Welfare of laying hens housed in cages and in avairies: what about fearfulness?

Introduction

In numerous countries, laying hens are mainly kept in conventional cages. In France, for example, in 2002, about 83% of hens were kept in conventional cages (Chalimaud, 2003). Many criticisms about this system have been raised for several years, because the space is restraint and the only furnishings consist in nipple drinkers and feed troughs. In Europe, the Council Directive 1999/74/EC intends to increase the laying hens’ welfare by authorising only wider housing systems with more furnishings: furnished cages and non-cage systems (aviaries and floor systems, with or without access to outdoor areas). These authorised systems are supposed to diversify the behavioural repertoire of hens, e.g. performance of comfort behaviours thanks to the increased space and the presence of perches, nesting and dust-bathing areas.

This directive was based on comparative research on the welfare of hens housed in cages and in alternative systems, including avairies (for review see Appleby and Hughes, 1991). Most of the studies comparing cages and avairies took into account mortality (Abrahamsson and Tauson, 1995; Tauson et al., 1999), performance of targeted behaviours such as dust bathing (Blokhuis and Metz, 1992), space use (Abrahamsson and Tauson, 1995), time budgets and abnormal behaviours (Hansen, 1994). These studies showed that mortality and health are not always better in aviaries than in cages, but that welfare is better in terms of behavioural priorities (like dust bathing, pecking and scratching), frequency of activity transitions, level of general activity and abnormal behaviours in avairies.

The welfare of laying hens is mainly assessed on the basis of the parameters previously mentioned. Assessment via emotional reactivity can give complementary information. Emotional reactivity is the set of emotional states felt by an individual which, after being integrated in the central nervous system, govern its coping responses to a disturbance (Boissy, 1998). The most studied of these emotional states is fearfulness, which is the individual's propensity to be more or less easily frightened (Boissy, 1998). Jones (1996) and Boissy (1998) emphasised that fearfulness and adaptation are linked. Too high fearfulness reduces adaptation abilities. Impaired adaptation abilities can in turn increase fearfulness. The process is that fearfulness competes with, and can inhibits, a variety of fundamental behaviours motivated by other motivational systems (exploration, social interactions, learning...). Moreover, fearfulness could elicit dangerous behaviours such as panic, which directly compromise welfare (Jones, 1996). In spite of the fact that welfare is influenced by fearfulness, comparisons of the welfare between cages and alternative systems are rarely based on fearfulness, even if studies on fear exist. They used a novel object test to compare cages (2 to 4 birds) and pens (4 birds) (Hughes and Black, 1974), and a tonic immobility test to compare cages (4 birds) and pens (4 birds) (Jones and Faure, 1981) and cages (3 birds) and aviaries (1500 birds) (Hansen et al., 1993).

Fearfulness can be inferred from behavioural coping responses to threatening situations (Boissy, 1998). These threatening situations have been classified into: stimuli evoking an unlearned fear response, novelty, dangers the animal has learned to avoid, stimuli which arise from con-specifics and characteristics of stimuli presentation. These different threatening stimuli induce different behavioural responses. Stimuli evoking an unlearned fear response and novelty are threatening situations classically used in birds to assess fear and fearfulness (Gallup, 1979; Jones, 1996). The tonic immobility reaction is an unlearned anti-predator reaction to physical restraint which is induced by the contention of the bird for a few seconds (Gallup et al., 1971). In novelty tests, individuals are introduced in a novel environment (Jones, 1977b; Faure, 1980) or confronted to a novel object (Jones, 1985).

The aim of this study was to compare the welfare, mainly on a fearfulness basis, between hens housed in conventional cages and in laying avairies. Two rearing systems for the pullets assigned to laying avairies were evaluated: rearing aviaries and furnished floor pens. Furnished floor pens have the advantage of being less expensive to install and easier to manage than avairies. However, the former rearing system can influence the adaptation to laying avairies, but also the hens' fearfulness, because early experiences modulate fearfulness (Denenberg, 1969; Jones, 1986a; Reed et al., 1993; Boissy, 1998). The level of fearfulness of hens was assessed during the laying period by tonic immobility, novel environment and novel object tests. In addition, we used viability and egg production as indicators of welfare.

Materials and Methods

Animals and housing

The study involved ISA Brown hens. They arrived at one day, were beak-trimmed at nine days, transferred from...
rearing to laying systems at 17 weeks and slaughtered at 69 weeks of age. They were placed in three different combinations of housing during rearing and laying periods (three treatments): (1) 5060 were reared in floor pens, then kept in conventional cages (FC = Floor - Cage), (2) 2560 were reared in furnished floor pens, then kept in an aviary (FA = Furnished-floor - Aviary), (3) 2560 were reared in aviaries, then kept in an aviary (AA = Aviary - Aviary).

FC hens were reared in seven floor pens (69 m² each: 847 cm² of usable area per pullet) with automatic feed-hoppers on litter. After transfer, they were allocated to four three-tier batteries of conventional cages (five hens per cage: 582 cm² of usable area per hen) for the laying period. Cages (Big Dutchman, Germany) were 60 cm wide, 48.5 cm deep and 40 cm high (at 2/3 depth) with two water nipples at the rear and an automatic feeding-chain in the front. FA hens were reared in three furnished floor pens, containing perches and two slatted platforms (69 m² each: 1020 cm² of usable area per pullet), with automatic feed-hoppers on slatted platforms (Figure 1). After transfer, they were kept in one laying aviary. AA hens were reared in four rearing aviaries (Natura Rearing type, Big Dutchman, Germany, 24 m² each: 546 cm² of usable area per pullet), identical to laying aviaries but adapted to pullets' size and without nest boxes, with automatic feeding-chains on slatted platforms. After transfer, they were kept in another laying aviary. Laying aviaries (Natura Nova, Big Dutchman, Germany) are described in Figure 2. They were 7.5 m wide and 30 m deep, and gave 1149 cm² of usable area per hen.
Conventional cages and laying aviaries were in two barns, in which all conditions (lighting, temperature...) were standard and similarly controlled. However, luminosity slightly differed between barns: from 6 lx in front of first tier to 30 lx in front of third tier of the cages, and from 2 lx over the litter to 18 lx over slatted platforms in aviaries.

**Assessment of fearfulness**

To assess fearfulness, tonic immobility tests, novel environment tests and novel object tests were used. Hens were sampled from 30 areas for tonic immobility, and from 12 areas for novel environment and novel object. Areas were distributed on the length and the vertical levels of cage batteries and aviaries. All hens involved in tests were tested only once, and in only one type of test. Tests were performed either in the evening for tonic immobility (from 17:00 to 22:00) and novel environment (from 20:30 to 21:00) or in the morning and in the afternoon for novel object (from 09:00 to 17:00).

**Tonic immobility tests.** Tonic immobility tests were performed over five days, when hens were 66 weeks old. 30 hens per treatment were tested. They were caught one by one with care and carried in the arms of the experimenter to the test location. Two cradles were used, which were visually isolated from each other. The observer was totally silent, but hens could hear each other. The method described by Jones (1986b) was adapted. Tonic immobility was induced by placing the hen on its back and restraining it for 10 seconds, with one hand over the head and one hand on the sternum, in a U-shaped wooden cradle covered with a cloth. If the hen righted itself before 10 seconds after induction, a new induction was started.

The duration of tonic immobility until the hen righted itself (maximum of 1800 seconds) was video-recorded, as well as the number of inductions (maximum of five) and the number of scanning head movements with great amplitude rather than a postural change of head (given in number per 30 seconds of tonic immobility).

**Novel environment tests.** Novel environment tests were performed when hens were 52 to 59 weeks old. Test-arenas were 100 cm wide, 100 cm deep and 80 cm high; they were composed of a wire lid, two contiguous wooden and two contiguous wire walls. Their floor was divided into four quarters. They contained one tray feeder, one flow drinker and a piece of Astroturf® (40×40 cm). Twelve groups of four hens per treatment were tested. Each group of FC hens was constituted of hens housed in a same cage. Each group of FA and AA hens was constituted of hens close together. One group of AA hens was removed from analyses because of testing procedure problems. Hens were carried carefully in a closed plastic box to the visually isolated test-arenas. They were individually identified, placed in test-arenas – always in the same quarter named “departure-quarter” – behind a board. Measures were taken for 10 minutes after removal of the board. Hens were tested in their own background: in a test-arena located in the cage barn for FC hens, and in another test-arena located in the aviary barn for FA and AA hens.

Observed behaviours were indicators of mobility, exploration, activity and disturbance due to the test situation. We measured the latencies to first movement, first floor-peck (wooden floor or Astroturf®), first feeding bout, first exit from departure-quarter, and also the numbers of quarter changes, attempts to exit (flying or jumping in direction of the lid and passing the head through wire walls) and the presence/absence of pacing (back-and-forth steps), by focal sampling on video recording. From 20 scans on video recording (1 scan every 30 seconds for each hen; *i.e. 80 observations*), we measured an activity score: number of hens observed pecking, scratching, eating, drinking, preening or engaged in social interactions; a movement score: number of hens observed walking, jumping or flying; and an inactivity score: number of hens engaged in none of the activities mentioned above.

**Novel object tests.** Novel object tests were performed when hens were 66 weeks old on 12 groups of four hens. Arenas of novel environment tests were used. They were empty and a square (50 cm per 50 cm) was added on the floor to delimit a central zone. The testing procedure was the same as in novel environment tests, except that hens were not placed behind a board. They were left undisturbed for 15 minutes to get accustomed to the test-arena, then the novel object was slowly lowered into the centre of the central zone and suspended at the level of hens’ head. The novel object was a transparent plastic pot (5×10 cm) filled with white artificial lures to attract hens. This object was chosen instead of an object covered with colour stripes, because it was attractive and not too frightening, what permits us to avoid too strong responses. Artificial lures had not been placed outside the object, because we have previously observed that hens eat them. Measures were collected for 15 minutes before and 30 minutes after the presentation of the object.

Observed behaviours were indicators of general mobility, reaction to novel object and disturbance due to the test situation. Before the presentation of the object, we measured the mean duration of time spent in the central zone (i.e. total duration divided by frequency of entries), the latencies to first entry in the central zone and first floor-peck, the numbers of quarter changes, of attempts to exit and of pacing, by focal sampling on video recording. After the presentation of the object, we measured the same parameters, and the latencies to first movement and first object-peck, the presence/absence of panic reaction (hens flying or running very quickly in all directions) and of object-pecks, by focal sampling on video recording.

The influence of hens’ reactions to test-arena has been taken into account for the time spent in the central zone, the latencies to first floor-peck and first entry in the central zone, the numbers of quarter changes, attempts to exit, and pacing. For these variables, the value measured before the presentation of the object (over 15 minutes) was deducted from the value measured after the presentation of the object (mean value by 15 minutes). Therefore, positive differences indicated an increase in numbers, latencies and durations after the presentation of the object. Conversely, negative differences indicated a decrease in these measurements.

**Viability and egg production**

Viability and egg production were measured every day. The viability rate (number of hens alive / total number of hens transferred × 100) and the laying rate (eggs produced/hen/day) were calculated per week.

**Statistical analyses**

For tonic immobility tests, the statistical unit was the hen (*n = 30*). For novel environment and novel objects, the statistical unit was the group of four hens (*n = 12*).

As data had a non normal distribution and some samples were of small size, variables were analysed using non parametric tests: a Kruskal-Wallis test for overall comparison of the three treatments, followed by pair comparisons with Mann-Whitney U test when significant (*p* < 0.05). Pres-
Table 1. Means ± standard deviation of variables measured in the novel environment tests. FC hens reared in floor pens and then kept in conventional cages - FA hens reared in furnished-floor pens (with perches and slatted platforms) and then kept in a laying aviary - AA hens reared in rearing aviaries and then kept in a laying aviary.

Table 2. Means ± standard deviation of scores measured in the novel environment tests. FC hens reared in floor pens and then kept in conventional cages - FA hens reared in furnished-floor pens (with perches and slatted platforms) and then kept in a laying aviary - AA hens reared in rearing aviaries and then kept in a laying aviary.

Results

Tonic immobility tests
There was no significant difference between FC, FA and AA hens concerning the duration of tonic immobility (FC 607 ± 550; FA 472 ± 449; AA 415 ± 411 seconds; p = 0.50), the number of inductions (FC 1.57 ± 0.7; FA 1.80 ± 1.0; AA 1.97 ± 1.2; p = 0.60) and the number of scanning head movements per 30 seconds (FC 0.12 ± 0.03; FA 0.27 ± 0.10; AA 0.28 ± 0.07; p = 0.37).

Novel environment tests
For all the variables, FC and AA hens significantly differed from FC hens. FC hens were less mobile, explored the novel environment less, were less disturbed by the test situation (Table 1), and were also less active (Table 2). Among the variables measured, one significant difference was found between FA and AA hens (Table 1). It concerned the latency to first feeding bout that was lower in FA than in AA hens. There were not enough hens performing pacing to do statistical analyses (FC 0 hens; FA 2 hens; AA 2 hens).

Regarding the presence/absence of object-pecks, there was a significant difference between the three treatments (FC 3/12; FA 9/12; AA 7/12; p = 0.044). Fewer FC than FA hens pecked the object (p = 0.014). AA hens took an intermediate position and did not differ significantly from FC and FA hens. Concerning other reactions to the novel object, no significant differences were found between FA and AA hens, but both significantly differed from FC hens (Table 3). FC hens had a longer latency to first object-peck, a higher increase in the latency to first entry in the central zone after the presentation of the object, and a higher decrease in the mean duration of time spent in the central zone. Furthermore, panic reactions after the presentation of the object were only observed in FC hens.

Regarding general mobility, FC hens significantly differed from FA and AA hens only in the number of quarter changes, which decreased in FC hens only.
The increase of the laying rate was faster in AA peaks of mortality occurred from weeks 22 to 36. No difference was found between the three treatments in responses to tonic immobility tests. This is in contrast with three treatments: the number of attempts to exit increased and AA hens did not differ significantly from FC and FA hens, compared to FC and FA hens. The peak of lay was reached in week 22 in FC and AA hens, and in week 24 in FA hens. During the whole laying period, FA hens laid more eggs outside the nests than AA hens did (0.08 vs. 0.04 eggs/hen/day). The laying rate of FC hens remained higher than those of FA and AA hens for the whole laying period (FC 0.88, FA 0.84, AA 0.85).

**Viability and egg production**

Until week 62, viabilities of FC and AA hens were very high and above ISA reference (Figure 3). In week 62, a peak of mortality occurred among FC hens. Among FA hens, three peaks of mortality occurred from weeks 22 to 36. Hens of all treatments began to lay at 18 weeks of age (Figure 4). The increase of the laying rate was faster in AA hens, compared to FC and FA hens. The peak of lay was reached in week 22 in FC and AA hens, and in week 24 in FA hens. During the whole laying period, FA hens laid more eggs outside the nests than AA hens did (0.08 vs. 0.04 eggs/hen/day). The laying rate of FC hens remained higher than those of FA and AA hens for the whole laying period (FC 0.88, FA 0.84, AA 0.85).

**Discussion**

**Assessment of fearfulness**

No difference was found between the three treatments in responses to tonic immobility tests. This is in contrast with several previous studies using tonic immobility test, which pointed out a greater fearfulness of caged hens compared to hens kept in pens or in aviaries (JONES and FAURE, 1981; HANSEN et al., 1993).

In our study, hens could hear each other during the tests. This may have increased the variability in tonic immobility duration within treatments, and then reduce the differences between treatments. Indeed, the coefficients of variation recorded in our study (FC 91%, FA 95%, AA 99%) were greater than those recorded by JONES and FAURE, (1981) and HANSEN et al. (1993) (from 44% to 87%). The later found a significant difference in tonic immobility responses between cage and aviary hens. They had experimental conditions close to ours, but not totally similar: 3 hens per cage and 1500 hens per aviary whereas we had 5 hens per cage and 2560 hens per aviary. Moreover, they did not use the same strain as us: they used a White Leghorn strain. Several authors have pointed out that hens from different strains react differently under different husbandry conditions. For example, ALBENTOSA et al. (2003) reported that White Leghorn hens show a longer tonic immobility duration than ISA Brown hens. Differences in tonic immobility responses between treatments might be greater among White Leghorn hens than ISA Brown hens, what explains probably the lack of difference we obtained.

Compared to aviary hens (FA and AA) cage hens (FC) were less mobile, less active, showed more panic reactions after the presentation of the novel object and explored less the novel environment and the novel object. It is known that fearfulness competes with and inhibits a variety of fundamental behaviours such as exploration, social interactions or comfort behaviours. In a given situation, the less an individual explores, moves or is active, the more fearful
she is considered (FAURE, 1975; JONES, 1977a; MURPHY, 1978; FAURE, 1980). In cases of extreme fear, the individual can even freeze (MURPHY, 1978). Thus, it appears that cage hens were more fearful than aviary hens. Moreover, aviary hens seemed uninterested in the test situations. Even though some of them pecked at the object in novel object tests, they quickly returned to the activity in which they were engaged before the presentation of the object. This behaviour demonstrates a low level of fear (BOISSY, 1998).

**Figure 3. Viability rate during the laying period.** FC hens reared in floor pens and then kept in conventional cages - FA hens reared in furnished-floor pens (with perches and slatted platforms) and then kept in a laying aviary - AA hens reared in rearing aviaries and then kept in a laying aviary, in comparison with ISA reference (ISA).

**Figure 4. Laying rate of FC hens reared in floor pens and then kept in conventional cages - FA hens reared in furnished-floor pens (with perches and slatted platforms) and then kept in a laying aviary - AA hens reared in rearing aviaries and then kept in a laying aviary, in comparison with ISA reference (ISA).**
pens because of their indifference to the object. Diversified experiences can lower fearfulness by regulation of emotional and cognitive processing, and therefore, enhances adaptation abilities to unfamiliar stimuli (Dennenberg, 1969; Reed et al., 1993). The greater fear shown by caged hens in the present experiment is probably related to the low level of stimulation from their environment: small flock, no furnishings except feeders and drinkers. The aviary environment, in contrast, is richer: large flock, entries of farmers, varied furnishings such as nests, perches, etc. If there is a clear difference between cage and aviary hens, pullets’ rearing environment (furnished floor pens vs. rearing aviaries) had no effect on the fearfulness of hens kept in aviaries during the laying period.

Indicators of disturbance (attempts to exit and pacing) were less frequently observed in cage hens than in aviary hens. This may be due to an inhibition of the expression of fear-related behaviours in cage hens. This notion is supported by Murphy (1978) who stated that a very fearful individual will stop moving rather than fleeing. This difference may also be due to the desire of aviary hens to get out of the test-arena. According to Jones (1977a), attempts to exit may reflect avoidance of the test situation without involvement of fear, with a gradually increasing predominance of active search to regain contact with the living environment. During novel environment tests, the flying/jumping directed to the lid occurred more often than the passing of the head through the wire walls. These tests took place in the evening shortly before turning the light off, at a time when hens in aviaries were usually flying/jumping to reach perches. Tested hens were probably inclined to move upward. During novel object tests, the proportion of attempts to exit was the opposite. These tests took place in the morning and the afternoon, at a time when hens were usually moving more horizontally in aviaries. Tested hens were probably inclined to move sideward. Furthermore, pacing is usually described as a behaviour of frustration, not as one of fear, in many species (Mason, 1991; Zimmerman et al., 2003; Appleby et al., 2004). In our experimental conditions, this behaviour seemed linked to the attempts to exit. It was mainly observed along the wire walls, not along the plain-wooden walls, and was often associated with the passing of the head through the wire walls.

Similarities between different tests of fear have been reported by several authors. Jones and Mills (1983) reported a good correlation (>0.50) between the results obtained in four tests of fear: novel environment, startling stimuli, tonic immobility, emergence test of timidity. Jones (1987) found a correlation of more than 0.60 between three tests: novel rod, pen with cone and tonic immobility. However, other authors found that responses to tonic immobility and novel environment test are either almost independent (Mignon-Grasteau et al., 2003) or not correlated (Heiblum et al., 1998). In our experiment, we obtained similar results in behavioural responses in novel environment and novel object tests, but not in tonic immobility tests. This result underlined the importance to use several tests to assess general fearfulness, as mentioned by Jones (1987).

Viability and egg production

The peak of mortality in FC hens, due to a heat wave, underlines that the welfare of cage hens can be badly compromised in heat stress situations. Aviary hens suffered less because they had higher possibilities to decrease their body temperature by moving to cooler areas, fluffing and wing-raising, thanks to the larger usable area available. The peaks of mortality in FA hens were due to a problem of adaptation to laying conditions: FA hens did not use the space as efficiently as AA hens did. FA hens were strongly attracted to the egg-collecting area during cleaning, what led to crowding and suffocation, whereas no problem occurred in AA hens, which were housed in the same conditions.

The slower increase of the laying rate in FC hens, in the beginning of laying period, indicates a slight problem of adaptation to cages. The lower laying rate and the more numerous eggs laid outside the nests in FA hens compared to AA hens indicate a long-term problem of adaptation: some hens did not use properly the furnishings (such as nests) probably because of their impaired space use (Colson et al., 2005).

General discussion

The results of behavioural tests did not indicate any effect of the pullets’ rearing environment (rearing aviary or furnished floor) on the fearfulness of hens kept in aviaries during the laying period. However, in the beginning of the laying period, viability and egg production indicated a poorer adaptation to aviaries of hens coming from furnished floor. This could be explained by a temporarily higher fearfulness of these hens, and by a different space use in the beginning of the laying period: litter more occupied, nests and feed-troughs less occupied than hens coming from rearing aviaries (Colson et al., 2005).

Regarding to the results of novel environment tests, novel object tests, viability and early egg production indicate that globally, under the conditions of our study, welfare seems more compromised in conventional cages than in aviaries. Our results are in accordance with those of previous studies using tonic immobility (Hansen et al., 1993), comfort behaviours (Blokhuis and Metz, 1992), or time budgets and abnormal behaviours (Hansen, 1994) to assess welfare in cage-aviary comparisons (for review, see Appleby and Hughes, 1991).

The fearfulness, measured after week 51, was not affected by the rearing conditions of aviary hens (FA and AA). It would be of interest to determine whether a difference exists in the early beginning of the laying period. The viability and egg production results indicate that FA hens faced problems of adaptation to aviaries. Furnishings (perches and platforms) proposed in the furnished floor rearing system have to be improved, if we want to obtain a wholly successful adaptation and then high production.

Acknowledgments

The present study was partly supported by the OFIVAL (Office National Interprofessionnel des Viandes, de l’Elevage et de l’Aviculture) and the DGAL (Direction Générale de l’Alimentation of the French Agriculture Ministry). S. Colson was supported by a grant from the Conseil Général des Côtes d’Armor. We are grateful to the staff of the experimental farm (Service d’Expérimentations Avicoles et Cunicoles - AFSSA) for husbandry and collecting the production parameters. S. Colson also thanks D. Huonnic for his demonstration of tonic immobility induction.

Summary

This study, mainly based on emotional reactivity, compared the welfare of laying hens (ISA Brown) from three different combinations of housing during rearing and laying periods: (1) hens reared in floor pens, then kept in conventional cages for the laying period (FC), (2) hens reared in furnished floor pens (with perches and platforms), then
kept in a laying aviary (FA) and (3) hens reared in rearing aviaries, then kept in a laying aviary (AA). Thirty hens per treatment were tested for tonic immobility at 66 weeks of age, twelve groups of four hens were tested in a novel environment at 52-59 weeks of age, and twelve groups of four hens were tested with a novel object at 66 weeks of age. Viability and egg production were recorded all along the laying period. Treatment did not influence the tonic immobility response, but FC hens were more fearful than FA and AA hens in novel environment and novel object tests. Peaks of mortality only occurred in FC and FA hens, and egg production was lower in FA than in FC and AA hens. This study suggests that welfare is more compromised for hens kept in conventional cages than for those kept in aviaries, and that furnishings, as proposed in our furnished floor rearing system, need to be improved in order to ensure good adaptation to laying aviaries. This study does not show any difference in fearfulness between FA and AA hens at the end of the laying period, but it would be of interest to determine whether a difference exists at the early beginning of the laying period.

Key words
Layers, behaviour, housing, adaptation, fearfulness, tonic immobility

Zusammenfassung
Wohlbefinden von Legehennen in Käfigen und Volieren: Furchtsamkeit


Stichworte
Legehennen, Verhalten, Haltung, Anpassung, Furchtsamkeit, tonische Immobilität

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