National Poultry Improvement Plan

USDA APHIS VS Career Services Program
Program Diseases Training Module

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This course is designed to provide updated information on the major domestic diseases for which Veterinary Services (VS) has program responsibility. It will provide information on surveillance, disease control and eradication for these diseases. It will also give an overview of the duties of a field Veterinary Medical Officer (VMO) as a support worker of VS animal disease programs and how they interact with other units in APHIS.

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1. HISTORY OF THE CONTROL PROGRAM

The National Poultry Improvement Plan (NPIP) was established in 1935 in response to a request made by the poultry hatchery industry to standardize the requirements for breeding, shipping, and disease control of poultry in the United States.\(^1\,^2\,^3\) The plan consists of a variety of programs designed to prevent and control egg-transmitted and hatchery-disseminated poultry diseases. The driving force behind this request was a series of events beginning with the discovery of *Salmonella pullorum* by Dr. Leo Rettger in 1899.\(^3\) *S. pullorum* causes a disease known as ‘bacillary white diarrhea’, latter changed to ‘pullorum disease’, which was devastating to poultry producers causing up to 80% mortality in young poultry.\(^1\,^2\) In 1913, Dr. F.S. Jones developed a diagnostic blood test leading to testing for *S. pullorum* and elimination of reactors in breeding flocks.\(^3\) It was soon discovered that the diagnostic test also reacted to birds who were infected with *Salmonella gallinarum* which causes a very similar disease called ‘fowl typhoid’. A great demand soon developed for chicks free of *S. pullorum* and *S. gallinarum*, and individual states began formulating their own testing programs to identify flocks that were free of the disease. It soon became readily apparent that a nationwide program was needed to define criteria and terminology, so the NPIP was born.\(^1\,^2\,^3\)

The National Poultry Improvement Plan is a cooperative Industry-State-Federal program. In each state, the plan is administered by an official state agency, in cooperation with the USDA. The NPIP:

- Establishes standards for hatchery-disseminated diseases in poultry breeding stock and hatchery products. These standards are changed periodically, upon the recommendation of the state and industry delegates at National Plan Conferences.
- Identifies hatchery products that conform to these standards.
- Regulates the sanitation and disinfection of premises.
- Regulates adherence to breed standards.
- Regulates the minimum weight of hatching eggs sold.
- Inspects participating hatcheries monthly.

Currently, the NPIP has control programs for *Salmonella pullorum*, *Salmonella gallinarum*, *Salmonella enteritidis*, *Mycoplasma gallisepticum*, *Mycoplasma synoviae*, and *Mycoplasma meleagrisid*.

2. CURRENT CONTROL PROGRAM

The current objective of the NPIP is to provide a cooperative Industry-State-Federal program that allows effective application of new technology that results in the improvement of poultry and poultry products.\(^1\,^2\,^3\) Industry members and State and Federal officials mutually develop the provisions of the plan, which aim to provide standards for the assessment of poultry breeding stock and hatchery products that are free from hatchery born diseases. Nationwide, authorized terms are used to identify products that meet the specified standards. The NPIP is modified periodically to correspond with changes in the industry. Recommendations for change are made by
delegates of the National Plan Conference who represent flock owners, breeders, and hatchery owners from cooperating states. Although participation is optional within States, flocks, hatcheries and dealers must qualify as “U.S. Pullorum-Typhoid Clean before participating in any other plan program. The Plan is managed by the official state agency in each state that works with the USDA.3

The Plan participants are organized under five subparts:2,3
Subpart B – Egg-Type Chicken
Subpart C – Meat-Type Chicken
Subpart D – Turkey
Subpart E – Waterfowl, Exhibition Poultry, and Game Bird Breeding Flocks
Subpart F – Ostrich, Emu, Rhea, and Cassowary Breeding Flocks

The programs available for the commercial sector of the poultry industry (Subparts B, C, and D) include Pullorum-Typhoid Clean, Mycoplasma gallisepticum Clean, Mycoplasma synoviae Clean, Mycoplasma meleagridis Clean, Avian Influenza Clean, Salmonella enteritidis Clean, Mycoplasma gallisepticum Monitored, Mycoplasma synoviae Monitored, Salmonella Monitored, and Sanitation Monitored.2,3

The programs available for the waterfowl, exhibition poultry, and game bird flock (Subpart F) include Pullorum-Typhoid Clean, Mycoplasma gallisepticum Clean, and Mycoplasma synoviae Clean.2,3

Ostrich, Emu, Rhea, and Cassowary (Subpart F) were recently added to the Plan in 1998. Currently the only program available for them is Pullorum-Typhoid Clean.3

Participating flocks, the products produced by them, and states which have met the designated requirements are labeled with designated symbols depending on the programs they qualify for.3

3. INDIVIDUAL PROGRAMS AND TESTING REQUIREMENTS

Producers who ship eggs or other hatchery products interstate must participate in the NPIP. Participation is voluntary if a producer sells products only intrastate. Some states implement the same or stricter standards as NPIP.

Poultry must be more than four months of age when officially tested; however, turkeys must be blood tested at more than three months of age; game birds may be test when more than four months of age or when reaching sexual maturity which ever come first; and ostrich, emus, rhea, and cassowary may be tested when more than 12 months of age. A minimum of 30 birds per house (up to 300 birds with at least one bird per pen) must be tested. If a house contains less than 30 birds, all birds must be tested. The ratio of male to female birds tested must represent the ratio of males to females in the flock.3
a. U.S. Salmonella Pullorum-Typhoid Clean

1) Flock. A flock may be considered Pullorum-Typhoid Clean if it meets the following specifications. It has been officially blood tested with no reactors within the past 12 months. The flock is a multiplier breeding flock or a breeding flock of progeny of a primary breeding flock intended solely for the production of multiplier breeding flocks. The flock is composed entirely of birds that originated from Pullorum-Typhoid Clean breeding flocks and is located on a premise where the only birds housed there within the last year were Pullorum-Typhoid Clean. All poultry, excluding waterfowl, shall have a negative pullorum-typhoid test within 90 days before going to public exhibition.1,3

2) State. The State in which the flock is located must also meet several specifications. All hatcheries within the State must be qualified as “National Plan Hatcheries” and have met the requirements for pullorum-typhoid control. The poultry disease diagnostic services within the State are required to report any positive specimens for *S. pullorum* or *S. gallinarum* within 48 hours and any disease outbreaks are promptly investigated by the official state agency. Finally, shipments of products other than Pullorum-Typhoid Clean into the State are prohibited.3 A State can be declared an U.S. Pullorum-Typhoid Clean State if no *S. pullorum* or *S. gallisepticum* has been isolated in the chicken hatchery supply flocks within the State in the past 12 months and in the turkey hatchery supply for 24 months, and the State is in compliance with the required specifications.3


1) Flock. A flock may be considered M. Gallisepticum Clean if it meets the following specifications. For egg-type and meat-typed chicken, a minimum of 300 birds have been tested with no reactors. To retain the classification, a minimum of 150 birds must be tested every 90 days, or if the flock originated from a U.S. M. Gallisepticum Clean primary breeding flock, a minimum of 150 birds per flock must be tested with no reactors. To maintain the classification, the producer has the choice of performing an official blood test on 75 birds every 90 days (subjecting 25 cull chicks to detection and recovery of *M. gallisepticum* every 30 days, or egg yolk testing every 30 days). Before male birds can be added to the flock, 3% (10 birds minimum) shall be tested for *M. gallisepticum* 14 days before the arrival into the flock.3

Turkeys have slightly different specifications in order to be classified as M. Gallisepticum Clean. No reactors can be found in a random sampling of a minimum of 300 birds and in order to retain the classification, a minimum of 30 samples from male flocks and 60 samples from female flocks are to be retested at 28-30 weeks of age followed with retesting at 4-6 week intervals.3

Birds included in Subpart E are subject to slightly different specifications. No reactors can be located in a sample of at least 300 birds. To retain this classification, a random sample of serum or egg yolk from 5% of the flock (minimum of 30 birds) shall be tested every 90 days. If the flock originated as U.S. M. Gallisepticum Clean baby poultry, a random sample of 50% of the flock (30-200 birds) must have no reactors. To maintain the classification, the producer has the choice of
random sampling serum or egg yolk from 2% (30 birds minimum) of the flock every 90 days, or
subjecting 25 cull baby poultry to detection and isolation of *M. gallisepticum* every 30 days. \(^3\)

Finally, all products and poultry qualified as U.S. M. Gallisepticum Clean shall be kept separate
from other products and shall be shipped in cleaned and disinfected containers according to the
official state agency specifications. \(^3\)

**2) State.** A State may qualify as a U.S. M. Gallisepticum Clean State if no *M. gallisepticum* has been isolated from breeding flocks in
the past 12 months and all the breeding flocks in production have met
the requirements for *M. gallisepticum* control. The State must also
prohibit the importation of products other than M. Gallispeticum Clean
products into the state.\(^3\)

c. U.S. Mycoplasma Synoviae Clean

**1) Flock.** For egg-type and meat-type chickens, the requirements for M. Synoviae Clean
are the same as U.S. M. Gallisepticum Clean. \(^3\)

Turkeys can qualify to be U.S. M. Synoviae Clean if they meet the following
specifications. No reactors can be found in a sample of a minimum of 100 birds.
In order to maintain Clean status, 30 samples from male flocks and 60 samples
from female flocks need to be retested at 28-30 weeks and at 4-6 week intervals.
Flocks on grounds that have housed breeding flocks classified as U.S. M. Synoviae
Clean for three consecutive years may qualify by a negative blood test from a
minimum of 100 birds when 12 weeks of age and testing 30 samples from male
flocks and 60 samples from female flocks at 28-30 weeks and at 45 weeks. \(^3\)

Birds categorized as Subpart E can be classified as U.S. M. Synoviae Clean if they meet the
following criteria. No reactors must be found in a random sample of 300 birds and in order to
maintain this classification, 150 birds must be retested every 90 days. If the flock originated from
U.S. M. Synoviae Clean primary breeding flock, no reactors must be found in a minimum of 75
birds and the producer has the choice of sampling 50 birds every 90 days or performing egg yolk
testing every 30 days. \(^3\)

**2) State.** A State may qualify as a U.S. M. Synoviae Clean State if no *M. synoviae* has been isolated from breeding flocks in the past 12 months and all the
breeding flocks in production have met the requirements for *M. synoviae* control.
The State must also prohibit the importation of products other than M. Synoviae
Clean products into the state. \(^3\)
d. U.S. Mycoplasma Meleagridis Clean

1) Flock. Turkey flocks may qualify to be U.S. M. Meleagridis Clean if they meet the following specifications: No reactors are found in a random sample of 100 birds. To retain the classification, 30 samples from male flocks and 60 samples from female flocks are to be retested at 28-30 weeks of age and at 4-6 week time periods following the initial testing.

2) State. A State may qualify as a U.S. M. Meleagridis Clean State if no M. meleagridis has been isolated from breeding flocks in the past 12 months and all the breeding flocks in production have met the requirements for M. meleagridis control. The State must also prohibit the importation of products other than M. Meleagridis Clean products into the state.

e. U.S. Avian Influenza Clean

1) Flock. This program is designed to allow the chicken breeding and hatching industry to organize a plan to prevent and control avian influenza. Its purpose is to locate the presence of avian influenza in primary breeding chickens through serologic surveillance. A flock can reach this classification by meeting the following specifications. No antibodies to avian influenza can be found in a minimum of 30 birds in a primary breeding flock. To maintain this classification, a random sample of 30 birds must test negative every 90 days, or if the flock is a multiplier breeding flock, no antibodies to avian influenza can be found in a minimum of 30 birds. To remain qualified, 30 birds must be sampled every 180 days and remain negative.

f. U.S. Salmonella Enteritidis Clean

1) Flock. This program is designed for egg-type and meat-type chicken breeders looking to assure consumers that their eggs and chicks are certified free of S. enteritidis. In order to qualify, the flocks need to adhere to the following guidelines. The flock must have originated from a U.S. S. Enteritidis Clean flock or 25 grams of meconium from chicks and a collection of 10 chicks succumbing within seven days of hatching must be inspected for Salmonella and serotyped if any positives are found. All mashed and pelleted feed shall be free of animal protein or contain only animal protein allowed under the Animal Protein Products Industry (APPI) Salmonella Education/Reduction Program or the Fishmeal Inspection Program of the National Marine Fisheries Service, and be processed under the NPIP’s guidelines and be warehoused and transported to prevent contamination. Environmental samples shall be collected when the flock is 2-4 weeks of age and cultured and serotyped for Salmonella group D. Subsequent samples shall be taken every 30 days thereafter. Serum from 300 birds shall be tested with the pullorum antigen when the flock is 4 months old. If a Salmonella vaccine is used that reacts with the pullorum-typhoid antigen, the flock should either be vaccinated after the pullorum-typhoid testing is done or 350 birds shall be unvaccinated and banded for identification until the flock is four months of age. If the unvaccinated birds are negative serologically and bacteriologically, the banded birds can be vaccinated. Hatching eggs are to be quickly collected and sanitized or fumigated. The hatchery should be in compliance with recommendations of the NPIP and either sanitized or fumigated.
g. U.S. Sanitation Monitored

1) **Flock.** This program is designed for the prevention and control of *Salmonella* in the breeding-hatching industry through the use of an efficient sanitation program at the breeding farm and hatchery. A flock can be certified as U.S. Sanitation Monitored if it meets the following specifications. The flock must originate from a source that follows sanitation and management practices stated in the NPIP and must be maintained in the same conditions. Turkey pouls that die within 10 days of hatching must be examined and cultured for *Salmonella* along with any hatchery debris. All pelleted and mashed feed shall be obtained from participants in the APPI Salmonella Reduction Program or the Fishmeal Inspection Program of the National Marine Fisheries Service, and amassed and shipped in a way to avoid contamination. Chicks are to be born in hatcheries that have been properly sanitized or fumigated. Environmental samples shall be taken when the chicks reach four months of age and repeated every 90 days. Environmental samples from turkey pouls should be taken at 12-20 weeks, repeated at 35-50 weeks, and mid-lay of any molted birds. Any flocks infected with paratyphoid *Salmonella* may use an autogenous bacterin to vaccinate the flock. 3

h. U.S. Salmonella Monitored

1) **Flock.** This program is designed to allow the breeding and hatching industry to direct a program for the prevention and control of *Salmonella*. The main purpose of the program is to decrease the frequency of *Salmonella* in hatching eggs and chicks by providing an efficient sanitation program for the breeder farm and hatchery. To be labeled U.S. Salmonella Monitored, a flock must adhere to the following specifications. 3 The flock must originate from a source and be maintained on a premises where sanitation and management practices outlined in the NPIP are followed. Any animal protein feed to the flock must be purchased from participants in the APPI Salmonella Education/Reduction Program and be stored and transported to prevent contamination. Chicks are to be born in hatcheries that meet specifications outlined in the NPIP and be sanitized or fumigated. Environmental samples shall be taken from the hatchery every 30 days and examined for *Salmonella*. Flocks may be vaccinated with a paratyphoid vaccine if 250 birds are banded and not vaccinated until the flock is four months old. 3

i. U.S. Mycoplasma Gallisepticum Monitored

1) **Flock.** A multiplier breeding flock may qualify as U.S. M. Galliseticum Monitored if the following guidelines are met. No reactors were found in a minimum of 20 birds per house. In order to retain this classification, at least 20 birds per house are to be retested at 36-38 weeks and at 48-50 weeks. The samples must come from two locations within the house, and a representative sample of males and females should be taken and marked accordingly. 3

All eggs, chicks, and products labeled U.S. M. Gallisepticum Monitored are to be kept separate from other products. Eggs from U.S. M. Gallisepticum Monitored multiplier breeding flocks are to remain separate from eggs of U.S. M. Gallisepticum Clean primary breeding flocks. Chicks are to be shipped in boxes and distributed in vehicles that have been properly cleaned and disinfected. 3
j. U.S. Mycoplasma Synoviae Monitored

The requirements to be U.S. M. Synoviae Monitored are the same as U.S. M. Gallispeticum Monitored. 

4. ROLE OF VMO IN THE NATIONAL POULTRY IMPROVEMENT PLAN

a. Testing and diagnosis

The Veterinary Medical Officer (VMO) is responsible for the collection of blood samples and the banding of birds for identification purposes. The official tests and diagnostic protocols for the diseases monitored by the NPIP are as following:

1) *Salmonella Pullorum-Typhoid*. The official blood tests for pullorum-typhoid are the standard tube agglutination test, the microagglutination test, the enzyme-linked immunosorbent assay test (ELISA), or the rapid serum test. The rapid whole-blood test may be used for all poultry, except turkeys. Any bird testing positive is labeled a reactor. Any drug that has been proven to mask the test reaction or recovery of *Salmonella* shall be discontinued three weeks prior to testing.

2) *Mycoplasma Gallisepticum, M. Synoviae, and M. Meleagridis*. The official blood tests for *M. gallisepticum* and *synoviae* are the serum plate agglutination test, the tube agglutination test, the hemagglutination inhibition test (HI), the microhemagglutination inhibition test, and the ELISA test. The official blood tests for *M. gallisepticum* are the serum plate agglutination test, the tube agglutination test, or the microagglutination test. The HI test, the microhemagglutination inhibition test and the ELISA test are to be used to confirm positives of the other serological tests.

3) *Avian Influenza*. The official tests for avian influenza are the agar gel immunodiffusion (AGID) test and the ELISA. Positive tests are to be examined by Federal reference laboratories.

An authorize laboratory must notify the official state agency within 48 hours of any positive sample.

b. Collection and submission of samples

All birds must be identified by an official band for identification and all blood samples must be submitted to an authorized laboratory. Reactors to *S. pullorum, S. gallinarum*, or *S. enteritidis* will have to be cultured and serotyped. The tissues needed for culture are liver, heart, pericardial sac, spleen, lung, kidney, peritoneum, gallbladder, oviduct, missshapen ova or testes, and inflamed or unabsorbed yolk sac. The digestive tract should be taken separately to avoid cross-contamination and should include crop wall, duodenum, jejunum, ceca, cecal tonsils, and rectum-cloaca. Any visibly abnormal tissues should be swabbed for culture. Environmental samples may be taken of fecal matter, litter, dust, nest boxes, and chick meconium.

Reactors to *M. gallisepticum, synoviae*, or *meleagridis* will also have to be cultured and serotyped. The recommended tissues for culture and isolation are turbinates, trachaea, air sacs, sinuses, nasal
passages, respiratory exudates, synovial fluid, and eggs. Live birds are the preferred specimens for mycoplasma recovery followed by refrigerated fresh tissue and then tissues packed with dry ice. ³

c. Managing an infected flock

1) **Salmonella Pullorum-Typhoid:** When reactors are found or a VMO determines that a flock has been exposed to *S. pullorum* or *S. gallinarum*, blood samples must be taken from every bird on the premises exposed to the reactor birds, equipment, supplies, or personnel from the primary breeding flock and be sent to an authorized laboratory. All birds must be banded in order to identify any birds that may test positive. The flock is quarantined until marketed or destroyed, or until further testing shows no more reactors and all birds fail to exhibit *S. pullorum* or *S. typhoid* infection. For poultry of flocks that have a reaction to a qualification test for Pullorum-Typhoid infection, the official state agency has a choice of one of the following depending on the individual circumstances: 1) Reactors can be sent to an authorized laboratory for examination and isolation, 2) The serum specimen can be retested with the standard tube agglutination test or the microagglutination test, or 3) the reactors can be retested in 30 days; however, during these 30 days, the flock must be isolated to prevent contact with other birds and all personnel, equipment, and supplies must be sanitized.³

2) **Mycoplasma gallisepticum, M. synoviae, and M. meleagridis:** When reactors are found to Mycoplasma, random samples of 30 cloacal swabs and associated blood samples are to be cultured or examined by PCR for Mycoplasma. Fourteen days after the primary bleeding, all birds up to 75 will be retested by the serum plate or tube agglutination test and banded so any reactors can be identified. If birds are found positive by culture, PCR, or a rise in titers, the flock must be depopulated or quarantined until the flock is marketed.³

3) **S. enteritidis serotype enteritidis:** If *S. enteritidis* serotype enteritidis (SE) is found in a specimen of a bird from a flock that is classified as U.S. S. Enteritidis Clean, the flock is no longer eligible. If SE is isolated from an environmental sample, 25 random live birds from the flock and/or 500 cloacal swabs must be cultured for SE. If no SE is recovered, the flock is still eligible. If SE is recovered in only one of the birds, the flock may test another 25 birds to determine SE status.³

4) **Avian Influenza:** If reactors are found to avian influenza and confirmed by a Federal reference laboratory, the flock is no longer eligible to be classified as Avian Influenza Clean.³

5. **ROLE OF THE FEDERAL GOVERNMENT, STATES, AND INDUSTRY**

The Federal Government, namely the United States Department of Agriculture (USDA), cooperates with States in executing the NPIP. Any final regulatory decisions are made by the USDA.³

The States will provide an official state agency to oversee the regulations of the NPIP. The State shall train Authorized agents to collect samples and perform blood testing. They shall also employ State Inspectors who will supervise the selecting and testing of participating flocks and will inspect the premises to insure compliance with NPIP specifications. The NPIP is a volunteer program; however, many states have made participation in various programs mandatory.¹²³
The Industry encourages its producers to participate in the NPIP. Producers are responsible for the costs of testing materials; however, many States and international trade regulations require participation in various NPIP programs.\textsuperscript{1,2,3}

6. DISEASE INFORMATION

\textbf{a. \textit{Salmonella pullorum}}

\begin{enumerate}
\item \textbf{Agent.} Pullorum disease is a contagious disease of chickens, turkey, and other fowl that is caused by \textit{Salmonella} serovar \textit{pullorum}, a gram negative rod.\textsuperscript{4,5,6} \textit{S. pullorum} is a motile bacterium that produces flagella while inside a host bird, which initiates an immune response in the host.\textsuperscript{4} Chickens are the natural host and are believed to be the source of infection for turkeys. Infections in both species are generally lifelong. Wild birds such as ducks, pheasants, quail, and sparrows have also been known to carry the bacteria and can be a source of infection to domestic chickens and turkeys.\textsuperscript{4,5,6}

\item \textbf{Transmission.} \textit{S. pullorum} is usually transmitted through the egg; however, both direct and indirect transmission can occur.\textsuperscript{4,5,6} The bacteria often localize in the ovary which leads to contamination of the egg before or after ovulation.\textsuperscript{4} \textit{S. pullorum} can also be transmitted through fecal contamination of the water, feed, litter, or other materials such as poultry workers’ footwear, skin, clothing, incubators, etc.\textsuperscript{4,5,6} Chicks and adults can also become infected from eating infected eggs and carcasses.\textsuperscript{4}

\item \textbf{Clinical Signs.} Young chicks are most severely affected by \textit{S. pullorum}. Clinical signs include somnolence, inappetence, and drooping wings. Chicks will often huddle together under the nearest heat source. They quickly develop diarrhea and dehydration. A chalk-white excreta often develops around the vent, and breathing will become labored. The joints often swell leading to lameness and retarded growth.\textsuperscript{4,5,6}

Adults usually do not exhibit clinical signs; however, egg production, fertility, and hatchability of their eggs are often greatly reduced.\textsuperscript{4,5,6}

\item \textbf{Epidemiology.} Up to 33\% of eggs produced by infected hens are infected with \textit{S. pullorum}.\textsuperscript{4} Peak mortality in chicks generally occurs during the second to third week of life.\textsuperscript{4,5,6} Mortality is generally higher in birds that are stressed and can range from 0-100\%.\textsuperscript{4,5} Chicks that are infected at four days of age can become carriers leading to infected eggs and progeny when they begin to lay eggs.\textsuperscript{4} Death is generally not seen in adults but production is typically decreased.\textsuperscript{4,5,6} Control programs established in modern poultry producing countries have reduced the incidence of the disease; however, \textit{S. pullorum} is still a problem in developing countries.\textsuperscript{4}

\item \textbf{Diagnosis.} High death loss of young chicks is extremely suggestive of Pullorum Disease, but the only definitive diagnosis is isolation of the organism.\textsuperscript{4,5,6} Substantial lesions can be found on necropsy of young chicks. The liver, lungs, heart and ceca contain white nodules that are often confused with tumors. The kidneys and spleen will be swollen, and the ureters are often congested with urates. The lungs will have a yellow-gray interstitial pneumonia along with pleuritis and pericarditis. The ceca will contain a yellow cheesy material. Adults will have a distorted, discolored ovary with possible peritonitis, pericarditis, and white nodules may be found in the male testes.\textsuperscript{4,6} Serologic testing of blood will detect carriers of \textit{S. pullorum}.\textsuperscript{4,5,6}
\end{enumerate}
6) **Prevention and control.** Currently, there are no antibiotics approved by the FDA for the treatment of *S. pullorum.*6 The only effective way to prevent and control *S. pullorum* is complete eradication. Birds should be tested and all carriers removed from the flock.4,5,6 Only eggs, chicks, and pouls from Pullorum-Typhoid Clean flocks should be used as sources.4,5 All equipment should be sanitized between uses. Proper biosecurity measures should be implemented to prevent contamination from humans, insects, rodents, and feed.4,5,6

7) **Public health consequences.** *S. pullorum* has been known to cause occasional human infections, but is a limited public health threat.4

b. *Salmonella gallinarum*

1) **Agent.** Fowl Typhoid is a contagious disease of poultry caused by *S. gallinarum*, a bacterium very similar to *S. pullorum.*7 Both are motile, gram negative rods that swarm when grown in growth media.4 Most domestic and wild fowl are susceptible to *S. gallinarum.*5,7,8

2) **Transmission.** The routes of transmission are the same as *S. pullorum*, although mechanical transmission is more common with *S. gallinarum.*5,7

3) **Clinical Signs.** Fowl Typhoid is almost indistinguishable from Pullorum disease. Birds will often be listless and dehydrated with green to yellow diarrhea along with pale combs and wattles. The flock will often experience a decrease in feed consumption combined with an increase in water consumption.5,7,8

4) **Epidemiology.** Young adult birds greater than 12 weeks of age are most commonly affected, but birds of any age may develop the disease.5 Mortality varies from 1-40% but is often high.5,7 Cases are rare in countries with control programs, but the disease is still a serious problem in developing countries, such as South America, Asia, and Africa.8

5) **Diagnosis.** History, clinical signs, and lesions found at necropsy may lead to a tentative diagnosis, but a definitive diagnosis is only made by isolation and identification of *S. gallinarum.*5,7 Lesions commonly found at necropsy include enlarged and mottled spleen; swollen, friable and often bile-stained liver with occasional necrotic foci; tiny distinct hemorrhages in muscles and fat bordering internal organs; a swollen, inflamed cranial third of the small intestine.5,7 Turkeys will often have minute, white plaques that can be observed throughout the small intestines.5 Blood tests used for *S. pullorum* will cross-react with *S. gallinarum* due to a common antigen.4,8

6) **Prevention and control.** Prevention and control are often maintained by eliminating the disease from the flock. Many of the control measures used to control *S. pullorum* will also lead to elimination of *S. gallinarum.*5,7,8 Since the bacterium can live outside of the host for up to six months, it is very important to thoroughly clean and disinfect the premises following an outbreak.7

7) **Public health consequences.** To date, no human cases of *S. gallinarum* have been reported.8
c. Mycoplasma gallisepticum

1) Agent. M. gallisepticum is a mycoplasma organism, that like other members of this genus, it lacks a cell wall making it extremely fragile. Survival in the environment can be up to three days and the organism is easily destroyed by disinfectants, heat, and sunlight. M. gallisepticum commonly infects chickens and turkeys, but has also been found in many other species of wild fowl. The organism may be maintained in its host for long periods of time, until prompted by stresses (such as shipping, vaccination, or poor housing conditions). Viruses such as Newcastle disease virus and bacteria such as E. coli are often found in association with M. gallisepticum. The combination results in a much more serious disease called Chronic Respiratory Disease.

2) Transmission. Transmission of M. gallisepticum occurs over by several different routes. The main routes of transmission are via airborne respiratory droplets from infected birds and direct contact with infected birds, contaminated equipment, water, feed, and facilities. Transovarian transmission can occur and can lead to infected hens that produce infected chicks. Once infected, birds will become carriers for life and shed the organism periodically.

3) Clinical Signs. The clinical signs of a M. gallisepticum infection vary based on the severity of the infection and presence of secondary invaders. Birds often show an assortment of signs of respiratory distress including minor to severe rales, coughing, sneezing, nasal discharge, and watery eyes. Feed efficiency, weight gains, and egg production are often greatly reduced. The disease tends to be more severe in turkeys than chickens, with turkeys often having swollen paranasal sinuses along with respiratory signs.

4) Epidemiology. In the US, most turkey and chicken breeder flocks are free of M. gallisepticum due to extensive monitoring and depopulation programs; however, it is still a chronic problem in commercial layers and backyard poultry flocks. Flocks that have multiple ages of birds or farms that have a continuous flow of new birds onto the farm often have severe problems with M. gallisepticum. Young birds are often more severely affected than older birds. In an outbreak, morbidity rates are often high, but mortality is low in uncomplicated infections; however, if the birds are stressed or infected with secondary invaders, the mortality rates can be very high.

5) Diagnosis. Lesions noted on necropsy of chicken with uncomplicated M. gallisepticum infections include a minor sinusitis, tracheitis, and airsacculitis. Turkeys are often found with a severe mucopurulent sinusitis and a moderate to severe tracheitis and airsacculitis. The mucous membranes are often necrotic, hyperplastic, swollen, and filled with inflammatory cells. Secondary infections with bacteria such as E. coli can lead to severe air sac thickening with accumulation of exudates, fibrinopurulent pericarditis, and hepatitis. Definitive diagnosis can only be made by isolation and identification of the organism. Serologic tests can identify carriers in the flock.

6) Prevention and control. Eradication and maintenance of a seronegative flock is the most effective control program for M. gallisepticum. In multi-age commercial farms where depopulation is not a viable option, vaccines have gained popularity. Vaccinated birds remain carriers but production losses are minimized. An inactivated, oil-emulsion bacterin is available that prevents egg production decreases but not infection. A live vaccine that is licensed in the U.S. consists of a mild strain of M. gallisepticum (F-strain) and is usually administered at 10-14 weeks of age. The vaccine is virulent to turkeys and must be used only with the approval of the state
veterinarian. Two nonpathogenic live vaccine strains (6/85 and ts-11) have been developed and present a greater margin of safety. Antibiotics such as chlortetracycline, erythromycin, tylosin, or enrofloxacin can be used to reduce clinical signs, but will not abolish infection.

7) Public health consequences. To date, there have been no reported human cases of *M. gallisepticum*.

d. *Mycoplasma synoviae*

1) Agent. *M. synoviae* is a mycoplasma that produces an acute to chronic synovitis and a subclinical respiratory infection in chickens and turkeys. It is often associated with Newcastle disease virus or infectious bronchitis virus causing a severe airsacculitis. Although chickens and turkeys are the main reservoir for infection, it has also been found in ducks, geese, guinea fowl, parrots, pheasants, and quail.

2) Transmission. Lateral transmission of *M. synoviae* is virtually identical to that of *M. gallisepticum* although it spreads through a flock much more quickly. It is also egg transmitted, but at a very low rate. Some infected flocks may even produce progeny that are *M. synoviae* free. The eggs are most likely to be infected 1-2 months after primary infection of the breeding flock.

3) Clinical Signs. The most common clinical signs noted in birds with *M. synoviae* infection are lameness or minimal movement, swollen footpads, hocks, and wing joints, and a greenish diarrhea. Birds with respiratory disease seldom show symptoms unless infected with a secondary invader.

4) Epidemiology. Outbreaks tend to occur in younger birds, 4-6 weeks of age in chickens and 10-12 weeks of age in turkeys. Morbidity is often low ranging from 2-15% followed by a mortality of 1-10%. Drops in egg production are usually minimal.

5) Diagnosis. A tentative diagnosis of *M. synoviae* may be made by history and clinical signs; however, isolation and identification of the organism must be done to confirm the organism. Lesions commonly found on necropsy include a yellow to gray viscous exudates located in practically every synovial structure especially the keel bursa, hock, and wing joints. The liver is often enlarged and bile stained. The spleen and kidneys are also enlarged and pale. Birds suffering from the respiratory syndrome often have airsacculitis that generally resolves within 1-2 weeks. Serologic tests can be used to find reactors in a flock, but cross reaction with *M. gallisepticum* is common.

6) Prevention and control. Isolation and removal of reactors in flocks has lead to virtual eradication of *M. synoviae* in most primary breeder flocks. Tetracycline may be beneficial as a feed supplement or at the time of vaccination for Newcastle disease and infectious bronchitis to prevent synovitis or respiratory infection, but transmission to the eggs will not be eliminated.

7) Public health consequences. To date, no cases of human infection with *M. synoviae* have been reported.

e. *Mycoplasma meleagridis*

1) Agent. *M. meleagridis* is also a member of the genus *Mycoplasma* that is primarily found in turkeys. The organism is found worldwide.
2) **Transmission.** *M. meleagridis* infection is primarily a sexually transmitted disease. The organism is commonly found on the phallus and neighboring tissues of the tom. The semen easily becomes contaminated leading to infections of the hen’s vagina. The organism travels up the reproductive system to the ovary. Eggs are then inoculated with *M. meleagridis* before leaving the reproductive tract. Respiratory infection is also possible leading to lateral transmission between birds in the flock.\(^{14}\)

3) **Clinical Signs.** Decreased hatchability, poor poulт quality, and reduced growth rate are often seen in hatcheries with *M. meleagridis* outbreaks. Young turkeys may develop crooked, deformed necks and legs. Mild respiratory infections may occur in older poults.\(^{13,14}\)

4) **Epidemiology.** Environmental stress can cause tremendous mortality in very young poults infected with *M. meleagridis*. Respiratory infection in poults 3-8 weeks of age usually results in high morbidity but low mortality. Transmission through the egg can reach levels greater than 50% in hens at the beginning of the production cycle.\(^{14}\)

5) **Diagnosis.** Clinical signs and history can be suggestive of a *M. meleagridis* outbreak, but isolation and identification of the organism is the only definitive way to make a diagnosis. Lesions vary with age in birds with *M. meleagridis*. Day old poults are overwhelmed with thoracic airsacculitis characterized by striking caseous exudates. As the disease progresses, 1-3 week old poults with have similar lesions that extend to the abdominal air sacs. Tracheitis may also occur. Hens will often have microscopic lesions of the fimbria, uterus, and vagina.\(^{14}\)

6) **Prevention and control.** Identification and removal of reactors in turkey breeding flocks has greatly reduced the number of positive flocks. Flocks derived from *M. meleagridis* free birds should be continually monitored by examining pipped embryos or cull poults for airsacculitis. Semen should also be monitored and only used if free from infection. Dipping eggs in tylosin may be helpful in infected flocks to decrease the frequency of transmission. Antibiotic injections at one day of age or water medication for the first 5-10 days may also decrease the signs of infection.\(^{14}\)

7) **Public health consequences.** To date, no human cases of *M. melagridis* infection have been reported.\(^{12}\)

**f. Salmonella enteritidis**

1) **Agent.** *S. enteritidis* is a motile gram negative rod that may or may not cause disease in chickens, but is a serious health concern for people who consume raw eggs.\(^{16,18,19}\) *S. enteritidis* is able to infect all types of domestic fowl.\(^{19}\)

2) **Transmission.** *S. enteritidis* causes a subclinical infection of the ovaries and reproductive tract of hens. As the eggs are being produced inside the hen, they are being inoculated before the shell is formed. The hens appear healthy, while the eggs are contaminated with *Salmonella*.\(^{16,19}\)

3) **Clinical Signs.** Some serotypes, such as phage type 4-*S. enteritidis*, may cause a mild disease in chickens leading to depression, poor growth, weakness, diarrhea, and dehydration. Environmental stresses often exacerbate signs.\(^{19}\)
4) Epidemiology. Mortality rates are often restricted to the early weeks of life and tend to be more severe in ducks and turkeys than chickens. Phage type 4- S. enteritidis is found throughout Europe and can cause a mortality rate up to 20% in the first three weeks of life.19

5) Diagnosis. Diagnosis is often made on culture of fecal and environmental samples. On necropsy of birds, there are often no lesions, although, an enlarged liver with areas of focal necrosis may be found. An unabsorbed yolk sac and cecal cores may also be noted. Direct culture from the liver or yolk sac is an excellent technique to isolate the organism.19

6) Prevention and control. The best method to control S. enteritidis contamination is to begin with a clean flock and follow strict quarantine measures. Periodic culturing of litter, dust, water, hatchery debris and cull chicks can give an accurate assessment of the status of the flock. Heat treating all pelleted and mashed feed is often effective at eradicating S. enteritidis. Housing for birds should also be free of rodents, wild animals, and pets.18,19

7) Public health consequences. S. enteritidis has been linked to a serious growing problem of egg-associated salmonellosis in people.16,17,18,20 The problem emerged during the 1980s in the northeastern region of the U.S.; however, it quickly spread across the country.20 The disease is associated with consuming raw or undercooked eggs or egg products. People infected with S. enteritidis often suffer from fevers, abdominal cramps, and diarrhea occurring 12-72 hours after eating a contaminated item. Symptoms usually persist for 4-7 days with most recovering without the aid of antibiotic therapy. Nonetheless, the diarrhea can be severe enough to require hospitalization and possibly lead to death. People who are immunocompromised are at the greatest risk for severe illness.18,20 In 2001 alone, there were 46 confirmed outbreaks of S. enteritidis resulting in 1,681 illnesses and 102 hospitalizations.17 Basic practices such as avoiding raw or undercooked eggs, refrigerating eggs at all times, and routine handwashing after handling eggs can significantly decrease the risk of salmonellosis.18,20

g. Avian influenza
   a) Agent. Avian influenza (AI) is a respiratory disease of domestic poultry and a wide range of other domestic and wild fowl.21,23,24,25,26,27 The organisms responsible for the disease are Type A influenza viruses from the virus family Orthomyxoviridae.21,27 The viruses are classified by the identification of two surface proteins, hemagglutinin (HA) and neuraminidase (NA).21,25 There are currently 15 hemagglutinin and 9 neuraminidase antigens isolated amongst the Type A viruses.21 Not all strains of AI are capable of producing clinical signs, so the strains are divided into two groups based on their pathogenicity: low pathogenic avian influenza (LPAI) or highly pathogenic avian influenza (HPAI).21,23,25 Most viruses found in avian species are LPAI; however, LPAI are capable of mutating to HPAI with often devastating results.23 HPAI was first recognized in 1878 as an extremely infectious and deadly disease of chickens in Italy.21,25,26 The influenza connection was made in 1955, and as of 1999, 17 major outbreaks have occurred.25

   b) Transmission. Direct contact with infected birds or their feces is a common route for flock contamination. The virus then spreads quickly by aerosol droplets or direct contact. Once a bird is infected, it will shed intermittently for life. The virus also remains viable in the environment for extended amounts of time and can be easily transmitted on contaminated shoes, clothing, egg crates, vehicles, and other equipment.21,23,26,27 There is no evidence of direct vertical transmission because the embryos normally do not survive, however the exterior of eggs can become infected and serve as a vector for disease.21
**c. Clinical Signs.** Clinical signs vary greatly depending on the strain of influenza and can range from mild to rapidly fatal. The extremely lethal strains may manifest as sudden death. Fowl exhibiting clinical signs will often be depressed, off feed, and have a sudden drop in egg production. The wattles and combs may be cyanotic and there will be marked edema of the head, eyelids, comb wattles, and hocks. Some birds may develop diarrhea and respiratory distress. Petechial hemorrhages may be noted on the hocks and feet. Neurologic signs such as ataxia and torticollis may be noted.\(^{21,23,24,26,27}\)

**d. Epidemiology.** Morbidity and mortality rates are highly dependent on the strain of influenza infecting the flock.\(^{21,26}\) In outbreaks of HPAI, mortality can easily reach 100% within 2-12 days after initial signs.\(^{21}\) The most common subtypes associated with HPAI have been H7 and H5 although not all of these subtypes will cause HPAI.\(^{21,25,26,27}\)

The virus is known to be widespread in waterfowl and migratory birds without causing any evidence of disease. These birds serve as a huge reservoir and can shed the virus for long periods of time. They are also able to be infected with more than one virus strain at a time, therefore increasing the probability of mutation and genetic reassortment.\(^{25}\)

**e. Diagnosis.** Lesions noted on necropsy will vary depending on the strain of influenza infecting the flock. Chickens that die peracutely will often have no lesions except severe congestion of subcutaneous tissues and musculature. Other birds will have significant lesions such as excessive mucous exudates in the trachea, severe swelling of the neck and face, petechial hemorrhages on the serosal surfaces of the abdominal and thoracic organs. The kidneys are often congested with urate deposits in the tubules. The conjunctiva are often congested with petechiation.\(^{21,24,26,27}\) Lesions in turkeys and ducks are similar but usually not as severe.\(^{27}\)

History and clinical signs can lead to a presumptive diagnosis of AI; however, virus isolation is needed for definitive diagnosis.\(^{21,24,27}\)

**f. Prevention and control.** Strict sanitation and biosecurity measures are very important in preventing avian influenza. Every attempt must be made to prevent the contact, direct or indirect, of domestic poultry and wild bird populations. Farm workers and visitors to poultry operations must practice strict sanitation measures such as showering and changing clothes before handling poultry.\(^{21,23,26,27}\) If an outbreak does occur, vaccination along with strict quarantine may be used with viruses of low pathogenicity, but flocks infected with HPAI are forced to rapidly depopulate infected birds followed by thorough disinfection of the premises.\(^{21,24,26,27}\) Antiviral medications are not considered efficacious against AI as resistance is quickly established.\(^{24}\)

**g. Public health consequences.** Avian viruses are Type A influenza viruses that have the possibility of developing new mammalian strains through mutation and genetic reassortment. In 1997, 18 humans in Hong Kong were infected with a H5N1 avian influenza virus. Six deaths were reported. The human diseases corresponded with an outbreak of H5N1 HPAI of chickens in the area. This was the first reported outbreak of humans infected with avian influenza.\(^{22}\) Since then, several outbreaks have occurred including two in 2003. The first was reported in February, with two cases of H5N1 in a single family in Hong Kong\(^{29}\) and the second transpired in April, with 83 poultry workers and their families suffering from H7N7 in the Netherlands. The latter case
coincided with an outbreak of chickens in Belgium and Germany. One death was reported, a veterinarian visiting the flocks died from complication of the H7N7 infection.28,29

**h. Economic impact.** The economic impact of an outbreak of avian influenza can be devastating to a poultry producer and the industry. The last outbreak of HPAI in the United States occurred in 1983-84 in the Northeast. Seventeen million birds were destroyed at a cost of more than $65 million. Retail egg prices increased by more than 30 percent as a result.23

7. REFERENCES


