INCUBATOR HYGIENE
In the Control of Pullorum Disease

By ROBERT GRAHAM
and V. M. MICHAEL

Healthy chicks come from healthy parent stock and disease-free environment.

UNIVERSITY OF ILLINOIS
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PULLORUM DISEASE is one of the most prevalent and costly enemies of hatcherymen and farm flock owners. It prevails unsuspected in many flocks in a chronic, nonfatal form, resulting in lowered egg production and in reduced hatchability of eggs. The heaviest fatalities from it, however, occur in chicks under three weeks of age. Mature fowls also occasionally suffer from a fatal type of the malady.

Infected chicks that survive pullorum infection are temporarily unthrifty and more susceptible to other ills than are chicks that have not had the disease. Chicks that reach maturity perpetuate the infection by passing it on to young chicks thru infected eggs. The infection may also spread from egg-infected young chicks to chicks hatched from disease-free eggs.

Fumigation carried out under proper conditions and at the proper times checks the spread of pullorum disease in incubators, but does not cure egg-infected chicks; it is preventative, not curative. Accordingly, best results in reducing chick mortality from this disease can be expected only when chicks are hatched from eggs of disease-free flocks in clean and disinfected incubators.

Flocks in Illinois are accredited for type, following culling, by inspectors of the Poultry Division of the State Department of Agriculture. Flocks may also be tested for freedom from pullorum disease by approved veterinarians and accredited by the State Department of Agriculture, if found free from disease. The two kinds of accreditation should not be confused. Purchasers of day-old chicks are warned that chicks from flocks or hatcheries accredited for type are not necessarily protected by tests which have established the health of the parent stock, nor have they necessarily been protected by state supervised measures of incubator hygiene. Incubator hygiene is the responsibility of the individual hatcheryman.
Incubator Hygiene in the Control of Pullorum Disease

By Robert Graham and V. M. Michael,
Laboratory of Animal Pathology and Hygiene

In incubators, studies on incubator hygiene have been conducted at the Illinois Experiment Station. These studies have shown that the basic factor in guarding against the dissemination of pullorum disease in incubators is physical cleanliness. Proper fumigation of incubators and incubator rooms at the time the young chicks are hatching further reduces the spread of the disease.

Cleanliness and fumigation are also helpful in the suppression of other contagious diseases of young chicks, such as laryngotracheitis. Since incubators and incubator rooms in routine operation are subject to accumulation of dirt, dust, and contaminated down, frequent cleaning and disinfection must be carefully and systematically carried out if desired results are to be obtained.

SANITARY MEASURES

The following sanitary measures are of value in the control and suppression of disease in incubators:

A. Prevent Disease From Entering the Incubator. — Contamination of the incubator may be greatly reduced by using eggs from healthy tested flocks and by safeguarding the incubator against contacts with contaminated matter. Since microorganisms may be carried on shoes and other clothing, workmen who have handled sick chicks should not be allowed to enter the incubator room.

B. Keep Incubator and Incubator Room Clean. — Any accumulation of organic material such as chick down, fecal material, egg shells, or dead chicks forms an excellent medium for the growth of bacteria at incubator temperature and humidity. In clean incubators pathogenic bacteria do not survive longer than a few days. The first step in incubator hygiene is, therefore, to remove all dirt.

1. Before the hatching season starts, wash the walls and floor of the incubator and incubator room with a reliable disinfectant. Between hatches, clean egg trays and hatching trays by scrubbing with a steel brush and scalding hot lye water (1 pound of lye to 40 gallons of water). After cleaning, allow the trays to dry and then disinfect them (Fig. 1).
2. During the hatching season keep all dirt, egg shells, droppings, and down removed from the incubator. Clean, dry, and disinfect the trays after each hatch.

C. Use Chemical Disinfectants.—If the incubator and the trays are clean, any of the following chemical disinfectants may be used to destroy disease germs on egg trays and hatching trays.

1. Compound solution of cresol, USP (Liquor cresolis compositus), approximately a 3-percent solution:
   - Compound solution of cresol: 4 ounces
   - Water: 1 gallon

2. Chlorinated lime (“chlorid of lime”), approximately a 3-percent solution:
   - Chlorinated lime: 3 ounces
   - Water: 1 gallon

3. Carbolic acid, approximately a 5-percent solution:
   - Crude carbolic acid: 7 ounces
   - Water: 1 gallon

The above mentioned disinfectants may be applied by washing, spraying, or immersing. Rubber gloves will protect the operator’s hands.

TWO FORMALDEHYDE METHODS TESTED

Two methods of releasing formaldehyde in forced-draft incubators have been employed at the Illinois Agricultural Experiment Station in tests of fumigation efficiency: (1) the cheesecloth method and (2) the potassium permanganate method (recommended by incubator manufacturers). Tests were made with two types of forced-draft incubators. The results are summarized in Tables 1 and 2.

Fumigation of Egg Shells and Cotton Squares.—S. pullorum, the causative agent of pullorum disease, was placed on egg shells and pieces of cotton (1" x 1" x \(\frac{3}{16}\)"), which were then placed in different locations in the incubator. These contaminated materials were removed from the incubator at 5- to 30-minute intervals and cultured on suitable media. The results suggest that the location of S. pullorum in the incubator may be a factor which influences the time required by the fumigant to destroy the infection. When S. pullorum was exposed on cotton squares or egg shells attached to the inside of a false door of the incubator (Figs. 2 and 3) so that the fumigant had access

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2. Investigations on incubator hygiene conducted at the Illinois Experiment Station during the past two years were limited to a Buckeye Mammoth No. 44 and a Smith Junior incubator installed by the Smith Incubator Company, Cleveland, without cost to the University.
FIG. 1.—CLEANING AND DISINFECTING
HATCHING AND EGG TRAYS

Scrub the hatching and egg trays with a steel brush and scalding hot lye water, then stack them and allow to become thoroughly dry. When the trays have dried, immerse them in some reliable disinfectant such as cresol, “chlorid of lime,” or carbolic acid solutions, and allow them to soak until all dirt has been loosened.

to all sides of the contaminated material, it was killed much more quickly than when the material was placed in an open petri dish set in the hatching trays or on the floor of the incubator.

Likewise, the nature of the contaminated material seemed to influence the resistance of *S. pullorum* to the fumigant. The organism was killed more quickly on egg shells than on cotton squares (Tables 1 and 2). This may be explained by the fact that formaldehyde gas does not penetrate the cotton squares easily. Droplet or air infection was most rapidly destroyed, while contaminated cotton squares offered the greatest obstacle to fumigation. Ten fumigations with formaldehyde gas by the potassium permanganate method were made in one incubator. In one of the ten, *S. pullorum* on cotton squares in the egg trays was alive at the end of 180 minutes, while in the remaining 9 fumigations, as well as in 10 fumigations with formolized cheesecloth, *S. pullorum* was consistently killed within 180 minutes. In 25 fumigations with potassium permanganate in another incubator and in 25 with
### Table 1. Fumigation of Type A Incubator With Formaldehyde Released From Cheesecloth and With Potassium Permanganate

(Top vents open; wet bulb, 90-92° F.; dry bulb, 99-100° F.)

<table>
<thead>
<tr>
<th>Location of S. pullorum</th>
<th>Contaminated material</th>
<th>Number of fumigation tests</th>
<th>Minutes S. pullorum survived</th>
</tr>
</thead>
<tbody>
<tr>
<td>False door of incubator</td>
<td>Egg shells</td>
<td>25</td>
<td>10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190</td>
</tr>
<tr>
<td></td>
<td>Cotton squares</td>
<td>25</td>
<td>10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190</td>
</tr>
<tr>
<td>Open petri dishes on floor of incubator near hatching trays</td>
<td>Egg shells</td>
<td>25</td>
<td>10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190</td>
</tr>
<tr>
<td></td>
<td>Cotton squares</td>
<td>25</td>
<td>10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190</td>
</tr>
<tr>
<td>Day-old chicks in hatching trays</td>
<td>Feet</td>
<td>22</td>
<td>10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190</td>
</tr>
<tr>
<td></td>
<td>Down</td>
<td>22</td>
<td>10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190</td>
</tr>
</tbody>
</table>

- ○○ Average time in which $S. pullorum$ was killed by fumigation with formaldehyde released with potassium permanganate (35 cc. of formalin per 100 cubic feet; total amount, 95 cc.).
- ○ Average time in which $S. pullorum$ was killed by fumigation with formaldehyde released from cheesecloth (20 cc. of formalin per 100 cubic feet; total amount, 55 cc.).
- + Control, no fumigant released.
- Range of time in which $S. pullorum$ was killed in 25 fumigations.
- + In one or more fumigations $S. pullorum$ survived beyond time range indicated; the exact time was not determined.

Formalized cheesecloth, $S. pullorum$ on contaminated cotton squares was consistently killed within 180 minutes.

Fumigation of artificially contaminated cotton squares placed on egg trays and hatching trays of two forced-draft incubators yielded results comparable to those obtained in the fumigation of artificially contaminated chicks. These observations suggest the necessity of keeping incubators free from organic material (egg shells, down, droppings, and dead chicks) to obtain efficient fumigation.

**Fumigation of Artificially Contaminated Chicks.**—Chicks hatched from infected eggs are sometimes covered with a suspension of $S. pullorum$, the cause of pullorum disease. As the down dries and fluffs out, $S. pullorum$ may be carried by incubator air currents from the infected chicks to disease-free chicks. The chief purpose of fumigating incubators is to kill disease-producing bacteria at hatching time before healthy chicks become infected.

In an effort to determine the efficiency of formaldehyde fumigation in destroying natural $S. pullorum$ infection on chick feet and down,
TABLE 2.—FUMIGATION OF TYPE B INCUBATOR WITH FORMALDEHYDE RELEASED FROM CHEESECLOTH AND WITH POTASSIUM PERMANGANATE
(Top vents open; wet bulb, 90° F.; dry bulb, 99-100° F.)

<table>
<thead>
<tr>
<th>Location of S. pullorum</th>
<th>Number of fumigation tests</th>
<th>Minutes S. pullorum survived</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton squares in doors of incubator</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Upper doors</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Lower doors</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Cotton squares in petri dishes in trays</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Egg trays</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Hatch ing trays</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Day-old chicks in hatching trays</td>
<td>10</td>
<td>*</td>
</tr>
<tr>
<td>Feet</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Down</td>
<td>10</td>
<td>0</td>
</tr>
</tbody>
</table>

○○ Average time in which S. pullorum was killed by fumigation with formaldehyde released with potassium permanganate (25 cc. of formalin per 100 cubic feet; total amount, 150 cc.).
○○ Average time in which S. pullorum was killed by fumigation with formaldehyde released from cheesecloth (16½ cc. of formalin per 100 cubic feet; total amount, 160 cc.).
+ Control, no fumigant released.
----- Range of time in which S. pullorum was killed in 10 fumigations.
* In one or more fumigations S. pullorum survived beyond time range indicated; the exact time was not determined.

healthy day-old chicks, following immersion in a suspension of S. pullorum, were placed in the hatching trays of two forced-draft incubators and fumigated with formaldehyde. The formaldehyde gas was released from formalin by means of potassium permanganate (in amounts recommended by manufacturers) and from formolized cheesecloth. Artificially infected, fumigated chicks were examined for living S. pullorum at intervals of 30 minutes for a period of 3 hours after the release of the formaldehyde (Tables 1 and 2). S. pullorum survived on the feet and down of chicks exposed to formaldehyde fumigation for periods ranging from less than 30 minutes to more than 180 minutes. In the majority of fumigations, however, S. pullorum was killed in less than 60 minutes. The average lethal times of different fumigations for S. pullorum on chick feet and down in two forced-draft incubators ranged from 57 to 93 minutes.

The results of fumigating artificially contaminated chicks suggest that formaldehyde gas released in forced-draft incubators in amounts recommended by manufacturers may not always destroy S. pullorum.
on the feet and down of infected chicks within three hours, since in one of the forced-draft incubators, 2 of 22 fumigations by the potassium permanganate method failed to destroy *Salmonella pullorum* within 180 minutes. Twenty fumigations of the same incubator with formolized cheesecloth consistently destroyed *S. pullorum* on the feet and down of artificially infected chicks within 180 minutes. In the other forced-draft incubator *S. pullorum* on the feet and down did not survive as long as 180 minutes in any one of 10 fumigations with formaldehyde gas released from formalin with potassium permanganate nor in any one of 10 fumigations with formolized cheesecloth (Tables 1 and 2).

**Influence of Fumigation on Chick Mortality.**—No noticeable injury to healthy chicks resulted from the fumigation at time of hatching, but weak chicks were sometimes injured. Injury to weak chicks is, however, a negligible factor and more than overbalanced by the good the fumigations accomplish in preventing the spread of the disease in incubators. But it is apparent that chicks from infected eggs cannot be cured by fumigation.

![Fig. 2.—Type A Incubator Fitted With False Door for Holding Test Materials](image)

In order to facilitate the removal of contaminated materials for bacteriological examination during the process of fumigation, the incubator was fitted with a matstock panel in which holes were cut for No. 1 rubber stoppers. The materials used as carriers for the test microorganism, *S. pullorum*, consisted of cotton squares (1" x 1" x 1/16") and egg shells (1" x 1½"). These materials were fastened to wire clips which could be inserted in the rubber stoppers. Immediately before fumigation these materials were immersed in a suspension of *S. pullorum* and exposed on the inside of the false door. At intervals varying from 5 to 30 minutes after the release of formalin, squares and egg shells were removed and cultured to determine whether *S. pullorum* had been killed.
The percentage of survival among the chicks of 15 hatches fumigated with formolized cheesecloth was, after the first two weeks following hatching, 5 points higher than the percentage of survival among the chicks of the 3 unfumigated hatches. The 15 fumigated hatches included 2,305 chicks, of which 13 percent died during the first two weeks. The 3 unfumigated hatches included 397 chicks, of which 18 percent died during the same period.

The part which pullorum disease played in the chick mortality of these hatches was suggested by the direct isolation of *S. pullorum* from 7.56 percent of the chicks that died in the control hatches and from 4.47 percent of the chicks that died in the fumigated hatches. Eggs from the same infected flocks were used for both control and fumigated hatches. *S. pullorum* was isolated from approximately 50 percent of the dead embryos in fumigated and unfumigated hatches.

**Disinfecting Values of the Two Methods of Fumigation.**—The results of these experiments indicate that either the potassium perman-
ganate method or the formolized cheesecloth method of fumigation of incubators, if properly dispatched, is valuable in reducing the dissemination of pullorum disease in incubators. The method to be employed is optional. The individual hatcheryman will probably obtain the best results with the method that he can employ most accurately. It is not safe to assume that the results of fumigation may be precisely the same in different incubators unless the rate of air change, humidity, temperature, and physical cleanliness are comparable. Incubator fumigation is regarded as a relative procedure, having maximum efficiency in clean incubators and well-ventilated rooms.

**COMPARATIVE COSTS**

About 60 percent of the formalin used during a hatch by the potassium permanganate method is saved when the cheesecloth method is followed. Moreover, the latter method does not require the use of potassium permanganate. With both methods an additional fumigation 24 hours before each hatch is recommended.

Two fumigations by the cheesecloth method or three by the potassium permanganate method are ordinarily employed during a hatch. For a single fumigation by the cheesecloth method 20 cc. of formalin per 100 cubic feet of incubator space in Incubator A and approximately 17 cc. per 100 cubic feet of space in Incubator B were germicidal to *S. pullorum* when the wet bulb reading was 90-92° F. and the dry bulb 99-100° F. These amounts were $66\frac{2}{3}$ percent and 57 percent, respectively, of the amounts used in the potassium permanganate method for a single release of formaldehyde. For one entire hatch the cheesecloth method required in Incubator B 44.4 percent, and in Incubator A only 38 percent, of the formalin employed in the potassium permanganate method to produce about the same germicidal effects.

**DOUBLE FUMIGATION BEFORE HATCHES**

Twenty-four hours before each hatch, it is advisable to give the incubator a double-strength fumigation in order to destroy latent or mass infection. Double-strength fumigations are also recommended for disinfection of clean incubators at the start of the hatching season.

Eggs will not be injured by repeated fumigations with double amounts of formalin, but chicks should not be exposed to these amounts. Hatching chicks are tolerant to amounts of formaldehyde that possess distinct germicidal properties for *S. pullorum*, but chicks of low vitality or chicks that harbor pullorum disease may be injured by routine fumigation. Chicks more than 48 hours old should not be subjected to formaldehyde fumigation.
FORMALIZED CHEESECLOTH METHOD

The relative humidity of the air inside the incubator should be approximately 68 percent (a wet bulb reading of 90° F. when the dry bulb reading is 100° F.). Proper humidity reduces the circulation of dust particles and down, favors hatching, and facilitates the germicidal action of formaldehyde. During the time hatching chicks are being fumigated, the ventilating fan should be kept running. Avoid using old solutions of formalin which have been allowed to stand exposed to the air or in bottles insecurely stoppered.

Materials and Equipment

(1) Formalin (commercial solution of 40-percent formaldehyde, aqueous solution); (2) measuring cylinder; (3) clean cheesecloth; (4) small rod (preferably glass) or wire hooks, depending on type of incubator.

For Type A' Forced-Draft Incubator

1. Compute the number of cubic feet of air space in the incubator (length times width times height).
2. Cut cheesecloth into pieces approximately one yard square.
3. Place a glass rod in such a position that when the cheesecloth is hung over it the cloth will be as near the fan as possible without interfering with its movement. If the incubator has more than two fans, one piece of cheesecloth may be used for each fan or a double-sized piece hung near one fan.
4. Measure out 20 cubic centimeters (2½ ounce) of formalin for each 100 cubic feet of incubator space.
5. Dip the cheesecloth into the formalin, using enough cloth to absorb all the formalin without becoming wet enough to drip.
6. After all the formalin has been absorbed by the cloth, promptly hang it over the rod and close the door of the incubator (Fig. 4).
7. Let formolized cheesecloth remain in the incubator until at least three hours after the release of the formaldehyde. At this time all dry chicks should be removed.
8. Only two fumigations during each hatching period are necessary with the cheesecloth method. Give the first when one-tenth to one-fifth of the chicks are out of the eggs, and the second, 12 to 15 hours later.

For Type B' Forced-Draft Incubator

1, 2. Proceed as directed under 1 and 2 above.
3. Use a piece of cheesecloth large enough to absorb all the formalin (1½ yards will absorb 100 cc.). Hang the cloth under one of the fans by means of small wire hooks so that the cloth spreads out as much as possible.

1Buckeye Mammoth No. 44. 2A total amount of 55 cubic centimeters (1.8 ounces) should be used for the Buckeye Mammoth incubator No. 44. 3Smith incubator.
FIG. 4.—FUMIGATING TYPE A INCUBATOR WITH FORMOLIZED CHEESECLOTH

Dip the cheesecloth into the computed amount of formalin. After all the formalin is absorbed, hang the cloth over a glass rod as near the fans as possible without interfering with their action. The cheesecloth should be large enough to absorb all the formalin without becoming wet enough to drip.

FIG. 5.—FUMIGATING TYPE B INCUBATOR WITH FORMOLIZED CHEESECLOTH

(A) Formolizing the cheesecloth. The formalin is measured into a small container, such as a half-pint milk bottle. Then the cloth is thrust into the formalin and the container inverted. The formalin is absorbed almost instantly. The formolized cloth is then removed from bottle and hooked under the screened fan in a hammock-like manner. (B) Cheesecloth suspended under fans after it has been formolized.
4. Measure out 16½ cubic centimeters (.56 ounce) of formalin for each 100 cubic feet of incubator space.

5. Turn off the fans and thrust the cheesecloth into a milk bottle or fruit jar containing the proper amount of formalin. Invert the container and allow the formalin to be completely absorbed (Fig. 5, A). This absorption requires only a few seconds.

6. As soon as the cloth has been fumigated, remove the container, fasten the free end of the cloth under another fan, close the door of the incubator, and turn on the fans (Fig. 5, B).

7, 8. Proceed as in 7 and 8 above.

**POTASSIUM PERMANGANATE METHOD**

The same conditions of humidity, temperature, and cleanliness as required for fumigation with cheesecloth are employed in releasing formaldehyde with potassium permanganate.

**Materials and Equipment**

(1) Potassium permanganate crystals; (2) formalin (commercial solution of 40-percent formaldehyde, aqueous solution); (3) measuring cylinder; (4) deep enamel pan.

**For Forced-Draft Incubator Type A or B**

1. Compute the number of cubic feet of air space in the incubator (length times width times height).

2. For each 100 cubic feet of incubator space, use 35 cubic centimeters of formalin (1½ ounces) and 17.5 grams (½ ounce) of potassium permanganate. If more than 17.5 grams of potassium permanganate is used, it will simply be lost—the chicks will not be injured. If, however, more than 35 cubic centimeters of formalin is used, the chicks may be injured.

3. Place the calculated amount of potassium permanganate in an enamel pan large enough to hold about ten times the quantity of material used. Do not use glass or earthenware containers, for the heat generated by the chemical combination of formalin and potassium permanganate may be great enough to break them.

4. Set this pan into the central compartment of the incubator below the fan. For large incubators more than one pan may be necessary. In some forced-draft incubators the fumigating materials may be placed in a broad,

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1 A total of 180 cubic centimeters (6 ounces) should be used for the Smith Senior incubator and 100 cubic centimeters (3½ ounces) for the Smith Junior incubator.

2 Smith or Buckeye Mammoth. 3 A total of 95 cubic centimeters (3½ ounces) of formalin and 47½ grams (13½ ounces) of potassium permanganate should be used for the Buckeye Mammoth incubator No. 44; 25 cubic centimeters of formalin per 100 cubic feet has been found to be sufficient for the Smith incubator, that is, a total of 250 cubic centimeters (8½ ounces) of formalin and 125 grams (4½ ounces) of potassium permanganate for the Smith Senior incubator; and 150 cubic centimeters (5 ounces) of formalin and 75 grams (2½ ounces) of potassium permanganate for the Smith Junior incubator.
shallow pan which is set in a cabinet under the intake pipe. Leave damper in the intake pipe wide open so that the gas can pass freely into the incubator.

5. Pour the computed amount of formalin over the permanganate crystals and close the door of the incubator as quickly as possible. The formaldehyde gas is liberated immediately (Fig. 6).

6. Do not open the incubator until 3 hours after the release of formaldehyde, if maximum germicidal results are desired. At the end of this time the chicks should be removed from the incubator and placed in clean, new boxes or brooders.

7. Three fumigations 12 hours apart should be made during the course of the hatch. Make the first shortly after the first chicks have come out of the egg. In experiments conducted at the Illinois Experiment Station, a few chicks subjected to three fumigations showed transitory symptoms of irritation. The number of chicks that have died from the effect of fumigation has not been important, fatalities being confined largely to subnormal chicks.

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**FIG. 6.—FUMIGATING TYPE A INCUBATOR WITH POTASSIUM PERMANGANATE AND FORMALIN**

Pour the computed amount of formalin over the potassium permanganate crystals in a pan large enough to prevent splashing and close the door of the incubator immediately.

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**FLOCK MANAGEMENT AND BLOOD TESTING**

The centralization of the hatching industry in recent years has increased the importance of incubator hygiene in the control and suppression of pullorum disease. It must not be supposed, however, that incubator hygiene alone will eliminate all losses from pullorum dis-
ease. Efforts must also be directed to reducing egg infection to a minimum. This means that the breeding stock must be healthy and free, or relatively free, from pullorum disease as established by tests. While sanitary measures in hatcheries and incubators prevent the spread of pullorum disease to healthy chicks at the time of hatching, egg-infected chicks are not cured by these measures. Healthy chicks come from healthy, properly managed flocks and clean, disease-free incubators.

Frequent blood tests for the detection of fowls infected with pullorum disease should be made and the reactors removed. There are various agglutination tests that may be employed, including tube test, plate test, field tube test, and stained antigen whole-blood test. Selection of the test to be employed depends upon the skill and preference of the veterinarian. No agglutination test is reliable in untrained hands.

The removal of diseased stock from a flock will not, however, in itself assure the good health of a flock. The environment of the chickens must be relatively free from disease if healthy parent stock is to be assured. Proper flock management is essential for this purpose. Poultry houses must be clean, dry, and well ventilated. In order to facilitate cleaning and disinfection, the floors should be made of concrete, but if dirt floors are employed, the old dirt should be replaced each year with fresh dirt. Overcrowding of poultry must be avoided, for it lowers vitality and facilitates the spread of contagious diseases. Daily removal of droppings and changing of scratch litter at weekly or bimonthly intervals is essential. Poultry houses should also be cleaned and disinfected in the spring and in the fall, and oftener if disease appears. Boiling hot lye water (1 pound of lye to 40 gallons of water) is a valuable agent for cleansing after all refuse has been removed. After the poultry house is thoroly dry, spray it with a disinfectant, such as a 3-percent compound cresol solution (USP).

Rations should be properly balanced; and both feed and water should be given clean and kept clean. Since intestinal parasites and various diseases may invade fowls thru contaminated feed and water, sanitary feed and water containers are essential.

Sparrows, pigeons, and other wild birds should, so far as possible, be kept away from the domestic fowls.

Clean ground on which fowls have not been kept for one or two

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1 The testing of flocks for pullorum disease is discussed in Circular 432 of this Station; also in an article by E. H. Barger and J. P. Torrey, of the Illinois State Department of Agriculture, entitled "The Whole-Blood, Stained-Antigen Agglutination Test for Pullorum Disease," in Jour. Amer. Vet. Med. Assoc., Vol. 82, n.s. 35, January, 1933, page 84.
years should be provided to check soil-borne diseases. Hence run­
ways and poultry ranges should be frequently rotated. Idle ranges
should if possible be plowed and cropped.

No medicine can be placed in the feed or drinking water that will take the place of clean ground, clean feed, clean water, and clean houses.

**SUMMARY OF RECOMMENDATIONS**

Formaldehyde fumigation of forced-draft incubators by either the cheesecloth method or the potassium permanganate method is of definite value in the suppression of pullorum disease.

Incubator fumigation, however, does not completely eliminate losses from pullorum disease when infected eggs are used for hatching. It is therefore not a substitute for disease-free flocks. The testing of flocks and the elimination of reactors, in conjunction with good flock management and incubator hygiene, reduce the losses from pullorum disease to a minimum.

Veterinarians, flock owners, and hatcherymen may cooperate to the best advantage in the suppression of pullorum disease by observing the following fundamental principles of poultry hygiene:

1. **Eliminate pullorum disease from breeding flocks.** Subject the flock to frequent blood tests and remove all reactors to pullorum disease. Different agglutination tests, including tube test, plate test, field tube test, and stained antigen whole-blood test, may be employed, depending on the skill of the veterinarian. None of the agglutination tests is reliable in untrained hands. *Testing is the veterinarian’s job.*

2. Provide clean, dry, well-ventilated poultry houses, clean and balanced rations, clean water, and clean ranges. Use sanitary feed hoppers and water containers. Avoid overcrowding. *Good flock management is the flockowner’s job.*

3. **Prevent spread of pullorum disease in incubators.** Keep incubators and incubator rooms scrupulously clean. Scrub and disinfect egg and hatching trays after each hatch. Fumigate forced-draft incubators with formaldehyde gas while chicks are hatching. Either one of two methods of liberating formaldehyde gas in forced-draft incubators may be employed: (1) by hanging formolized cheesecloth in the incubator, or (2) by mixing potassium permanganate with formalin. The cheesecloth method requires less formalin and no potassium permanganate. *Cleaning, disinfection, and fumigation of incubators is the hatcheryman’s job.*