Enteritis in sheep, goats and pigs due to *Yersinia pseudotuberculosis* infection

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**SUMMARY:** The features of naturally occurring *Yersinia pseudotuberculosis* serotype III infections in 16 sheep, one goat and 3 pigs, and *Y. pseudotuberculosis* serotype I infections in 3 goats, are described. Affected animals usually had diarrhoea and were in poor condition or emaciated. A number were moribund or dead when submitted for necropsy. Thickening of the caecal and colonic mucosa was the only gross lesion attributable to *Y. pseudotuberculosis* infection, with liver or other visceral abscesses not being seen. Characteristic microabscesses were demonstrated in the intestinal mucosa of 10 sheep, one goat and one pig infected with *Y. pseudotuberculosis* serotype I. Sheep, goats and pigs dosed orally with *Y. pseudotuberculosis* serotype III, the serotype isolated most commonly from these species, developed intestinal infection. In sheep and pigs, infection was accompanied by diarrhoea. Haematological changes and specific antibodies were elicited in all 3 species in response to infection. Microabscesses were seen in the intestinal mucosa of all experimentally exposed animals. The occurrence of field cases and the results of experimental exposure confirm that *Y. pseudotuberculosis* serotype III is an enteropathogen of sheep, goats and pigs. The association of *Y. pseudotuberculosis* serotype I with lesions in a goat, indicates that this bacterium may also be a pathogen of this species.

It is concluded that *Y. pseudotuberculosis* serotype III is an enteric pathogen of a wide range of ungulate species including cattle, buffalo, deer, antelopes, sheep, goats and pigs. Serotypes I and II, while having a more restricted host range, are probably also pathogens of ungulates and, in particular, deer, antelopes and goats.

**Introduction**

*Y. pseudotuberculosis* has been recognised as a sporadic cause of outbreaks of a fatal disease in sheep in Australia for many years (Gilruth 1911; Pullar 1932). The disease that these authors described is similar to that recognised in rodents and birds (Bercovier and Millaret 1964), which is characterised by extensive abscessation in visceral organs such as liver and spleen. Pullar (1932) did, however, note that diarrhoea and intestinal lesions occurred in a percentage of affected animals. Both Gilruth (1911) and Pullar (1932) exposed sheep experimentally to *Y. pseudotuberculosis* but failed to reproduce disease.

More recently, infection with *Y. pseudotuberculosis* has been shown to be associated with enteritis in a range of ungulate species including cattle (Slee et al 1988), deer (Henderson 1983; Mackintosh and Henderson 1984; Jerrett et al 1990), antelopes (Baskin et al 1977), buffalo (Behra et al 1984), a goat (Buddle et al 1988) and pigs (Morita et al 1968; de Barcelos and de Castro 1981). Most of these infections have been due to *Y. pseudotuberculosis* serotype III, although serotypes I and II are reported, particularly from deer (Hodges et al 1984; Jerrett et al 1990) and antelopes (Baskin et al 1977).

Although there is circumstantial evidence that *Y. pseudotuberculosis* is an enteropathogen of ungulates, only cattle have been exposed to experimental infection (Slee et al 1988). These authors failed to produce clinically apparent disease in calves exposed experimentally to *Y. pseudotuberculosis* serotype III, but did establish intestinal infection and demonstrated haematological changes, antibody production and the intestinal microabscesses characteristic of naturally occurring infection.

Other than the early infection experiments in sheep by Gilruth (1911) and Pullar (1932), there are no reports of the experimental exposure of sheep, goats or pigs to *Y. pseudotuberculosis*. Since this bacterium can be isolated from apparently normal sheep

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neutrophilia. A gross post-mortem examination was done and tissues were collected for histological examination. Swabs were collected from the stomach or abomasum, duodenum, jejunum, ileum, caecum, colon, mesenteric lymph node and liver and were cultured for *Yersinia* sp and *Salmonella* sp. Faeces were also examined for virus particles by transmission electron microscopy.

**Results**

**Field Cases**

*Y. pseudotuberculosis* was isolated from 16 sheep, 4 goats and 3 pigs. Eleven of the affected sheep were weaners and 5 were mature animals. Goats were from 3 to 24 months old and pigs were from 8 to 12 weeks old. Animals infected with *Y. pseudotuberculosis* serotype III usually had no contact with cattle. The majority of sheep, goats and pigs infected with *Y. pseudotuberculosis* had a watery, non-bloody diarrhoea. Sheep and goats were often in poor body condition and were moribund or dead when received. Many had been treated with anthelmintics and sulphonamides prior to submission to the laboratory. Usually a number of animals were affected in the flock and, in some instances, other deaths had already occurred.

Gross lesions were seen in some of the infected sheep, goats and pigs. Four sheep had thickening of the caecal and colonic mucosa, while sub-mucosal oedema was seen in a further animal. Intestinal intussusception was found in one pig, while a second had thickening of the mucosa of the spiral colon with associated fibrin tags. One goat had extensive thickening, ulceration and fibrin plaque formation in the caecum and proximal colon, but not in the mid or distal colon.

Pathologically significant parasite burdens were demonstrated in 3 of the 14 sheep. No other disease entities were diagnosed.

Lesions typical of *yersiniosis* were seen in the small and large intestine of 10 of 16 sheep. Two of 4 goats had lesions in the small and large intestine and one goat had a single microabscess in the liver. Microabscesses were present in the small intestine of one of 3 pigs. Autolysis precluded histological assessment of intestinal mucosa in 2 sheep.

Sheep and pig isolates were all serotype III, while goat isolates belonged to serotypes 1 (3) and 111 (1). *Y. pseudotuberculosis* serotypes I and 111 were both associated with lesions in goats.

Neutrophilia was found in 11 of the 12 sheep tested and band-form neutrophils were present in 5 animals. Low serum albumin concentrations were measured in 9 of 10 sheep tested. Blood was available from only one pig, one of those without lesions. This pig had neutrophilia and increased band-form neutrophils.

The seasonal occurrence of *Y. pseudotuberculosis* infection was the same for sheep, goats and pigs, being restricted to the winter and spring months. One infection was recorded in May, one in June, 8 in July, 8 in August, 2 in September and 3 in October.

**Experimental Infections**

The 2 sheep experimentally exposed to *Y. pseudotuberculosis* began excreting the bacterium after 2 d. Both developed mild, non-bloody diarrhoea and a left-shift in blood neutrophils (0.3 x 10^9/1 and 0.2 x 10^9/1) on days 4 and 6. One sheep was producing 10^9 ml of clear fluid in the
that this bacterium causes enteritis in these animals. The aetiology of the intermittent diarrhoea during the trial.

No other bacterial pathogens or parasites were demonstrated in the intestines of sheep, goats or pigs, although viral particles resembling coronavirus were seen in the faeces of the control goat. The control sheep and pigs remained normal throughout the study. No biochemical changes were detected in exposed or control animals. All 3 goats, including the control animal, had jejunal and ileal lesions. Although artificially exposed animals of diarrhoea, haematological changes suggestive of infection, specific antibodies and typical intestinal lesions. Although

Discussion

The isolation of Y. pseudotuberculosis from the intestine of 16 sheep, 4 goats and 3 pigs, the association with diarrhoea and the finding of gross and microscopic intestinal lesions is evidence that this bacterium causes enteritis in these animals. The aetiological role of Y. pseudotuberculosis serotype III in the disease in sheep, goats and pigs was confirmed by the development in the intestines of sheep, goats or pigs, although viral particles resembling coronavirus were seen in the faeces of the control goat. The control sheep and pigs remained normal throughout the study. No biochemical changes were detected in exposed or control animals. All 3 goats, including the control animal, had intermittent diarrhoea during the trial.

Y. pseudotuberculosis serotype III was isolated from a number of intestinal sites in all exposed animals but not from liver or mesenteric lymph node. Typical microabscesses accompanied by bacterial colonies were seen in the gastro-intestinal lamina propria of all exposed animals. Occasional foci of necrosis and neutrophil infiltration were present in the liver of one sheep. No microabscesses were seen in mesenteric lymph node sites. Sites from which Y. pseudotuberculosis was isolated and where lesions were seen are listed in Table 1.

No other bacterial pathogens or parasites were demonstrated in the intestines of sheep, goats or pigs, although viral particles resembling coronavirus were seen in the faeces of the control goat. The control sheep and pigs remained normal throughout the study. No biochemical changes were detected in exposed or control animals. All 3 goats, including the control animal, had jejunal and ileal lesions. Although artificially exposed animals of diarrhoea, haematological changes suggestive of infection, specific antibodies and typical intestinal lesions. Although

There are apparently no previous reports of the association between Y. pseudotuberculosis infection with the characteristic intestinal lesions of yersiniosis in either sheep or goats. However, these lesions have been described previously in pigs (Morita et al 1965).

Discussion

Field-acquired Y. pseudotuberculosis infection was restricted to the cooler months, May to October, and to younger animals as has been previously reported in cattle (Slee et al 1988) and sheep (Pullar 1932). Although Y. pseudotuberculosis serotype III is commonly isolated from cattle (Slee et al 1988), field infections in sheep, goats and pigs were not dependent on contact with cattle, suggesting that these species may all be capable of maintaining infection with this serotype.

Tetracyclines have been shown to be effective for treating cattle infected with Y. pseudotuberculosis (Slee et al 1988) and may be useful in treating yersiniosis in other species including sheep, goats and pigs.

Further investigation of possible production losses caused by yersiniosis in sheep, goats and pigs is warranted. Beside direct losses due to deaths, yersiniosis may also cause decreased production or result in the over-use or inappropriate use of anthelmintics and antibiotics. Diarrhoea also predisposes sheep to flystrike. Since Y. pseudotuberculosis is a pathogen of human beings (Bercovier and Mollaret 1984), the zoonotic potential of yersiniosis in livestock species also requires further investigation.

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