GUIDELINES ON CLEANING, DISINFECTION AND VECTOR CONTROL IN SALMONELLA INFECTED POULTRY FLOCKS

WITH PARTICULAR REFERENCE TO S. ENTERITIDIS

WORLD HEALTH ORGANIZATION
VETERINARY PUBLIC HEALTH UNIT
GUIDELINES ON CLEANING, DISINFECTION AND VECTOR CONTROL IN SALMONELLA ENTERITIDIS INFECTED POULTRY FARMS

Report of a Workshop on “Preparation of Guidelines on Cleaning and Disinfection/Sanitation in Poultry Farms with S. enteritidis”

Bakum/Vechta, 7-11 June 1993

WORLD HEALTH ORGANIZATION
VETERINARY PUBLIC HEALTH UNIT
Contents

1. INTRODUCTION ............................................................................................................. 8

2. BASIC CONSIDERATIONS ......................................................................................... 8

3. BIRD REMOVAL ........................................................................................................... 9

4. CLEANING .................................................................................................................... 9
   4.1 Dry cleaning ............................................................................................................. 9
   4.2 Wet cleaning ........................................................................................................... 10
      4.2.1 Soaking ........................................................................................................... 10
      4.2.2 Washing .......................................................................................................... 11
      4.2.3 Rinsing ............................................................................................................ 11

5. REPAIRS ...................................................................................................................... 11

6. INSPECTION ............................................................................................................... 11

7. DISINFECTION .......................................................................................................... 11

8. FUMIGATION ............................................................................................................. 12

9. PREPARATIONS FOR RESTOCKING ........................................................................ 13

10. MICROBIOLOGICAL MONITORING OF THE EFFECTIVENESS
    OF CLEANING AND DISINFECTION ........................................................................... 13
    10.1 Sample sites ........................................................................................................ 13
        10.1.1 Breeding flocks and other non-caged flocks ............................................... 13
        10.1.2 Caged layer flocks ..................................................................................... 13
        10.1.3 Broiler flocks .............................................................................................. 14
        10.1.4 Additional samples .................................................................................... 14
    10.2 Sampling methods ............................................................................................... 14
    10.3 Culture methods ................................................................................................. 14

11. CONTROL OF RODENTS IN POULTRY HOUSES .................................................. 15
    11.1 Rodents - A critical source of Salmonella enteritidis ......................................... 15
    11.2 Estimating rodent populations ......................................................................... 15
    11.3 Rodent control .................................................................................................... 17
       11.3.1 Rodent proofing .......................................................................................... 17
       11.3.2 Management and sanitation ......................................................................... 18
       11.3.3 Non-chemical rodent elimination ............................................................... 18
       11.3.4 Chemical rodent control (rodenticides) ....................................................... 18
    11.4 References ........................................................................................................... 20
<table>
<thead>
<tr>
<th>Annex</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annex 1</td>
<td>List of participants</td>
<td>21</td>
</tr>
<tr>
<td>Annex 2</td>
<td>Literature</td>
<td>22</td>
</tr>
<tr>
<td>Annex 3</td>
<td>Cleaning and disinfection or other appropriate methods to be applied after S. enteritidis infections in poultry houses of the Louisiana type with earth (dirt) floors</td>
<td>23</td>
</tr>
<tr>
<td>Annex 4</td>
<td>List of recommended disinfectants</td>
<td>25</td>
</tr>
<tr>
<td>Annex 5</td>
<td>Compatibility of disinfectants and several surface materials</td>
<td>26</td>
</tr>
<tr>
<td>Annex 6</td>
<td>Cleaning and disinfection of water lines</td>
<td>27</td>
</tr>
<tr>
<td>Annex 7</td>
<td>Hot steam fumigation</td>
<td>28</td>
</tr>
<tr>
<td>Annex 8</td>
<td>Microbiological monitoring of the effectiveness of cleaning and disinfection</td>
<td>29</td>
</tr>
<tr>
<td>Annex 9</td>
<td>List of disinfectant neutralizing agents</td>
<td>31</td>
</tr>
<tr>
<td>Annex 10</td>
<td>Rodent evaluation and inspection form</td>
<td>32</td>
</tr>
<tr>
<td>Annex 11</td>
<td>Rodent control index form</td>
<td>33</td>
</tr>
</tbody>
</table>
PREFACE

Since the middle of the 1980s Salmonella enteritidis has caused an increase in foodborne diseases and deaths in many countries, particularly in Europe and North America, but also increasingly in the Middle East and in Asia.

As yet, there has been virtually no substantial decline in the incidence of human cases even though knowledge gained about the epidemic process in the human population has resulted in improvements within the food chain (introduction of "use by" dates for eggs, cooling of eggs during storage and transport, prohibition of the use of raw eggs in restaurants and large kitchens, consumer education, etc.).

To effectively reduce the entry of S. enteritidis and other Salmonella into the food chain, strict measures are necessary at the farm level. Therefore, the WHO Consultation on National and Local Schemes of Salmonella Control in Poultry (Ploufragan, France, 18-19 September 1992), recommended that a Code of Good Husbandry Practices should be drawn up based on the available knowledge and experiences of the control of S. enteritidis at farm level.

This code should take into account the complex pathways of transmission and infection as well as the relevant conditions at the different levels of production.

As a first phase in the elaboration of the above-mentioned code, guidance should be provided to governments, veterinary and production services on steps and measures to be taken after the detection of S. enteritidis infection on the farm and before restocking can be undertaken with S. enteritidis-free birds.

The first part of the guidelines on cleaning and disinfection were elaborated by a group of experts at the Epidemiological Field Station of the Veterinary School of Hanover in Bakum/Vechta from 7-11 June 1993, (see Annex 1: List of participants). Drs H.M. Opitz, D.J. Henzler and S. Foster contributed to the document with Chapter II: Control of rodents in poultry houses. The measures recommended in these guidelines may not only be conducive to reducing or eliminating S. enteritidis from poultry farms but also in the control of other foodborne salmonella.

The participants stressed that although cleaning, disinfection and vector control are vitally important to S. enteritidis control at the farm level, they should not be considered as the complete solution to the S. enteritidis problem.

Field experience has shown that to fully succeed in reducing the risk of S. enteritidis infection in poultry flocks, cleaning and disinfection as well as vector control measures must be integrated in a comprehensive control programme including sound management schemes, surveillance programmes and additional measures such as competitive exclusion. In order to cover other important fields for the control of S. enteritidis and other invasive serotypes of Salmonella, the Veterinary Public Health unit has initiated the elaboration of two additional documents⁹.

It is known that many commercial flocks producing broilers and eggs, and even some breeder flocks are still considered to be infected in various countries. Many of them have experienced reintroduction of S. enteritidis.

However, the knowledge is available to effectively combat S. enteritidis at the various levels of poultry production until the ultimate aim is reached: eliminating S. enteritidis from poultry production.

This final goal can only be achieved in stages, considering the wide territorial distribution of the agent and the many factors favouring S. enteritidis vertical and horizontal transmission within the poultry production chain.

However, whatever risk reduction programmes for the prevention of salmonella foodborne diseases in humans are implemented at the animal production level, cleaning, disinfection and sanitation will be one of their main components.

Dr K. Stöhr, Veterinary Public Health Unit.

¹ Guidelines on Detection and Monitoring of Salmonella in Poultry Flocks (WHO document WHO/Zoon.94.17).
1. INTRODUCTION

If *S. enteritidis* is known to be present in egg-layer or broiler flocks, an integrated programme of control should be initiated. This should include:

- provisions for the supply of *S. enteritidis*-free feed and chicks;
- vigorous biosecurity measures (vector control, access restriction including vehicles, etc.);
- rodent and insect control;
- routine cleaning and disinfection of every cycle of production, with subsequent microbiological evaluation and under some conditions, the use of other supportive measures such as salmonella vaccines and/or competitive exclusion (CE).

Only programmes which take into consideration the complex pathways of transmission and the interdependence of the individual control measures taken at farm level will have a good chance of success.

The guidance given in this report on cleaning and disinfection of egg-layer and broiler farms represents a compilation of some of the most current experiences and results acquired in several countries during *S. enteritidis* control activities. Many sources were used (see Annex 2).

2. BASIC CONSIDERATIONS

*S. enteritidis* can infect poultry flocks from the environment as well as through infected parent birds. To be able to protect birds from environmental infections, certain requirements should preferably be met, such as quality of houses and materials, feed and water, as well as rodent and insect control, quality and storage of litter, and staff education.

When a poultry flock is infected with *S. enteritidis*, large numbers of bacteria will contaminate the environment both inside, and, to a certain extent, outside poultry houses.

Day old chicks are extremely sensitive to *Salmonella* and even a very small number of salmonella bacteria can result in chickens becoming infected.

Sanitation should therefore be thorough. Adequate time to complete the task of cleaning and disinfection should be allowed. Additional time should be allowed for culture results to be obtained and, if necessary, for the re-cleaning of houses, parts of houses or equipment before the new flock is housed.

Culturing (*Salmonella* and total viable counts of bacteria) is highly recommended in flocks found *S. enteritidis* positive prior to cleaning and disinfection. Microbiological investigations may also provide useful information about critical points for cleaning and disinfection and sites at which infection may be maintained or reintroduced into poultry houses.

1. Invest in good equipment and training of the staff for cleaning and disinfection or contract a professional cleaning and disinfection company.

2. A comprehensive cleaning and disinfection plan should be drawn up before removal of birds. The procedures should be designed to meet the particular needs and should be set down in written schedules which should be made available for the guidance of employees and management.
The cleaning and disinfection programme should include the following items:

- time schedule
- type, amount, concentration, preparation, and effective time of disinfectants used
- desired level of cleaning and disinfection (visual indicators)
- check and inspection.

3. These procedures should be established not only for cleaning and disinfecting the equipment and surfaces, but also the equipment which is itself used for cleaning.

4. There must be adequate supervision by management to ensure the procedures set down are carried out in an effective manner at the specified intervals of time. The use of a checklist is recommended.

5. Invest in thorough dry cleaning with removal of all caked and loose debris. This simplifies future cleaning operations and reduces the expense of wet cleaning.

6. Carefully follow all manufacturers' instructions for disinfectant safety, dilution and application. Consult the suppliers of both equipment and disinfectants for the best and safest procedures for such items as feeders and waterers. Consult animal health veterinarians.

7. Disinfectants are effective only on clean surfaces. It is therefore imperative that all surfaces be thoroughly cleaned before disinfection. After cleaning all surfaces should be dried as soon as possible.

8. Inspections carried out between the individual steps of cleaning and disinfection should help to assess the quality of the procedure and to prevent possible carelessness. Establishment of checklists are useful to ensure thorough and comprehensive inspection.

9. Safety and hygiene of staff

9.1 Staff involved in cleaning and disinfection of poultry houses should be aware of potential hazards and take all necessary safety precautions. These should include the use of protective clothing and boots, which can be disinfected; as well as face visors, goggles, respirators, nose and mouth masks and gloves as appropriate.

9.2 On completion of the procedures staff should change out of their protective clothing and boots after they have been disinfected. Hands should be washed.

9.3 Smoking, eating and drinking should not be permitted during the work or in work areas.

3. BIRD REMOVAL

1. Remove all dead and live birds from the building; this includes all escaped birds in the deep pit or outside.

2. Immediately begin rodent and insect control procedures after bird removal.

4. CLEANING

A clean and tidy area, drained to prevent standing water and free of vegetation should be maintained around the houses (1.5-3 m).

4.1 Dry cleaning

1. Clean fans and other air inlets from the outside.

2. Remove all litter and manure from floors or cage houses3, including all corners, augers and pit ends. Completely remove all manure. Hand sweeping and shovelling will be necessary around the perimeter, doorways, support poles, and corners of most houses to do a satisfactory job. If
possible, fill trailers with manure inside the house and cover before moving for disposal.

3. Dismantle all equipment, e.g. fans, feeders, bell drinkers, etc.

4. Promptly open feeder lines and remove all feed. Particular attention should be paid to all line corners and all points of feed accumulation. Use wire brushes and industrial vacuum cleaners with appropriate filters.

5. Remove all miscellaneous equipment (bell drinkers, hand feeders, etc.) out of the house and stack on a concrete area where washing, cleaning and disinfection will be facilitated.

6. On the inside, brush, sweep, vacuum and wipe dust and other dirt from ceilings, light fixtures, beams, ledges, walls, cages, fan parts, air inlets and walkways. Move from top to bottom. Crusted areas should be hand scraped and wire brushed until they are spotless.

7. Remove all dust and egg debris from egg conveyance equipment outside the houses. Remove all broken parts and all soiled items that cannot be cleaned.

8. Remove as much manure as possible from dropping boards. Manual scraping, in addition to low speed mechanical scraping, may be helpful.

9. Remove egg belts for cleaning and disinfection or replacement and sweep away all debris from pullet and layer houses.

10. Rid pullet or layer houses, storage and egg rooms, egg coolers, hallways and stairways of all debris and non-essential items.

Repeat for adjacent wash- and rest-rooms and toilets.

11. Turn off power to all electrical devices prior to dry or wet cleaning. Immovable motors, switches, etc., should be dry cleaned by vacuum cleaning, brushing or using compressed air. Duct tape can be used to cover the slots in motor housings prior to wet cleaning and disinfection. These areas should be wiped with a cloth soaked with a disinfectant prior to covering and again afterwards.

12. Dirt floors are virtually impossible to fully disinfect and should preferably be concreted, particularly in breeder houses. An example for cleaning and sanitation of Louisiana type houses with earth floors is given in Annex 3.

4.2 Wet cleaning

Wet cleaning includes soaking, washing and rinsing steps. Use of warm water (40°C = 104°F optimum) is recommended for soaking and washing.

The addition of cleaning agents to soaking solutions facilitates the procedure. Risk of aerosol distribution of infectious agents during cleaning might be further reduced by adding a disinfectant (for concentration see Annex 4) to the soaking solution.

Salmonella can multiply to high numbers in the presence of debris and moisture. Therefore, the following steps should be executed without interim waiting periods:

4.2.1 Soaking

Soften dirt in heavily soiled areas. An average of 1-1.5 litres of soaking liquid per m² should be adequately distributed using a low pressure sprayer (10-20 bar, or 140-280 psi). An average soaking time of 2-3 hours is recommended.
4.2.2 Washing

Washing should be performed in such a way, that all debris and dirt is removed until surfaces are visibly clean. The most preferable way is the use of high pressure cleaners working at 80-100 bar (900-1200 psi) (warm water: 600-800 litres per hour, cold water: 900-1100 litres per hour). Use sprayer attachments and nozzles that permit washing of hard-to-reach areas. Work should start at the back and proceed towards the front of the building. Spray ceiling first, then the walls and finally the floor.

1. Wash ceilings, walls, walkways, steps and crossover platforms, cages\(^5\), egg rollers, all egg conveyors, cross belts, floors under conveyors, stairs to the pit, outside stairs and concrete pit floors – clean everything completely. Always wash towards the drain working from the back of the house to the front.

2. Pay special attention not only to the top, but also to the undersides of troughs and obvious and hidden surfaces of all chains and augers. Bell drinkers and cups must also be included.

3. Extreme care is needed for the cages and the egg elevator. Check for cleanliness from every possible angle from underneath the pit and from behind rollers. Remove all traces of egg breakage and spillage.

4. Clean and disinfect water lines (see Annex 6).

5. Wash storage and egg rooms, egg coolers, hallways, wash and restrooms.

6. Manually clean any areas that resisted prior cleaning.

4.2.3 Rinsing

1. A final rinse with cold water at low pressure is recommended to obtain a truly clean building and to reduce residues of cleaning chemicals. Allow one to two hours for aerosols to settle before rinsing.

2. Immediately dry all puddles and allow the building to dry overnight.

5. REPAIRS

All repairs should be made as quickly as possible at this point (i.e. floor cracks filled, door frames repaired, damaged panels replaced, etc.). Repair nest boxes, manure and egg transport, and other equipment. If necessary, additional cleaning has to be carried out.

6. INSPECTION

Visual inspection for completeness of the wet cleaning and repair operations is strongly recommended. This may be done by an outside authority or by an in-house person responsible for quality control.

7. DISINFECTION

Because disinfectants are effective only on clean surfaces, do not begin disinfection until the house has passed its inspection for proper cleaning but not later than 24 hours after completing the rinsing procedure.

To be effective most disinfectants require an indoor temperature of at least 10°C (50°F). Most disinfectants working dilutions give an optimum effect when applied at a temperature of 40°C (104°F) (see Annex 4).

Ensure that manufacturers’ instructions in respect of concentration, amount and exposure time of disinfectants are properly complied with. A list of recommended disinfectants is given in Annex 4.

1. Determine the total surface area of the floor, ceiling and walls. Add 30% (100% for layer houses with 3-4 stages) to this area to allow for the cage surfaces and other equipment. At least 0.4 litres of disinfectant in use concentration is applied to 1 m², sprayed with low pressure equipment (10-20 bar; 140-280 psi).

2. If surfactants are applied in addition to the disinfectant, ensure compatibility (see Annex 5 for table for compatible disinfectants and surfactants).

3. Ensure that all surfaces are completely treated. Move from back to front and from top to bottom.

4. In breeder houses special attention has to be paid to nest boxes and other wooden material, bell drinkers and feeder troughs. After thorough cleaning, separate additional disinfection is recommended. Immersion of nest box boards in appropriate disinfectants (see Annex 4) for a minimum of 5 minutes is suggested.

5. In layer houses disinfect cages and egg handling equipment (elevators, egg belts, etc.) in accordance with recommendations provided by equipment and/or disinfectant manufacturers.

6. Egg transport belts and egg elevators must also be cleaned and disinfected. If fibre belts have become rotten from eggs or debris material they have to be discarded and replaced. Otherwise the belts can be reused after being soaked with a detergent and subsequently immersed in an appropriate disinfectant (see Annex 4).

7. Decontaminate feed bins, augers, hoppers and carts. Sanitize waterlines (for precise description see Annex 6).

8. After the required exposure time for the disinfectant, promptly dry the building.

9. Remove coverings and tape used to protect electrical circuits and motors. Covered areas should be wiped with a cloth soaked with a disinfectant prior to covering and again afterwards.

10. Verification of decontamination success by laboratory procedures is highly recommended. Bacteriological tests of the pullet or layer facility should be negative before placing either chicks or ready-to-lay hens (see Chapter 10).

8. FUMIGATION

In S. enteritidis infected flocks formalin fumigation is often recommended as a final disinfection option (crack and pore penetration).

Fumigation is advocated as the gases penetrate surfaces and sites where effective cleaning and disinfection cannot always be assured (e.g. intermediate ceilings, cracks, electric motors or other electrical equipment, fans, etc.).

Fumigation should follow soon after the disinfection procedures are completed. All cleaned and disinfected equipment should be reassembled and maintenance should be completed before fumigation. In order to be effective, the process requires a relative humidity of at least 70% and a temperature of at least 60°C (140°F).

Fumigants can make rodent baits unpalatable even if the chemicals have dispersed from the atmosphere. Thus all rodent baits and traps should be left in place until fumigation is imminent, then removed and replaced on completion of the process.

Since formaldehyde fumigation poses a certain human health risk a professional service should be chosen for this assignment. A more precise description of formaldehyde fumigation is given in Annex 7.
9. PREPARATIONS FOR RESTOCKING

Prevent recontamination of the hoses.

1. Replace disposable parts with new ones.

2. Repair and adjust egg handling and convey-ance systems from hen to cooler.

3. Restock restrooms and toilets with soap and paper towels or sealed hand washing packets.

4. Make sure that all electrical equipment, time clocks, feed and water lines, egg- and manure-handling devices, etc. operate properly.

5. All decontaminated equipment such as rakes, shovels, scrapers, brushes, trucks, manure spreaders, bucket loaders and cleaning/disinfection devices should also be cleaned and disinfected after use and stored in a secure location.

10. MICROBIOLOGICAL MONITORING OF THE EFFECTIVENESS OF CLEANING AND DISINFECTION

Sampling should be carried out once the cleaning and disinfection procedures have been completed and the house is dry.

Inadequately cleaned and disinfected buildings and equipment may act as sources of infection for newly-placed birds and it is important to confirm the effectiveness of the procedures before restocking. It may be necessary to consider repeating the disinfection of buildings, parts of buildings or equipment if *Salmonella* is isolated as a result of monitoring and depending on an assessment of the associated risks. Results may also indicate particular sites which will require more detailed attention on future occasions.

10.1 Sample sites

10.1.1 Breeding flocks and other non-caged flocks

For each house containing up to 10 000 birds it is recommended that a minimum number of samples should be taken as follows:

Floors – include cracks, crevices and expansion joints (4 swabs)

Walls – at each corner from the floor to about 1 metre up the wall (4 swabs)

Feeders – random 5 metre runs including angles where chain feeders change direction (3 swabs)

Ventilation system – include inlets and outlets; one swab may be used to sample up to three inlets or outlets (3 swabs)

Nest boxes – random 5 metre runs along the inside of the front board or edge (3 swabs)

Perches – random 5 metre runs (3 swabs)

For each additional 500 birds, a further swab should be taken from the feeders, ventilation system, nest boxes or perches up to a maximum of 30 samples in total.

10.1.2 Caged layer flocks

For each house containing up to 30 000 laying birds, samples should be taken as in 10.1.1 except that swabs from the egg rail/flap or conveyor belt should be substituted for the nest box and perch swabs.

For each additional 1 500 birds a further swab should be taken from the feeders, ventilation system or egg rail/
flaps or conveyor belt up to a maximum of 30 samples in total.

10.1.3 Broiler flocks
For each house containing up to 25,000 birds, samples should be taken as in 10.1.1 except that additional swabs from the feeders and ventilation system should be substituted for the nest box and perch swabs.

For each additional 1,000 birds a further swab should be taken from the feeders or ventilation system up to a maximum of 30 samples in total.

10.1.4 Additional samples
To increase the sensitivity of salmonella detection in a house, a greater number of samples may be taken from the sites indicated above and the following may also be taken:

- floor dust sweepings;
- swabs from high beams or pipes;
- swabs from the base of roof support posts;
- nest box floors;
- in-house “slave” feed hoppers.

10.2 Sampling methods
1. Swabs made of 10 g absorbent cotton wool, cellulose wadding or gauze pads in individual jars containing buffered peptone water (BPW) and a suitable disinfectant neutralizing agent should be sterilized by autoclaving for 15 minutes at 121°C (250°F) (see Annex 9 for a list of disinfectant neutralizing agents).

2. While wearing disposable gloves, a swab should be removed from its jar and excess BPW squeezed out. After vigorously swabbing an area of about 1 square metre of the relevant site, the swab should be replaced in the jar of BPW which should be suitably identified. New disposable gloves should be used when each swab is taken.

3. Approximately 25g of floor dust should be swept together using a sterile broom and transferred to a jar containing 225 ml sterile BPW and a suitable disinfectant neutralizing agent.

4. *Salmonella* isolation from post/base floor junctions, other junctions, cracks and crevices is enhanced if they are rehydrated by soaking the areas with BPW for 5-10 minutes before they are swabbed.

10.3 Culture methods
Many culture methods are available but sensitivity, accuracy, speed of obtaining a result and cost will be important factors in deciding which method to use in particular situations. In general, all methods will include the following stages:

(i) pre-enrichment in a non-selective liquid medium

(ii) enrichment in selective liquid or semi-solid media

(iii) plating onto selective solid media and recognition

(iv) confirmation.

A selection of methods cited in the literature is given in Appendix 8, although the list is by no means exhaustive. An unpublished method which has been found to be satisfactory is also given.
11. CONTROL OF RODENTS IN Poultry Houses

11.1 Rodents – A critical source of *Salmonella enteritidis*

Rats and mice are a significant source of *Salmonella enteritidis* contamination of poultry houses. They can become infected from contaminated chicken manure and other sources. They are more readily infected with *S. enteritidis* than with many other *Salmonella* serotypes commonly found in poultry houses. Experience has shown that *S. enteritidis* control is not possible without effective rodent control.

*S. enteritidis* can multiply in rodents and up to 1/4 million *S. enteritidis* bacteria have been found in a single faecal pellet from a naturally infected mouse caught in a chicken layer house. This number of bacteria is sufficient to infect a healthy laying hen. By concentrating the bacteria in their faeces and by defecating into feed troughs and on egg belts they amplify the contamination with *S. enteritidis* in a chicken house and the contamination can be distributed over the full length of the house by automated feeding, egg conveyor and manure removal equipment. Rodents can possibly infect chickens directly with *S. enteritidis* or contaminate feed and egg shells (Henzler and Opitz, 1992).

*S. enteritidis*-infected mice have been detected in a single poultry house for over two years. They remain a reservoir of the infection even after all chickens have been depopulated and can contaminate the next chicken flock. Mice may be useful for monitoring for *S. enteritidis* as they remain infected even after the environmental contamination has dropped to levels where detection by standard techniques may be unreliable (Davies, 1994).

Rats can travel over a long distance, mice stay usually within close proximity of feed, water and nesting places. Mice can transmit the infection to other neighbouring houses or farms far away by migrating to neighbouring houses during clean out, travelling on conveyor equipment or by being carried on equipment such as fibre egg filler flats. Rodents have also been seen in loads of grain that has been transported over hundreds of miles. Placement of manure contaminated with *S. enteritidis* or containing infected mice may provide an additional source of exposure to nearby poultry facilities.

Rodents are one of the most important risk factors for the introduction of *S. enteritidis* at any stage of poultry production, e.g. at the breeding, broiler, pullet or egg laying flock level. They also can contaminate feed at the feed mill.

An intensive and sustained rodent control programme at all levels of production is not only necessary for the control of salmonella. Rodents can also transmit other diseases, they consume poultry feed, cause palatability problems, damage to the building structures, and increased losses through cannibalism of live poultry. Rodent control not only makes economic sense it also reduces the risk of contamination of poultry and eggs and ensures public health confidence in poultry products.

Rodent control needs to be well planned, flexible, continuous, and its effectiveness monitored.

11.2 Estimating rodent populations

Poultry farmers are often unaware of the extent of the problem. Rodents are nocturnal animals preferring areas with minimal human traffic. For every mouse seen during the day there will be 100 roaming through the feeders at night. Signs of rodents are usually obvious.
Rodents are prolific (Table 1). Rodents can be found where nesting places, feed and water are available. Mice can share communal nesting sites. Even in a new house, with the entrance of just a few mice, they can proliferate to high numbers during the life of a single flock. Mice have minimal requirements for daily water and they can survive completely by extracting water from feed and manure. Rats require a daily source of water which is available through water leaks and other sources inside or outside the poultry house.

<table>
<thead>
<tr>
<th></th>
<th>MICE</th>
<th>RATS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home range</td>
<td>small; 3-6 m (10-20ft); very territorial</td>
<td>large; 15-30 m (50-100 ft.)</td>
</tr>
<tr>
<td>Maturity</td>
<td>1' months</td>
<td>2-3 months</td>
</tr>
<tr>
<td>Young/Litter</td>
<td>5-10</td>
<td>5-12</td>
</tr>
<tr>
<td>Litter/years (max.)</td>
<td>8</td>
<td>7</td>
</tr>
</tbody>
</table>

Rodent control begins with poultry house inspection and estimating the rodent populations.

a. **Inspection:** Each poultry house and facility needs to be inspected, inside and outside, at the beginning of a rodent programme and thereafter at least once a month. Look for signs of rodent activity (faecal pellets, urine stains, a sharp unpleasant odour from excreta, greasy or oily marks along the walls and other pathways, insulation pulled out, gnaw marks, holes and trails in dust). Walk the house the entire length of the building. Use a good flashlight and check also the pit, floor joists, egg and any storage room and attic. Record the observations on a rodent evaluation and inspection form (see annex 10). Note areas of heavy rodent activity.

b. **Estimating mouse population** by indexing method (Henzler, 1993): 12 multiple catch mouse traps (e.g. Tin Cat Repeating Mouse Trap or similar devices) are placed in areas that are most likely to catch mice as determined during the inspection, e.g. along the walk walls, side, front and rear, and on pit ledges. Support the traps on ledges by hammering a large nail underneath. Traps can be set in any other area including pit floors, or near feed spills or large openings. The traps are placed flush against the wall and may be baited with a handful of chicken feed or other bait, but this is not necessary. Traps that contain no mice may be moved to another location. The trapped mice are counted after seven days. An index is established from Table 2. The index is not designed to determine the actual number of mice in a poultry house, it is an assessment of the relative risk to the poultry flock should mice be infected with *S. enteritidis* or become exposed to the bacterium. An effective mice control programme will maintain an index of 0 - 1. This degree of effectiveness is also necessary for an effective *S. enteritidis* control programme. The mice index should be established at least twice a month for every house and recorded on a rodent control index form (see annex 11).
### Table 2: Mice Infestation Index

<table>
<thead>
<tr>
<th>Index</th>
<th>Number of Mice*</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>Insignificant</td>
</tr>
<tr>
<td>1</td>
<td>1-10</td>
<td>Slight</td>
</tr>
<tr>
<td>2</td>
<td>11-25</td>
<td>Moderate</td>
</tr>
<tr>
<td>3</td>
<td>26 or more</td>
<td>Severe</td>
</tr>
</tbody>
</table>

* Mice index is always based on the number of mice caught in 12 traps in seven days. If more or fewer traps are used and mice are counted after more or less than seven days, use the following formula to determine the mouse infestation index:

\[
\text{No. of mice caught in all traps} + \text{No. of functioning traps} + \text{No. of days since the last count (service)} \times 12 \times 7 = \text{No. of mice for Mice Index}
\]

**c. Alternative rodent population estimation methods:** The indexing method works well in most automated cage layer houses. Other methods may work better for broiler, floor litter or breeder houses.

Inspection of houses at night and flashing a light beam over manure surfaces, along feeders or walkways may provide a quick impression on the extent of the problem. Better suited is a walk through the entire length of the building with a dimmed flashlight or a red light source. Infrared cameras or infrared light beams have also been used to evaluate rodent populations. Rodent populations may also be estimated by placing baiting and determining the speed with which bait is being consumed.

### 11.3 Rodent control

The most efficacious approach to rodent control is a continuous integrated programme which includes rodent proofing of buildings, elimination of nesting places, appropriate management and sanitation, and chemical and non-chemical rodent elimination. Poultry producers have to be cognizant of biological, environmental, food safety, animal welfare, occupational safety, and regulatory issues which apply to rodent control. It may be advisable to employ trained and licensed pest control personnel to implement an effective and safe rodent control programme.

Preventing access to feed, water, and shelter is an important part of any rodent control programme.

A programme should be implemented at the first sign of rodent activity. Rodent populations and the associated cost of control can escalate quickly. The degree of infestation, rodent travel patterns, entrances, and nesting sites should be determined before embarking on a specific programme. Rodent control requires continuous efforts, and control methods should relate to the extent of infestation.

Rodents should be eliminated when poultry houses are empty. The building can be repaired, cleaned and baited, and all nesting sites destroyed.

#### 11.3.1 Rodent proofing

Locate and close all rodent access routes. Galvanized steel and concrete are the best deterrents. Seal and fasten outside building structures which are loose and provide an opening for rodents to enter. Doors should fit snugly
in their frames. Ventilation and auger openings should be screened. Feed storage areas and bins should be rodent proof. Remember, mice can squeeze through gaps of less than 1 cm wide and rats and mice can climb and jump.

11.3.2 Management and sanitation

The inside and outside of the poultry houses should be kept clean to deprive rodents of hiding and nesting places and feed. All vegetation outside should be kept short and debris and spilled feed inside and outside be removed. Manure piled up under the cages on the beams should be removed twice monthly. Total manure or litter removal from the poultry house will always hasten the success of a rodent control programme, and it is essential for heavily infested buildings.

11.3.3 Non-chemical rodent elimination

Traps, sticky tapes or cats can successfully supplement chemical control measures. Cats are not generally recommended for rodent control inside poultry houses since they may transmit diseases, become infected themselves or become injured by machinery used in automated buildings. Ultrasonic devices have been used with limited success.

11.3.4 Chemical rodent control (rodenticides)

Chemical methods of rodent control include bait, tracking powder, or fumigation. All rodenticides are poisonous at various levels for chickens, livestock and humans. Some rodenticides accumulate in rodents and cause secondary poisoning when these rodents or their faeces are ingested by non-target animals. Caution in the use of these products is required. Manufacturer’s label instructions should be strictly followed and local regulations be observed.

Some rodenticides are absorbed through the skin, therefore, wearing gloves while handling these products is recommended. Baits must be placed in tamper-proof bait boxes or in locations not accessible to children, pets, domestic animals, or wildlife. Food contamination should be avoided. The toxicity of rodenticides differs and some rodenticides may be registered for restricted use. Common rodenticides are listed in Table 3.

Rodenticides are available for single- or multiple-doses. Rodenticides may affect blood clotting, nervous system, calcium regulation or other functions. Single-dose rodenticides will kill rodents after one feeding if consumed in an adequate amount. Multiple-dose compounds have a cumulative effect and will kill rodents after several feedings. This bait has to be continuously available and other feed sources must be removed.

The rate of rodent kill depends on the type of rodenticide and the dose consumed. Some products kill within one hour and others 4-7 days after ingestion.

Baits are available in dry or wet form, in powder mixed with grain, pellets, micro-encapsulated, in paste, wax, or in water. For maximum effectiveness, bait should be offered in both feed and water.

Bait should be offered at bait stations located in the activity zone of rodents.
<table>
<thead>
<tr>
<th>Common Name</th>
<th>Single/Multiple feeding</th>
<th>Secondary Poisoning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bromethalin</td>
<td>Single</td>
<td>No</td>
</tr>
<tr>
<td>Cholecalciferol</td>
<td>Single/Multiple</td>
<td>No</td>
</tr>
<tr>
<td>Warfarin</td>
<td>Multiple</td>
<td>Yes</td>
</tr>
<tr>
<td>Brodifacoum</td>
<td>Single</td>
<td>Yes</td>
</tr>
<tr>
<td>Bromadiolone</td>
<td>Single</td>
<td>Yes</td>
</tr>
<tr>
<td>Pindone</td>
<td>Single/Multiple</td>
<td>Yes</td>
</tr>
<tr>
<td>Diphacinone</td>
<td>Single/Multiple</td>
<td>Yes</td>
</tr>
<tr>
<td>Chlorphacinone</td>
<td>Single/Multiple</td>
<td>Yes</td>
</tr>
<tr>
<td>PMP-Ca-Salt</td>
<td>Multiple</td>
<td>Yes</td>
</tr>
<tr>
<td>Scilliroside</td>
<td>Single</td>
<td>No</td>
</tr>
<tr>
<td>Zinc phosphide</td>
<td>Single</td>
<td>No</td>
</tr>
</tbody>
</table>

and in their routes between the nesting site and the common food source, and at the entrance to active burrows. In heavily infested poultry in poorly rodent-proofed houses, bait stations may have to be placed every 4 meters along the wall or ledges. Examples of safe and effective bait stations which can be cheaply constructed, are illustrated in Figure 2. T-pieces constructed from PVC drainage pipes, 4 or 10 cm in diameter, and about 15 cm long have been effective and cheap.

Random placement of bait throughout the facility is not cost-effective. Distribution of rodenticides over manure dropping boards, in areas frequented by people or pets, and loose placement above feeding troughs or chickens, may contaminate feed and expose poultry, non-target animals, and humans.

Empty poultry houses should be baited immediately after removal of feed from the troughs so that rodents will consume the bait. All alternative feed sources (spilled feed, broken eggs, and dead birds) must be removed.

Bait should be placed in active burrows outside houses.

Tracking powder comprising mixtures of a rodenticide and an inert powder can spread over the main pathways of rodents. Mice and rats are contaminated with the powder on their feet, fur, and tail and ingest the poison while grooming.

Bait station should be checked twice weekly to make sure they are always full. The bait should be fresh. Only small amounts of bait (1-3 tablespoons) should be placed in each bait station. Bait older than 4 weeks should be discarded.

Rodents may develop bait shyness. For that reason a different bait should be rotated into the bait station. Hence, an inventory of at least two baits should be maintained. Servicing bait stations,
checking for bait consumption and keeping a log of results is important for assessing the efficacy of the rodent control programme.

Fumigation with toxic gases may be used in empty buildings and outdoor burrows. All fumigants are toxic to humans and animals and should be used with care only by trained personnel. Fumigants have limited use in modern poultry houses. Rodents burrowing outdoors or within the walls will not be killed. Fumigants include methyl bromide, chloropicrin, calcium cyanide and carbon bisulphide. Formaldehyde fumigation is used by some poultry producers to disinfect poultry houses and may also kill some rodents, but it is an unreliable method of control.

Rodent control programmes must be monitored regularly. An inspection of the facility inside and outside every 2-3 weeks will also indicate whether the programme is effective. Attention must be paid to areas where rodents are most difficult to detect, such as attics, manure pits in laying houses, and the area under wooden slats in breeder houses. Appropriate action, including rodent surveillance, rodent proofing, sanitation and elimination, should be promptly implemented if rodent activity is observed.

11.4 References


LIST OF PARTICIPANTS

Professor T. Blaha, Head, Epidemiological Field Station, School of Veterinary Medicine
Hanover, Büscheler Strasse 9, D-49456 Bakum/Vechta, Germany

Dr R. Böhm, Chair, Division of Environmental Animal Hygiene, University of
Hohenheim, P.O. Box 700561, D-70574 Stuttgart, Germany

Mr J. D. Corkish, Bacteriological Department, Ministry of Agriculture,
Fisheries and Food, Central Veterinary Laboratory, New Haw, Weybridge,
Surrey KT15 3NB, United Kingdom

Dr A. Engvall, Head, Division of Epizootiology, National Veterinary
Institute, P.O. Box 7073, S-750 07 Uppsala, Sweden

Dr U. Löhren, Mastkükenbrüterei Weser-Ems, D-49425 Rechterfeld, Germany

Dr J. Mason, United States Department of Agriculture; Animal and Plant
Health Inspection Service, Director, Salmonella Enteritidis Control Program, 6525 Belcrest
Road, Suite 205, 20782 Hyattsville, MD, USA

Dr P. Trenner, Station für Hygiene/Forschung, Dr Zinn-Weg,
D-16225 Eberswalde, Germany

Secretariat

Dr K. Stöhr, Veterinary Public Health, Division of Communicable Diseases,
WHO, Geneva, Switzerland
LITERATURE


4. Code of Practice for the Prevention and Control of Salmonella in Breeding Flocks and Hatcheries (Brochure), MAFF Publication, London SE99 7TP, UK

5. Disinfection in Cases of Salmonellosis (VPH/84.59)

6. Guidelines on Prevention and Control of Salmonellosis (VPH/83.42)


CLEANING AND DISINFECTION OR OTHER APPROPRIATE METHODS
TO BE APPLIED AFTER S. ENTERITIDIS INFECTIONS IN POULTRY HOUSES OF
THE LOUISIANA TYPE WITH EARTH (DIRT) FLOORS

General remarks

The Guidelines for cleaning and sanitation/disinfection in poultry flocks with *S. enteritidis*
refer to buildings with concrete floors.

In many parts of the world simple chicken houses with earth (dirt) floors exist. In the USA
they are the predominant type of broiler houses and in France and Germany they are known as
Louisiana houses or as Naturstall. They are mainly used for broilers and occasionally also for
breeders although the latter is discouraged. Litter is usually not removed for a period of one year,
i.e. for 7-8 crops of broilers. These houses are normally only dry-cleaned and not disinfected.

From the economic point of view, these houses render good results and their application is
spreading. It is therefore necessary to provide recommendations on how to deal with these houses
in case of *S. enteritidis* infection even if it is known that disinfection measures in houses of this
kind will not be as effective as required.

House-cleaning procedures (see also paragraph 4.1 Dry cleaning)

1. Litter has to be removed and either spread on arable land and ploughed in or it may be used
   as a fertilizer without restrictions after lime treatment and composting.
   Solid manure as well as contaminated litter and soil from Louisiana houses must promptly be
treated:
   a. thoroughly mix contaminated material with quicklime (CaO, 100 kg lime per m³), choose
      a place with concrete floor away from inflammable material; steadily moisten pile whilst
      setting up (100 litres water per m³);
   b. foil cover the pile and allow for composting for five weeks;
   c. remove/convert the pile to a new one, cover and have it composted for another 5 weeks
      – Whilst composting pile temperatures should reach 70–90°C (158–164°F) and pH of above
      12.

2. All removable equipment (brooders, fans) should be stacked outside the house on concrete
   floors for later cleaning and disinfection.

3. The whole building must be dry cleaned with an industrial vacuum cleaner fitted with an
   appropriate dust/bacterial filter.

4. Visible caked dirt or dust on the walls, ceilings, doors, piers, pillars and curtains must be
   scraped and scrubbed with either:
   – hot sodium hydroxide (NaOH) solution (3 kg in 100 litres hot water) or
   – hot soap solution (3 kg liquid soap in 100 litres hot water)
5. Some Louisiana type chicken houses (mainly in Germany) have a plastic sheet at a 50 cm level beneath the earth floor to protect against nitrogen pollution of the ground water. Thus pressure cleaning or the use of abundant washing solution cannot be recommended.

6. The uppermost layer (approximately 25 cm) of the earth floor must be removed and renewed by a layer of uncontaminated earth or sand. The removed earth layer must be treated like the contaminated litter (see above).

Disinfection

Because of the earth floor, wet disinfection with a chemical disinfectant is not feasible.

Hot steam formaldehyde fumigation is the disinfection method of choice (Annex 7).

It is essential to ensure the curtains are properly closed to reduce steam or formaldehyde loss.

The effectiveness of cleaning and hot steam formaldehyde fumigation should be microbiologically monitored prior to reinstallation of the equipment (see Section 10).
## LIST OF RECOMMENDED DISINFECTANTS

<table>
<thead>
<tr>
<th>Disinfectant/Active Chemical Compound</th>
<th>Concentration/ Exposure Time</th>
<th>Influence of Low Temperatures *</th>
<th>Field of Application</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcohol</td>
<td></td>
<td>Low</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ethanol</td>
<td>E: 70-80%</td>
<td></td>
<td>E (B)</td>
<td>Flammable</td>
</tr>
<tr>
<td>Isopropyl alcohol</td>
<td>E: 60-70%</td>
<td></td>
<td>E (B)</td>
<td>Flammable</td>
</tr>
<tr>
<td>Commercial Preparations</td>
<td>E: undiluted</td>
<td></td>
<td>Flammable</td>
<td></td>
</tr>
<tr>
<td>Aldehydes</td>
<td></td>
<td>High</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Formaldehyde</td>
<td>A + C: 1% / 2 h B: 0.5% / 4 d</td>
<td></td>
<td>A, C</td>
<td></td>
</tr>
<tr>
<td>Glutaraldehyde</td>
<td>A + C: 1.5% / 2-4 h</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commercial Preparations</td>
<td></td>
<td>A: not to be used below 10°C</td>
<td>A, C, D</td>
<td></td>
</tr>
<tr>
<td>Chlorine Compounds</td>
<td></td>
<td>Low</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chloramine T</td>
<td>A: 10% / 2 h</td>
<td></td>
<td>A, C</td>
<td></td>
</tr>
<tr>
<td>Commercial Preparations</td>
<td>A: 3-5% / 2 h</td>
<td></td>
<td>A, C</td>
<td></td>
</tr>
<tr>
<td>Sodium hypochlorite</td>
<td>B: 250 mg available</td>
<td></td>
<td>B, C</td>
<td></td>
</tr>
<tr>
<td></td>
<td>chlorine / l h</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>C: 200 mg available</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>chlorine / l h</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jodophores</td>
<td></td>
<td>Low</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Povidone-iodine</td>
<td>A: 10% / 2 h</td>
<td></td>
<td>E, A, (B)</td>
<td>Plastic material may be stained by iodine</td>
</tr>
<tr>
<td>Commercial Preparations</td>
<td>A: 3% / 4 h B: 1% / 4 h</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>C: undiluted / 6 min</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lime</td>
<td></td>
<td>Low</td>
<td></td>
<td>D Lime wash (4%) is commercially available in several countries due to its application in municipal wastewater treatment</td>
</tr>
<tr>
<td>Lime wash</td>
<td>D: 60 kg/m² sterile / 4 d</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(40% w/v in water)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organic acids</td>
<td></td>
<td>High</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Formic acid</td>
<td>A + C: 1% / 2 h</td>
<td></td>
<td>A, B, C</td>
<td></td>
</tr>
<tr>
<td>Acetic acid</td>
<td>A + C: 2% / 2 h</td>
<td></td>
<td>A, B, C</td>
<td></td>
</tr>
<tr>
<td>Commercial Preparations</td>
<td>A + C: 2-3% / 2 h</td>
<td>A: not to be used below 10°C</td>
<td>A, B, C</td>
<td></td>
</tr>
<tr>
<td>Peroxide compounds</td>
<td></td>
<td>Low</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Persacetic acid</td>
<td>A + C: 0.5% / 1 h (D: 0.4% / 1 d)</td>
<td></td>
<td>A, B, C (D)</td>
<td>Peroxides are ineffective in the presence of blood and on rusty iron. Not stable in use dilutions.</td>
</tr>
<tr>
<td>Hydrogen Peroxide</td>
<td>B + C: 1% / 1 h</td>
<td></td>
<td>B, C</td>
<td></td>
</tr>
<tr>
<td>Commercial Preparations</td>
<td>A + C: 3-5% / 2 h</td>
<td></td>
<td>A, B, C</td>
<td></td>
</tr>
<tr>
<td>Phenolic compounds</td>
<td></td>
<td>High</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phenol</td>
<td>A + C: 5% / 2 h</td>
<td></td>
<td>A, B, C</td>
<td></td>
</tr>
<tr>
<td>Commercial Preparations</td>
<td>A + C: 2-5% / 2-4 h</td>
<td>A: not to be used below 10°C</td>
<td>A, B, C (E)</td>
<td></td>
</tr>
<tr>
<td>Sodi-Lye</td>
<td>B + C: 2% / 2 h (A: 3% / 2 h)</td>
<td></td>
<td>B, C, D (A)</td>
<td></td>
</tr>
<tr>
<td>D: 1.5% / 4 d</td>
<td></td>
<td>Low</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quaternary Ammonium Compounds (Quats)</td>
<td></td>
<td>High</td>
<td></td>
<td>Quaternary ammonium compounds lose their effect if they meet residual cleansing agents on the surfaces</td>
</tr>
<tr>
<td>Compound Preparations</td>
<td>B + C: 1-4% / 1-4 h</td>
<td>A: not to be used below 10°C</td>
<td>B, C (E)</td>
<td></td>
</tr>
</tbody>
</table>

A: Universal surface disinfection in poultry-houses
B: Application limited to smooth, non corroded and extremely clean surfaces (no wood, no concrete)
C: For submersion disinfection (sewage)
D: Disinfection of liquid manure up to a dry matter content of 8%. Components must be mixed carefully
E: Skin disinfection (hygiene hand disinfection)

* The bactericidal effect of several disinfectants on surfaces decreases dramatically at low temperatures especially in combination with high air velocity or low relative humidity of the air. Those disinfectants are marked in the column with "high". It must be taken into account that even at 10°C the use - concentration has to be elevated 2.5 - 3 times compared to 30°C at the same exposure time. For pre-disinfection or liquid manure disinfection the influence of temperature is relatively low with the same substances and does not limit the application in any case.
<table>
<thead>
<tr>
<th>Disinfectants/ Active Compounds</th>
<th>Al</th>
<th>Cu</th>
<th>Sn</th>
<th>Metals</th>
<th>Fe</th>
<th>Steel</th>
<th>Stainless Steel</th>
<th>Brick walls</th>
<th>Dyes</th>
<th>Textiles</th>
<th>Leather</th>
<th>PVC</th>
<th>Surfactants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcohols</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Aldehydes</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Chlorine</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>±</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Chloramines</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Jodophores</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>±</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Organic Acids</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>+</td>
</tr>
<tr>
<td>Peroxides</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Phenols</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>±</td>
</tr>
<tr>
<td>Soda Lye</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>±</td>
<td>±</td>
<td>-</td>
</tr>
<tr>
<td>Quats</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
</tbody>
</table>

+ Compatible  ± less compatible  - incompatible

*The compatibility concerns corrosion of material as well as the loss of activity of the disinfectant. The degree of corrosion correlates with the concentration of disinfectant; low concentrations are less or are not corrosive. In commercial preparations, the manufacturer often adds anticorrosives, so that the working dilutions do not adversely affect the materials. The lower the used concentration of disinfectant the higher the loss of activity.*
CLEANING AND DISINFECTION OF WATER LINES

1. Clear out all residual water in the header tanks. Clean the inside with a brush.

2. Bell drinkers or cups must be disconnected from the pipe system to allow for proper soaking and scrubbing. Calcium deposits (as a result of hard water) should be removed (Phosphorus acid 37%, pH 1-2, regard safety regulations).

3. The drinkers or cups can be reattached after immersion in a disinfectant solution for about 5 minutes (see Annex 5).

4. The best way to quickly distribute disinfectant throughout the drinking system is to fill the header tank and to remove the drain plug at the end of each line to disconnect the last drinker.

5. The disinfectant, preferably a quaternary ammonium base, should stay in the whole water pipe system for 24 hours.

6. Remove the disinfectant through the drain plug or last drinker.

7. In most cases this method removes a lot of dirt, slime and algae from the inside of the pipe system. The procedure has to be repeated until an almost clear disinfectant rinses out of the system after 24 hours.

8. Finally the whole system should be flushed extensively with clean water to remove all residues.

HOT STEAM FUMIGATION – A VALUABLE FINAL DISINFECTION OPTION IN POUlTRY FLOCKS, IN PARTICULAR IN CONJUNCTION WITH S. enteritidis CONTROL

Hot steam fumigation combines the disinfection activity of hot steam with formaldehyde. This disinfectant acts best in the presence of high humidity and high temperature. The method is particularly useful to complement conventional disinfection methods as it helps to overcome some of the shortcomings of spray disinfection.

However, for the treatment to be successful several prerequisites are to be met:
- homogenous distribution of steam in the entire house;
- steam temperature above 60°C and air humidity of 65-80% maintained in all parts of the house for at least 30 minutes;
- generators achieving an appropriate fumigation throwing range; and
- 20-30 litres of formaldehyde solution (30-40%) per 1000 m³ volume of the house.

Experience has also shown that other infectious agents (e.g., Gumboro-, Adeno-, or Anaemia-viruses) cannot efficiently be eliminated from chicken houses by conventional disinfection. However, after hot steam formaldehyde fumigation the next lots remained free from these infections as demonstrated by the absence of specific antibodies against these diseases.

Description of the procedure

Prevent fumigation staff (which is likely having already worked on other poultry farms!) from entering the cleaned and disinfected houses without meeting basic hygienic requirements (e.g., changing clothes and boots). All doors, fan outlets and other openings must be thoroughly closed.

Steam is provided from a mobile steam generator and led into the house through a 12 cm diameter hose which has two or three outlets, depending on the length of the house.

Several electronic thermometers with displays which can be read from outside register the temperature within the house. The material which limits the temperature which can be used for the procedure is usually plastic (e.g. drinkers, water lines, transport belts, etc.) which normally tolerates 60°C, but may well be damaged by temperatures exceeding 65°C.

Once the temperature inside the house has reached 60°C, the steam generator is reduced from full power to medium to maintain at least 60°C and not exceed 65°C for 30 minutes.

Even though openings are closed, the steam finds its way through small cracks and fissures of the building which can be observed from outside.

After 30 minutes at 60°C inside the building, formaldehyde is added by a bypass system to the steam. The amount is 35 ml of technical formalin (37% formaldehyde) per m³ volume of the chicken house.

Steam generation is stopped immediately after the calculated amount of formalin is brought into the building.

After 24 hours, the fans – and, if necessary, additional heating – are switched on to dry the building.
MICROBIOLOGICAL MONITORING OF THE EFFECTIVENESS OF CLEANING AND DISINFECTION

Culture methods

Methods cited in the literature


This method is carried out as described below.

1. Samples taken into BPW (Oxoid CM509) are pre-enriched for 18 hours at 37°C.

2. 20 ml Petri dishes of semi-solid Rappaport Medium (MRSV) (LabM LAB150) containing 20 μl novobiocin are prepared. 16-18 μl of a polyvalent “H” salmonella antiserum (e.g. Wellcome Diagnostics) are absorbed onto an autoclaved 8.5 cm diameter disc punched from a sheet of blotting paper (20.14 kg/1000). One disc is inserted beneath the surface of the MSRV agar about 2 cm from the edge of the plate using sterile forceps. Discs should be inserted immediately before the plates are used.
3. 0.2 ml of the BPW are inoculated into the depths of the MSRV agar in the centre of the plate to form a well defined bleb. If the inoculum disperses from the bleb immediately, a new plate should be used. The inoculated plate is incubated at 41.5°C for 24 hours.

4. The presence of presumptive motile salmonella is indicated by cloudy/opaque growth in the agar with a clear zone of inhibition around the disc.

5. A 10 μl loop is dipped into the agar 0.5-1 cm from the edge of the plate directly opposite the disc or at the edge of the opaque zone if this does not extend to the edge of the plate. The loop is then streaked onto a single plate of Rambach agar (Merck) which is incubated at 41.5°C for 18-24 hours.

6. The presence of a profuse growth of bright crimson colonies on the Rambach agar is specific for salmonella. Some strains occasionally occur as pale variants. A profuse growth of pale orange or colourless colonies together with a zone of inhibition on the MSRV plate also gives a specific identification of salmonella. Unless a non-motile strain of salmonella is present, pale colonies on the Rambach plate without a zone of inhibition on the MSRV plate will not be salmonella.

7. MSRV plates on which growth is slow and insufficient to show a zone of inhibition after 24 hours incubation are incubated for a further 24 hours. Only those plates which then show a zone of inhibition are subcultured onto Rambach agar as in 5. above.

8. Representative salmonella colonies from the Rambach plate are serotyped by standard methods.

**Culture Flow Chart**

<table>
<thead>
<tr>
<th>Day</th>
<th>Action</th>
<th>Temperature</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sample 1:10 BPW</td>
<td>37°C</td>
<td>18 hours</td>
</tr>
<tr>
<td>2</td>
<td>0.2 ml into 20 ml MSRV plate</td>
<td>41.5°C</td>
<td>24 hours</td>
</tr>
<tr>
<td>3</td>
<td>10 μl onto Rambach agar</td>
<td>41.5°C</td>
<td>24 hours</td>
</tr>
<tr>
<td>4</td>
<td>10 μl onto Rambach agar</td>
<td>41.5°C</td>
<td>24 hours</td>
</tr>
</tbody>
</table>

Read plates from day 3 and confirm suspect colonies if necessary

5. Read plates from day 4 and confirm suspect colonies if necessary.
LIST OF DISINFECTANT NEUTRALIZING AGENTS

The following neutralizers are recommended for:

- Commercial disinfectants except peroxides, jodophores and chlorine components: 3% polysorbate 80 + 0.3% lecithin + 3% saponin + 0.1% histidine

- Commercial disinfectants based on peroxides, jodine and chlorine components: 3% polysorbate 80 + 3% saponin + 0.1% histidin + 0.1% cystein

- Pure substances:
  - Aldehydes: 0.1% histidin
  - Chlorine: 0.5 sodiumthiosulfate
  - Quats: 3% polysorbate 80 + 0.3% lecithin
  - Phenols: 1% polysorbate 80
  - Organic acids: 0.1 mol/l Na₂HPO₄
# RODENT EVALUATION AND INSPECTION FORM

House ___________________________ Evaluation Date ________________________

Flock age _________________________ Evaluator _____________________________

<table>
<thead>
<tr>
<th>Rodent living and Nest Sites</th>
<th>Did not check or not applicable</th>
<th>None</th>
<th>Low (1-5)</th>
<th>Moderate</th>
<th>High (over 10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Holes and/or gaps or openings in wood sheathing of walls</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Holes or cracks in shallow pit floors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Holes or cracks in walkway floors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Holes or gaps in cleanout doors or other doors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Rodents living in debris or clutter inside building</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Holes or tunnels in attic insulation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Manure cones on cage support beams</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Holes or cracks on or near ledges in concrete blocks or walls in deep pit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Holes in manure piles</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Holes or cracks in egg room</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Weeds, tall vegetation or debris outside of house</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Holes/gaps exterior of house</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Estimate of mouse (rodent) population:  □ None  □ Slight  □ Moderate  □ Severe

Other vermin noted: ___________ Skunks ___________ Other
<table>
<thead>
<tr>
<th>Complex/Zone</th>
<th>Date</th>
<th>Index</th>
<th>Date</th>
<th>Index</th>
<th>Date</th>
<th>Index</th>
<th>Date</th>
<th>Index</th>
<th>Date</th>
<th>Index</th>
<th>Date</th>
<th>Index</th>
<th>Date</th>
<th>Index</th>
<th>Date</th>
<th>Index</th>
</tr>
</thead>
</table>

RODENT CONTROL INDEX FORM