.

The absolute score in Table 3 and Figure 6 have been computed by summing the attribute score (1 for the best level and 0 for the worst level) multiplied by the weighting factor, over the attributes. A hypothetical husbandry system with all attribute score equal to 1 would get 246 as the absolute score. This system is included in Figure 6 with the name '0: maximum'.

It can be seen in Figure 6, how the absolute score is composed of attribute score times weighting factor. Attributes with a high weighting factor also have a high contribution to the total score of a husbandry system.

The relative scores in Table 3 and Figure 5 are derived from the absolute scores: the relative score is 0 for the husbandry system with the lowest absolute score (cage system) and the relative score is 10 for the system with the highest absolute score (twelve-hen system). The relative scores of the other husbandry systems are between 0 and 10 in proportion with their absolute score.

## 4 Discussion

The welfare score of 22 husbandry systems has been calculated, they can be classified as:
- a minimal score is given to cage systems, a low score to the enriched cage;
- a moderate score is given to all barn and aviary systems, the mutual differences have minor influence on the welfare score;
- a high score is given to organic systems.

FOWEL makes it possible to compare husbandry systems on welfare. However, the minimum level for welfare is not evident. FOWEL can not be used to set the minimum level; it is up to the government to regulate husbandry systems or the consumer to choose eggs from preferred husbandry systems.

The results of the FOWEL computations have been validated with expert opinions on the welfare status of husbandry systems. There was a substantial agreement between the experts and the model on the ranking of attributes and husbandry systems. Details on this expert's validation are given in De Mol et al. (2004).

The weighting factor resembles the relative weight of an attribute for the welfare of laying hens. According to Table 1, the five most important attributes are: feeding level, space per hen, perches, water availability and nest. Free range is one of the minor important attributes. That is remarkable, as it is a major issue in discussion on the welfare of laying hens. The scientific evidence for this concern appears to be missing.

The relative welfare score is derived from the absolute welfare score, 0 for the worst system, 1 for the best system and the others proportionally. The resulting scores with this method depend on the set of available husbandry systems. The results would quite different if, for example, the cage systems were not included (as they are to be banned in the future). The ranking of the other systems will not change, but the level of the scores will be different. An alternative transformation is relating the relative score 0 to the absolute score 0, and relating the relative score 10 to the absolute score 246 (that is the score for a hypothetical perfect system). This alternative might be preferred as the results can be interpreted more as school marks.

## 5 Conclusion

The decision support system makes it possible to compare husbandry systems for laying hens on welfare status, based on available scientific knowledge. The method applied for pregnant sows in Bracke (2001) is also applicable for laying hens. It is possible to add new knowledge to FOWEL or to compute the welfare scores of other husbandry systems.

FOWEL has been used to compute the welfare score of 22 husbandry systems:
- a bad score is given to cage systems, although the score of an enriched cage system is less worse;
- a moderate score is given to barn and aviary systems, the mutual differences are small;
- a high score is given to organic production systems.

Important attributes for welfare are feeding level, space per hen, perches, water availability and nest. Free range is one of the minor important attributes.

FOWEL cannot be used to define the minimal acceptable welfare level, that is a task of politics and consumers.

## 6 References

Bracke, M.B.M., 2001. Modelling of animal welfare: The development of a decision support system to assess the welfare status of pregnant sows. PhD thesis IMAG Wageningen.

Bracke, M.B.M., B.M. Spruijt, J.H.M. Metz and W.G.P. Schouten, 2002. Decision support system for overall welfare assessment in pregnant sows A: Model structure and weighting procedure. Journal of Animal Science 80 (7): 1819-1834.

Mol, R.M. de, W.G.P. Schouten, E. Evers, W.C. Drost, H.W.J. Schouten & A.C. Smits, 2004. Integrale welzijnsbeoordeling leghennen. Agrotechnology & Food Innovations, Rapport 239.

Vestergaard, K.S. and Johnsen, P.F., 1998. The development of feather pecking in fowl: the dust-bathing hypothesis and the effect of distractability. Proceedings of the 32nd Congress of the International Society For Applied Ethology.

Wageningen UR projectteam Houden van Hennen, 2004. Laying Hens Husbandry - towards a happy hen life, proud farmers and a satisfied society. Wageningen - Lelystad, Wageningen UR, ISBN 90-6754-793-3.