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Evaluation of common cleaning and disinfection programmes in battery cage and on-floor layer houses in France

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Abstract 1. The aim in this study was to evaluate cleaning and disinfection programmes in battery cage and on-floor layer houses in France.

2. Cleaning and disinfection efficiency was assessed by a visual evaluation of cleaning and a bacteriological monitoring of surface contamination from counts of thermotolerant streptococci on contact agar plates.

3. In battery cage houses, dropping belts, manure conveyors, and house floors remained highly contaminated due to poor cleaning in half of the buildings examined.

4. In on-floor houses, a high standard of cleaning was achieved but errors in the planning of cleaning and disinfection operations sometimes led to a high residual contamination of nest boxes and egg sorting tables.

INTRODUCTION

One of the main disease prevention measures in poultry production is cleaning and disinfection of the house between two consecutive poultry flocks (Sainsbury, 1990; Zander *et al.*, 1997). The role of cleaning and disinfection is effective in the prevention of poultry diseases such as Newcastle disease (Bragg and Plumstead, 2003) and Coryza (*Haemophilus paragallinarum*) (Bragg, 2004) as well as for the prevention of food-borne zoonosis (Van de Giessen *et al.*, 1998; Garber *et al.*, 2003) and the improvement of zootechnical performance (Tablante *et al.*, 2002). An evaluation of cleaning and disinfection operations will help ensure effective disease prevention. Under field conditions, the assessment of decontamination efficiency involves determining the number of viable microorganisms present on surfaces (Drouin and Toux, 1985). Various sampling methods, such as swabbing, rinsing, direct surface agar plating and contact plating, have been developed to enumerate microorganisms (Favero *et al.*, 1968). Contact plating seems well suited to field studies because of its simplicity, portability and the absence of laboratory manipulation after sampling. This method is especially adapted to firm, flat surfaces such as food processing equipment and gives reliable and repeatable results on these surfaces (Niskanen and Pohja, 1977). Contact plates have already been used in poultry production to evaluate disinfectants (Fate *et al.*, 1985) or disinfection programmes in broiler houses (Rose *et al.*, 1997). Few data are available regarding disinfection programmes, or their efficiency, in layer houses when applied in the absence of sanitary problems (such as diseases needing to be notified to Veterinary Authorities and diseases entailing heavy economic losses).

Thus, the aim in this study was to assess the efficiency of cleaning and disinfection programmes adapted from those commonly used in French layer farms by means of two complementary methods: visual evaluation of cleaning and bacteriological monitoring of surface

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contamination with contact plates. This evaluation was carried out both in battery cage houses and in on-floor houses (where layers are kept on the floor), which are the two most common housing systems used for layers in France. Rather than comparing the practices between these two systems, the main purpose of this study was to highlight the key points in the programmes so that adequate corrective measures, suitable for battery cage and on-floor housing systems, can be recommended.

MATERIAL AND METHODS

This study was carried out in 30 houses (15 battery cage houses and 15 on-floor houses) located on 27 farms in Western France. Two-thirds of French laying farms are located in this area (Brittany, Normandy and Pays-de-la-Loire regions), according to the French Ministry of Agriculture. Farm selection was based on the willingness of the owners to participate in the study.

Cleaning and disinfection programmes

The programmes in the study were based on those routinely used by the farmer to clean and disinfect the premises when the last flock of laying hens was unaffected by a sanitary problem. In cage farms, the programmes were based on dry cleaning involving dust blowing and sweeping; these programmes were reduced in comparison with that commonly used in cases of *Salmonella* infection, which relies on washing the henhouse. After dry cleaning the houses were disinfected once or twice, governed by the length of time available before the loading of pullets. In on-floor flocks, the programmes consisted of high-pressure washing, generally followed by one or two disinfections.

Sampling and data collection

Data and samples were collected from each poultry-house three times during cleaning and disinfection operations:

- after depopulation of laying hen flock but before cleaning (BC). for bacteriological sample collection;
- after cleaning (AC) and before disinfection operations, for visual cleaning-inspection; and
- after the last disinfection treatment (AD) and before pullet loading, for bacteriological sampling.

In the case of houses disinfected twice, an additional visit for bacteriological sampling collection was undertaken between the two disinfection phases. At each visit, data on cleaning and disinfection variables were gathered by means of a questionnaire.

Visual cleaning-inspection

The efficiency of cleaning operations was assessed during the AC visit, by visually evaluating the cleanliness of equipment and buildings. Each building was divided into quarters for the inspection and a grid adapted from the one used in broiler houses by Rose *et al.* (2003) was completed (Table 1). Specific criteria to evaluate cleanliness were defined for each check-point and a score was assigned: 0 (dirty), 1 (not completely cleaned, traces of dust, feathers, egg or manure) and 2 (clean). The scores for all control points in a building were added together and the final score was expressed as a percentage. A final score of 100% corresponded to a house that, on visual inspection, appeared to be perfectly clean.

Bacteriological control of disinfection

Bacteriological samples were taken during the BC and AD visits to assess disinfection efficiency. Twenty-five cm^2 contact plates containing Slanetz and Bartley medium (AES laboratory, Combourg, France) were used to count thermotolerant streptococci. A disinfectant neutralising solution was added to the medium (polysorbate 80·3% + lecithin 0·3%). Forty-eight cage house and 40 on-floor house samples were taken per house at each visit according to the sampling design in Table 2. This sampling scheme was tailored to the design of each house. During each visit, one sample was taken from each sample site (or surface type) in each quarter of the house as for the cleaning-inspection. Therefore, each type of surface yielded 4 samples. Contact plates were pressed very firmly on to the visually clean surface for 5 s. The samples were stored at room temperature during transport and incubated at 37°C for 48 h. After incubation, the plates were counted and the result expressed as number of colony forming units per count plate (CFU/CP). Plates with over 200 CFU/CP were regarded as invaded. Plates with confluent colonies or soiled by organic matter were excluded.

Statistical analysis

The cleaning scores were compared by chi-square test and the bacteriological counts, coded in 5 classes of contamination, were subjected to the Kruskal–Wallis non-parametric test. Final cleaning scores were then correlated with (a) the number of non-contaminated samples, (b) the median count, or (c) the average count on CP

Table 1. *Grid used for the cleaning-inspection in layer houses*

System	Q1[a]	Q2[a]	Q3[a]	Q4[a]	Total
Ventilation system					
Air inlets					
Presence of dust	/2	/2	/2	/2	/8
Air outlets					
Presence of dust	/2	/2	/2	/2	/8
Nest boxes[b] or cages[c]					
Walls	/2	/2	/2	/2	/8
Presence of dust, feathers					
Floor					
Presence of dust, feathers, droppings	/2	/2	/2	/2	/8
Drinking system					
Drinkers[b] or recipients under nipples[c]					
Stained	/2	/2	/2	/2	/8
Feeding system					
Feed hoppers					
Presence of dust or feed waste	/2	/2	/2	/2	/8
Feeders					
Presence of dust or feed waste	/2	/2	/2	/2	/8
Egg gathering system					
Egg collectors					
Presence od dust or waste eggs	/2	/2	/2	/2	/8
Manure disposal system					
Slats[b] or dropping belts[c]					
Presence of dust or droppings	/2	/2	/2	/2	/8
House					
Walls					
Presence of dust or manure tracks[b]	/2	/2	/2	/2	/8
Floor					
Presence of dust	/2	/2	/2	/2	/8
Corners near the floor					
Stained	/2	/2	/2	/2	/8
Beams or pipes					
Presence of dust	/2	/2	/2	/2	/8
Total					104

A 3-point scale was used: 0 for a dirty surface, 1 for a surface not completely clean and 2 for a clean surface.
[a]Qx, quarter of the house. [b]On-floor house. [c]Cage house.

Table 2. *Sampling scheme for bacteriological monitoring in battery cage and on-floor poultry houses*

System	Sampling sites	Number of CP	
		Cage	On-floor
Ventilation	Air inlets	4	4
	Air outlets	4	ns
Cages	Walls	4	np
Nest boxes	Walls	np	4
	Tops	np	4
Feeding system	Feeders	4	4
	Feed hoppers	4	ns
Egg gathering system	Egg sorting table	ns	4
	Egg belts	4	ns
	Egg conveyors	4	ns
Manure disposal system	Dropping belts	4	np
	Dropping conveyor	4	np
	Dropping drying system	4	np
Building	Walls	4	12
	Floor	4	ns
	Sanitary room	ns	4
	Egg storage room	ns	4
Total		48	40

CP, Count Plate; np, not present; ns, not sampled.

after disinfection, using the Spearman correlation test separately for each housing system.

RESULTS

Fifteen battery cage houses and 15 on-floor houses were studied from September 2004 and April 2007. The cage-houses contained between 16 300 and 81 000 laying hens mean (43461 ± 1629) with a mechanical ventilation system in 13 houses and a natural ventilation system in two houses. Buildings were equipped with battery cages and the droppings disposal systems consisted of dropping belts in 14 houses and deep pits on one farm. Hens in two buildings were housed in accordance with European Directive 1999/74/EC in cages furnished with a nest box, a pecking and scratching area and perches.

In cage houses, double disinfection programmes included a spraying treatment followed by a thermal fogging treatment in

7 houses (Table 3). Disinfectants used consisted of commercial solutions containing quaternary ammonium compounds in association with formaldehyde and/or glutaraldehyde. When houses were disinfected with a single treatment the farmers used thermal fogging (5 houses) more often than surface disinfection by spraying (three houses). Six of these houses were disinfected with commercial solutions of quaternary ammonium compounds in association with formaldehyde and/or glutaraldehyde while the other two were disinfected by spraying a formaldehyde solution diluted at 25%.

Nine of the 15 on-floor farms specialised in organic egg production and 4 specialised in free-range production; the other two were conventional. On-floor houses contained between 2400 and 10 000 (mean of 4 927 $\pm$ 1675) laying hens, with an average density of 8·2 $\pm$ 1·1 hens per m^2. The on-floor poultry houses were slightly more recent than the cage houses (9·4 $\pm$ 5·6 years old vs. 15·2 $\pm$ 8·5). The buildings were divided into a slatted area covering a pit for manure collection and a litter area. All houses had a natural aeration system and laying hens in 14 out of 15 houses had access to an open range.

Ten on-floor houses were disinfected once after washing, 9 by spraying and one by thermal fogging. Four farmers carried out two spray disinfections and one building was washed but not disinfected. The disinfectants allowed on organic farms were limited to chlorine compounds, formaldehyde and caustic soda. Four farmers used commercial solutions of quaternary ammonium compounds in association with aldehydes.

For both battery cage and on-floor buildings, thermal fogging treatments were carried out by a contractor and only one fogger was used even in the large cage houses. Ancillary substances were present in the commercial solutions used for thermal fogging. In 4 out of the 5 battery cage houses disinfected by a single thermal fogging treatment, the volume of disinfectant solution used per m^3 was higher than the manufacturer's specifications, while no overdosage was observed when the thermal fogging followed a spraying treatment. The spraying treatment was carried out by a contractor in one third of the on-floor houses and in 7 battery cage houses out of 10. In the three cage houses where the spraying treatment was carried out by the farmer, the amount of solution used per m^2 was less than the manufacturer's specifications because the extended surface of the cages was not included in the calculation of the surface to disinfect.

Average scores for visual cleaning-inspection per location, for both cage and on-floor houses, are shown in Table 4. The average final score was 72% in on-floor houses and 57% in cage houses. However, in 9 of the 15 on-floor houses, the feed hoppers had been emptied but not washed and dust and feed wastes remained in the hoppers after cleaning. Individual nest boxes with a manual egg gathering system obtained higher cleaning scores than collective boxes with an automatic gathering system (average score: 75 vs. 45%, $P < 0{\cdot}01$) probably because the individual nest boxes had been removed and cleaned separately. In cage houses, poor cleaning was detected in locations difficult to access such as air outlets in the ceiling, cups under nipples and the floor beneath cages. In 12 out of 15 battery cage houses, droppings belts and conveyors remained soiled with hardened droppings.

Distributions of samples per contamination class before cleaning (BC) and after disinfection (AD) are shown in Table 5 for cage houses and in Table 6 for on-floor houses (results for the samples taken between the two disinfection treatments are not shown). In cage houses, the highest BC contamination was found on the

Table 3. *Cleaning and disinfection programmes, methods of disinfection and disinfection products used in the houses*

Housing system	Number of houses	Cleaning method	First disinfection		Second disinfection	
			Method	Disinfectant	Method	Disinfectant
Cage	5	Dry cleaning	Fogging	Ammonium IV + aldehydes	–	–
	2		Spraying	Formaldehyde	–	–
	1		Spraying	Ammonium IV + aldehydes	–	–
	7		Spraying	Ammonium IV + aldehydes	Fogging	Ammonium IV + aldehydes
On-floor	6	High pressure washing	Spraying	Javel Water	–	–
	2		Spraying	Ammonium IV + aldehydes		
	1		Spraying	Formaldehyde		
	1		Fogging	Formaldehyde	–	–
	1		Spraying	Ammonium IV + aldehydes	Fogging	Ammonium IV + aldehydes
	1		Spraying	Javel Water	Fogging	Ammonium IV + aldehydes
	1		Spraying	Javel Water	Spraying	Javel Water
	1		Spraying	Caustic soda solution	Spraying	Javel Water
	1		–	–	–	

manure disposal system and on the house floor. At the AD visit, the counts were less than 10 CFU on 77% of the contact plates compared to 10% before cleaning and disinfection ($P<0{\cdot}001$) and contamination was significantly decreased for all surfaces sampled. The decrease in contamination was especially marked on air inlets (43% of CP < 10 CFU at BC vs. 100% at AD), linear feeders (8% of CP < 10 CFU at BC vs. 76% at AD) and walls (17% of CP < 10 CFU at BC vs. 96% at AD). In contrast, the manure disposal system and the house floor remained highly contaminated with counts of more than 100 CFU/CP for 37 and 16% of the samples, respectively. Cleaning and disinfection was thus less efficient on those surfaces that were most highly contaminated at the end of the laying period.

In on-floor houses, a greater proportion of highly contaminated samples (>100 CFU/CP) was observed at the BC visit on linear chain feeders, air inlets and egg sorting tables. Contamination at the AD visit was reduced ($P<0{\cdot}001$) for all surfaces sampled. However one CP with more than 100 CFU at the AD visit was observed in the nest boxes in two houses and on the egg sorting table in two other houses.

In both on-floor and battery cage houses, the number of samples with 0 CFU at the AD visit was significantly higher in houses that were disinfected twice than in buildings disinfected only once (Figure). In cage houses, the proportion of non-contaminated CP after the first disinfection was 64% in the 10 buildings disinfected by spraying versus 37% in the 5 houses treated by thermal fogging ($P<0{\cdot}01$, not shown on Figure). This comparison was not possible

Table 4. *Average final scores and average scores by system (%) for visual cleaning-inspection according to type of house*

System	Cage houses	On-floor houses
Ventilation system		
Air inlets	60%	78%
Air outlets	53%	80%
Nest boxes[a] or cages[b]		
Walls	68%	72%
Floor	63%	65%
Drinking system		
Drinkers[a] or recipients under nipples[b]	44%	83%
Feeding system		
Feed hoppers	58%	37%
Feeders	53%	85%
Egg gathering system		
Egg collectors	55%	63%
Manure disposal system		
Slats[a] or dropping belts[b]	47%	85%
House		
Walls	64%	83%
Floor	51%	83%
Corners near the floor	62%	76%
Beams or pipes	62%	57%
Total	57%	72%

[a]On-floor house. [b]Cages house.

Table 5. *Number (and %) of CP samples per class of contamination before cleaning (BC) and after disinfection (AD) in battery cage houses (*n = *15)*

Sampling sites	Nb ufc/CP						Total
	0	0–10	10–100	100–200	>200	UN[a]	
All samples							
BC	7 (1)	53 (9)	156 (28)	119 (21)	195 (36)	26 (5)	556
AD	401 (62)	101 (15)	75 (12)	44 (7)	26 (4)	5 (1)	652
Ventilation							
BC	3 (4)	15 (20)	22 (30)	12 (16)	20 (27)	2 (3)	74
AD	75 (83)	10 (11)	4 (4)	1 (1)			90
Cages							
BC	2 (2)	5 (6)	34 (41)	26 (31)	12 (14)	5 (6)	84
AD	62 (62)	17 (17)	10 (10)	9 (9)	2 (2)		100
Feeding system							
BC	1 (1)	14 (13)	22 (21)	29 (27)	36 (33)	6 (5)	108
AD	88 (71)	17 (14)	11 (9)	4 (3)	4 (3)		124
Egg system							
BC		8 (8)	35 (34)	23 (21)	34 (33)	4 (4)	104
AD	77 (64)	23 (19)	10 (8)	7 (6)	1 (1)	2 (2)	120
Manure system							
BC		2 (3)	17 (24)	8 (11)	37 (51)	8 (11)	72
AD	23 (26)	14 (16)	15 (18)	15 (18)	17 (19)	3 (3)	87
House walls							
BC	1 (2)	9 (15)	26 (42)	15 (24)	9 (15)	1 (2)	61
AD	55 (80)	11 (16)	3 (4)				69
House floor							
BC				6 (11)	47 (89)		53
AD	21 (34)	9 (15)	21 (34)	8 (13)	2 (3)		61

[a]Unreadable.

Table 6. *Number (and %) of CP samples per class of contamination before cleaning (BC) and after disinfection (AD) in on-floor houses* (n = *15*)

Sampling sites	Nb cfu/CP						Total
	0	0–10	10–100	100–200	>200	UN[a]	
All samples							
BC	48 (9)	129 (25)	205 (40)	62 (12)	52 (10)	22 (4)	518
AD	346 (67)	116 (23)	42 (8)	5 (1)		3 (1)	512
Air inlets							
BC	8 (15)	20 (37)	16 (29)	2 (4)	7 (13)	1 (2)	54
AD	38 (73)	11 (21)	3 (6)				52
Nest boxes							
BC	4 (6)	28 (41)	32 (48)	2 (3)	1 (1)	1 (1)	68
AD	29 (45)	18 (28)	14 (22)	3 (5)			64
Chain feeders							
BC		2 (3)	21 (37)	12 (21)	13 (23)	9 (16)	57
AD	35 (59)	15 (25)	8 (14)			1 (2)	59
Egg sorting table							
BC		1 (2)	9 (19)	12 (25)	23 (48)	3 (6)	48
AD	15 (33)	20 (43)	9 (20)	2 (4)			46
House walls							
BC	2 (1)	16 (9)	109 (64)	34 (20)	7 (4)	4 (2)	172
AD	138 (77)	33 (19)	7 (4)			1 (1)	179
Sanitary room							
BC	9 (15)	37 (62)	12 (20)			2 (3)	60
AD	46 (76)	12 (20)	1 (2)			1 (2)	60
Egg storage room							
BC	25 (42)	25 (42)	6 (11)		1 (2)	2 (3)	59
AD	45 (87)	7 (13)					52

[a]Unreadable.

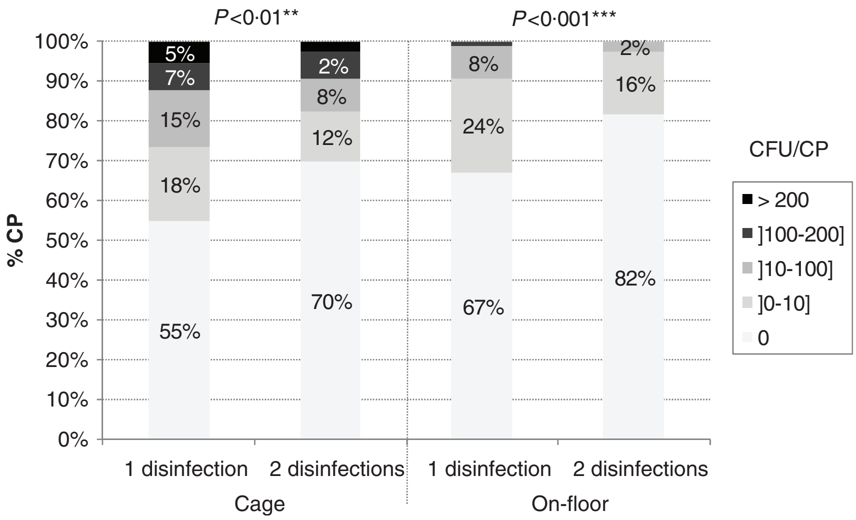

Figure. *Distributions of CP samples per class of contamination at the AD visit according to the number of disinfection treatments performed.*

in on-floor houses because in this system, only one building had been treated by thermal fogging for the first disinfection treatment. The final cleaning score could not be statistically correlated with the number of non-contaminated samples, the median count or the average count on CP after disinfection. For example, the Spearman correlation coefficient between the final score and the median count on CP was equal to 0·27 ($P = 0·33$) for cage houses and 0·53 ($P = 0·13$) for on-floor houses.

DISCUSSION

The cleaning and disinfection programmes used by farmers in this study were similar to those commonly used in French layer farms. Dry cleaning is used in a battery cage building when no sanitary problem has occurred on the farm; if it has, the henhouse is washed before being disinfected. In contrast, washing and disinfection of the house between two flocks is compulsory in organic and free-range egg productions, so all on-floor houses in this study were washed, even those in conventional production.

The effectiveness of the programmes used by farmers could not be compared between and within systems because they were not applied in a standard way or with the same disinfectant. However, some general conclusions could be drawn from this observational study: programmes based on two disinfections, rather than a single treatment, were apparently more efficient both in cage and in on-floor houses, as demonstrated previously on *Salmonella*-contaminated broiler and layer houses (Rose *et al.*, 2000; Valancony *et al.*, 2001; Gradel and Rattenborg, 2003). Furthermore, surface disinfection by spraying was more effective than thermal fogging in cage houses. Davies and Breslin (2003*a*) reported that fogging was more efficient on horizontal surfaces, rather than vertical and less accessible surfaces, whereas spraying allowed the direct treatment of all surfaces. In addition, fogging can only be carried out in totally sealed buildings, which is difficult to achieve in poultry houses (Linton *et al.*, 1987). Data collected on disinfectant concentrations applied showed that dilution errors occurred in both spraying and fogging treatments, even when the treatment was performed by a contractor. This underlines the necessity of improving farmers' and hygiene specialists' education on the use of disinfecting products in animal husbandry.

Both the visual-cleaning inspection and the bacteriological sampling by CP can be used as indicators of decontamination efficiency against *Salmonella* in poultry houses (Rose *et al.*, 2003). No correlation was found between scores obtained by cleaning-inspection method and residual contamination assessed by CP, either in on-floor or cage houses. The absence of a relationship between the results obtained by cleaning-inspection and bacteriological methods has been reported for the decontamination of hospital wards (Griffith *et al.*, 2000) and may be linked to the limitats of both methods. On the one hand, it has been demonstrated that visually clean surfaces may be still contaminated (Griffith *et al.*, 2000; Cooper *et al.*, 2007). Thus a visual-inspection on its own is an unreliable indicator of surface cleanliness, but it could be useful as a first step in a complete assessment protocol. On the other hand, CP can only be used on perfectly clean surfaces and cannot be interpreted if macroscopic particles have stuck to the agar surface. Thus a low level of residual contamination on clean surfaces, as assessed by CP, may sometimes be associated with a low cleanliness score in the visual inspection, which is carried out on the whole house. A systematic visual cleaning-inspection is thus prerequisite to the monitoring of disinfection efficiency by CP sampling method.

A lower standard of cleaning was achieved in battery cage houses than in on-floor houses, as previously observed by Davies and Breslin (2003*b*). On the one hand, dust blowing used in cage farms could not remove the dirt firmly attached to surfaces, as on dropping belts. With heavily soiled surfaces, blowing should be completed by scraping but this method is labour-intensive. High pressure washing is preferable to blowing as it has a more abrasive action on loose dirt but the increased environmental moisture may encourage the growth of coliform organisms (Davies and Wray, 1995; Rusin *et al.*, 1998). Large cage houses should only be washed when the building can be completely dried out before pullet loading. On the other hand, cleaning is made difficult by the complexity of cage equipment and the inaccessibility of certain parts. Improvements in equipment design are required, such as better access to dropping belts or a larger number of portable elements which can be removed and cleaned separately.

Most of the equipment in on-floor houses (slats, chain feeders, drinkers and sometimes nest boxes) was removed and cleaned separately. This resulted in a high standard of cleaning. Problems due to inaccessibility were observed with non-portable elements such as nest boxes closed by a curtain. It would be easier to clean such equipment if the curtain was removable. Feed hoppers remained dirty in 9 houses: the presence of electronic apparatus such as weighing systems or sensors meant that the hoppers could not be washed along with the rest of the house and were frequently missed during cleaning operations. A specific cleaning programme for hoppers should therefore be adopted, based on vacuum cleaning or blowing, disinfection by swabbing and complete covering of the hopper during washing to avoid recontamination.

Bacteriological monitoring highlighted the critical points in battery cage and on-floor houses where serious residual contamination remained after disinfection. In cage systems, the severe contamination of dropping belts, manure conveyors and the floor in half of the houses could be explained by high initial contamination and the described cleaning difficulties. Measures to decontaminate these surfaces need to be reinforced such as liming the floor, which has been shown to be efficient on concrete floors in broiler houses (Valancony *et al.*, 2002).

In some on-floor houses, major residual contamination was associated with egg sorting tables and nest boxes. These were made of untreated wood which is difficult to clean and unsuitable for poultry equipment (Meroz and Samberg, 1995; Sander *et al.*, 2003). Egg sorting tables in all houses were already heavily contaminated before cleaning, in accordance with reports by de Reu *et al.* (2005) and Davies and Breslin (2003*a*) showing that egg gathering and sorting systems may be a key point for eggshell contamination by aerobic mesophilic flora, Gram negative flora and *Salmonella*. In the present study, failure to decontaminate the egg sorting tables may be due to the fact that they had been missed during disinfection. The severe residual contamination of nest boxes might also be linked to an error in the planning of cleaning and disinfection operations: the nest boxes had been removed and cleaned separately but were put back in the house after disinfection. This error had previously been reported by Davies and Wray (1996) in breeder houses but can easily be corrected by putting all the cleaned portable elements back into place before disinfecting the house.

This observational study provides information on the efficiency of decontamination programmes representative of those commonly used in battery cage and on-floor layer houses in France. Key points in the cleaning and disinfection programmes have been identified and adequate corrective measures proposed. Visual cleaning-inspection and bacteriological monitoring with contact plates could easily be implemented by the technical management staff in layer farms and could help increase farmer awareness of the frequent problems occurring during cleaning and disinfection operations. Only two farms in this study were equipped with furnished cages so no conclusion could be drawn about this system. Further investigations are needed to propose suitable recommendations for the cleaning and disinfection of furnished cages, because their use in the European Community is expanding greatly as a result of European Directive 1999/74/EC.

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