Enterobacteriaceae: *Salmonella*

Cellular Description and Composition

The cell wall is typical of gram-negative bacteria, composed of lipopolysaccharide (LPS) and protein. There is one capsular type, a polysaccharide antigen that has been named Vi (for virulence). The O-antigens, together with the antigenic determinants on the surface of the flagella (H antigens), which are possessed by most salmonellae, define the serotype. All salmonellae except *S. enterica* serotype Pullorum and *S. enterica* serotype Gallinarum are motile. Motility is mediated by peritrichous flagella. As with O-antigens, the H-antigens are determined by agglutination testing using specific antiserum. *Salmonella* has been reported to produce an enterotoxin called *Salmonella* enterotoxin.

Reservoir

The reservoir for members of the genus *Salmonella* is the gastrointestinal tract of animals. Sources of infection include contaminated soil, vegetation, water and foods, particularly those containing milk, meat, or egg. Some salmonellae have become adapted to certain hosts; that is, they are not usually detected in host species other than the one to which they have adapted. Examples include Abortus-equi in horses, Abortus-ovis in sheep; Cholerae suis in swine (and occasionally humans); Dublin in cattle (and occasionally humans); Gallinarum (the cause of fowl typhoid) in poultry; Pullorum (the cause of pullorum disease) in poultry; Typhi (the cause of typhoid fever) in humans; and Paratyphi (also a cause of typhoid fever) in humans. Some salmonellae are non-host-adapted, that is, capable of infecting many different host species such as S. typhimurium.

Transmission

Salmonellae are primarily transmitted by the fecal–oral route, often through ingestion of contaminated food and water. The most common clinical manifestation of salmonellosis is diarrhea. In certain instances septicemia occurs. Poultry and poultry products (eggs) are a major source of salmonellosis in humans. *S.* Enteritidis is especially adapted for egg transmission.

Laboratory Diagnosis

In cases of intestinal infection, fecal samples are collected; in systemic disease, a blood sample is collected for standard blood culture. Spleen and bone marrow are cultured for the salmonellae when post mortem diagnosis of systemic salmonellosis is required. Salmonellae appear as lactose-non-fermenting colonies on lactose-containing media (Figure 2). Since most serotypes of salmonellae produce H_2S, colonies on iron containing media (e.g., XLD agar), they will have a black center (Figure 3). Suspicious colonies can be tested directly with polyvalent anti-*Salmonella* antiserum or inoculated into differential media and then tested with antisera. To cultivate salmonellae from tissue, blood agar (Figure 1) can be used. Definitive identification involves determination of somatic and flagellar antigens. Various *Salmonella*-specific DNA probes and primers for the polymerase chain reaction (PCR) have been developed for identification as well as detection in samples (food, feces, and water) containing *Salmonella*.

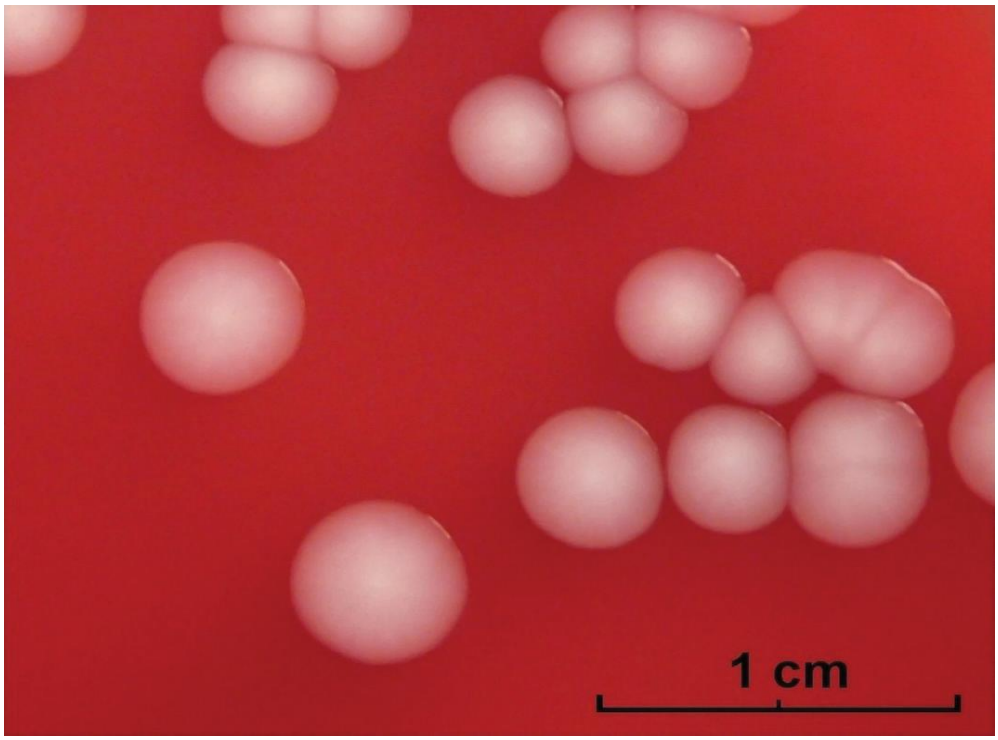

Figure 1. *Colonies of* S. enterica *ssp. Enterica serotype Enteritidis on blood agar*.

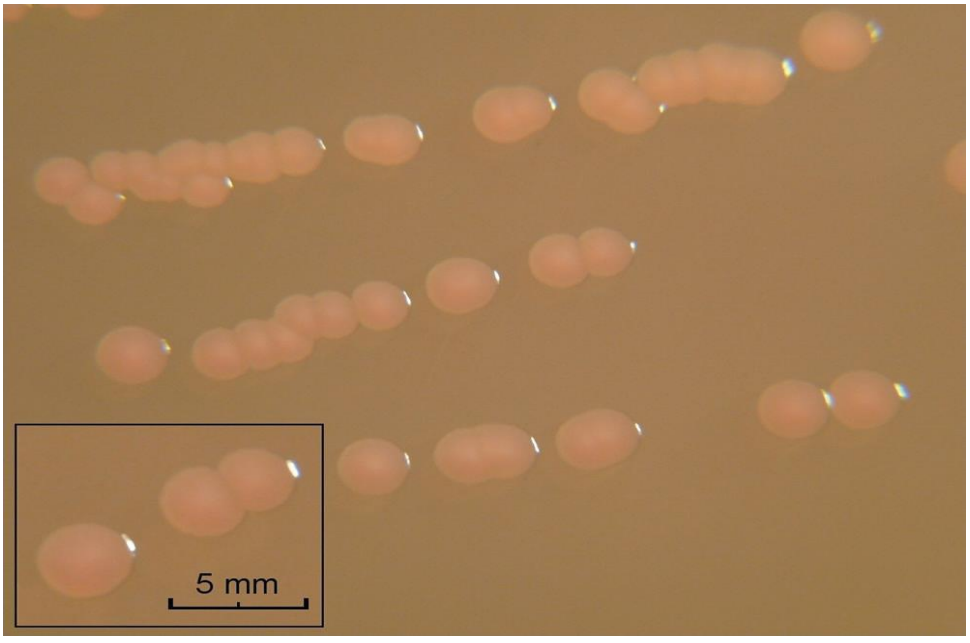

Figure 2. Colonies of S. enterica ssp. Enterica serotype Enteritidis on MacConkey agar

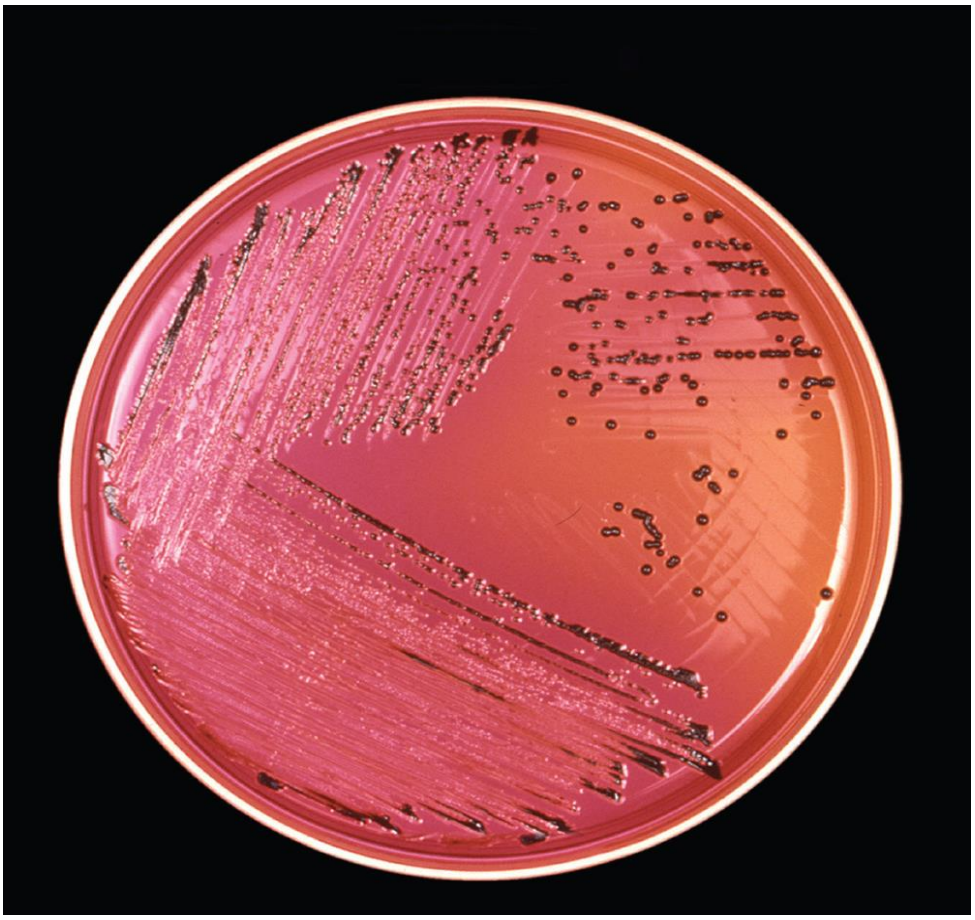

Figure 3. Salmonella colonies, XLD agar. When xylose lysine (XL) agar is supplemented with sodium thiosulfate, ferric ammonium citrate, and sodium deoxycholate, it is then termed XLD agar. The presence of any black-colored area indicates the deposition of hydrogen sulfide (H_2S), under alkaline conditions, and is highly suggestive of Salmonella.

Salmonellosis of Poultry

Pullorum Disease. Pullorum disease, caused by *S.* Pullorum which infects the ova of turkeys and chickens. Thus, the embryo is already infected when the egg is hatched. The hatchery environment is contaminated following hatching of an infected egg, leading to infection of other chicks and poults. Mortality is due to septicemia and is greatest in the second to third weeks of life. Surviving birds carry

the bacterium and may pass it to their off spring. It is difficult to detect infected breeding hens by bacteriologic means. Agglutination titers, produced 3–10 days after infection, are used to detect carrier birds. Eliminating infected breeding birds controls this disease. The disease has almost been eliminated in the United States due to a breeding flock testing program.

Fowl Typhoid. Fowl typhoid, caused by *S.* Gallinarum, is an acute septicemic or chronic disease of domesticated adult birds, mainly chickens. The disease is diagnosed by culturing the organism from liver or spleen. Fowl typhoid is controlled by management and eliminating infected birds. Fowl typhoid is rare now in the United States due to control programs.

Paratyphoid. "Paratyphoid" of poultry is salmonellosis produced by any of the motile strains of *Salmonella*. All salmonellae except *S. enterica* serotype Pullorum and *S. enterica* serotype Gallinarum are motile. The disease produces its highest losses in the first 2 weeks of life as a septicemic disease. Survivors become asymptomatic excretors. Infection is through ingestion.The source is usually feces or fecally contaminated materials (e.g., litter, fluff,andwater). Diagnosis is made by culturing the organism from affected tissue (e.g., spleen and joints) from birds that had been showing clinical signs of disease. It is more difficult to detect a subclinical carrier because such carriers only periodically shed the organism in feces. Some have suggested that culture of fluff and litter could be used to detect carrier flocks.

Treatment does not eliminate carriers, although it does control mortality. Treatment regimens have included avoparcin, lincomycin, furazolidone, streptomycin, and gentamicin. Exclusion of salmonellae by feeding "cocktails" of

normal flora has been used with some success to reduce the number of salmonellae shed by carrier birds (competitive exclusion).