

# Control of tapeworms in sheep: a risk-based approach

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Canine tapeworms that have sheep as their intermediate host can be responsible for unpredictable significant economic losses for individual farms. In addition, one of these dog-sheep tapeworms, *Echinococcus granulosus*, is zoonotic, causing cystic echinococcosis in humans, which can be fatal. Given that detection of tapeworm infestation is often only achieved at postmortem abattoir inspection, reactive control measures are limited. The aim of this article is to illustrate how the principles of the Hazard Analysis and Critical Control Points (HACCP) system, which is widely used in the food industry, can be used to identify proactive control measures. The role of the small animal veterinary surgeon in control is also discussed.

THE Hazard Analysis and Critical Control Points (HACCP) system is a strategy that was designed in the 1960s by the National Aeronautics and Space Administration (NASA) to ensure the safety of food products for space missions. In particular, it was designed to ensure minimal microbiological contamination of foodstuffs. It has subsequently been adopted more widely by the food industry to ensure food safety for the general public. It is also currently used in the medicine of farmed deer. There are seven prescribed principles (see Box 1).

As detailed in the HACCP guidelines, the principles can be adapted to all aspects of the food industry from production to processing. In terms of the control of tapeworms in sheep, the monitoring is effectively limited to abattoir feedback, but the principles of HACCP identification are extremely applicable. To this end, the biology of the parasites must be thoroughly understood.

## Dog-sheep cestodes

All tapeworms (cestodes) affecting sheep exhibit a two-host life cycle with the reproductive stage in a definitive or final host and an infective larval stage (metacestode) encysted within an intermediate host. The ruminant tapeworm *Moniezia expanza* (which has oribatid pasture mites as intermediate hosts) is largely considered to be of no clinical significance. The dog tapeworms that have sheep as their intermediate host can be economically significant, and one species (*Taenia multiceps*) frequently causes clinically significant disease. There are three *Taenia* species (*Taenia ovis*, *Taenia hydatigena* and *Taenia multiceps*) currently present in the UK, as well as the sheep strain of *Echinococcus granulosus*, which is zoonotic due to the fact that people may act as an aberrant host.

## Life cycle

The life cycles of the *Taenia* species and *E granulosus* are similar and the general pattern is illustrated in Fig 1. The adult tapeworm is found within the small intestine of the definitive host and gravid segments or individual eggs are both passed out with defecation.

Usually, only a single *Taenia* species adult is found in a dog's gut, but many hundreds of *Echinococcus* tapeworms may be present (see Table 1 for key differences between the tapeworm species). Ingestion of these eggs by the intermediate host results in the hatching of the oncosphere (embryo) from the egg in response to gastric and intestinal secretions. In the small intestine of the intermediate host the oncosphere penetrates the intestinal wall, migrating via the blood stream or lymphatics to its predilection site (muscle for *T ovis*, peritoneum for *T hydatigena*, brain for *T multiceps*, and lungs (70 per cent) and liver (25 per cent) for *E granulosus*).

### Box 1: Outline of HACCP principles (HACCP principles and application guidelines [FDA 1997])

#### Principles

- Conduct a hazard analysis
- Determine the critical control points (CCPs)
- Establish critical limits
- Establish monitoring procedures
- Establish corrective actions
- Establish verification procedures
- Establish record-keeping and documentation procedures

#### Key definitions

##### Critical control point (CCP)

A step at which control can be applied. This is essential to prevent or eliminate a hazard or reduce it to an acceptable level. CCP decision trees should be developed in order to restore deviations from predetermined ranges to within normal 'safe' parameters.

##### Verification

Activities, other than monitoring, that determine the validity of the HACCP plan and ensure that the system is operating according to the plan.

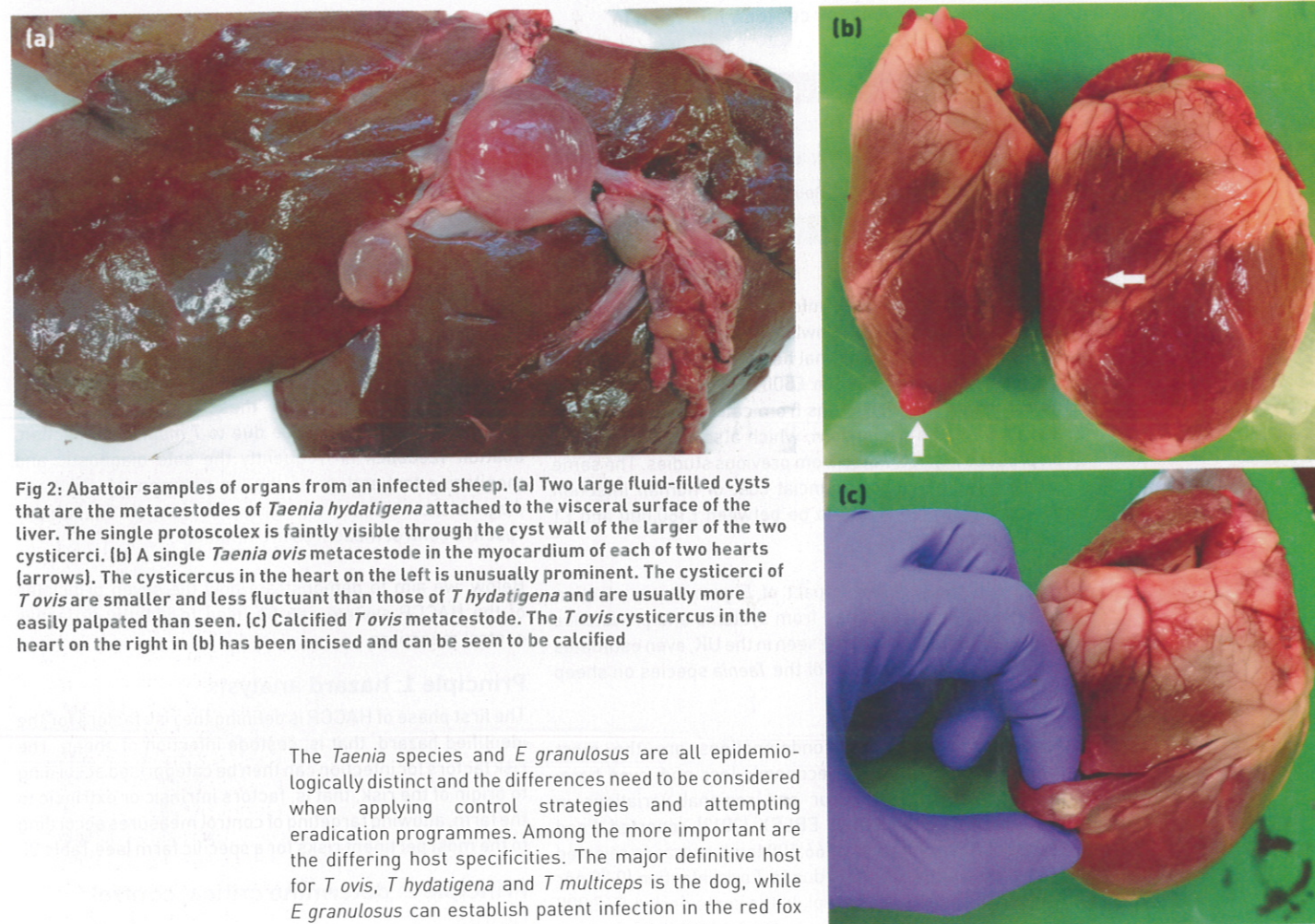


Fig 2: Abattoir samples of organs from an infected sheep. (a) Two large fluid-filled cysts that are the metacestodes of *Taenia hydatigena* attached to the visceral surface of the liver. The single protoscolex is faintly visible through the cyst wall of the larger of the two cysticerci. (b) A single *Taenia ovis* metacestode in the myocardium of each of two hearts (arrows). The cysticercus in the heart on the left is unusually prominent. The cysticerci of *T ovis* are smaller and less fluctuant than those of *T hydatigena* and are usually more easily palpated than seen. (c) Calcified *T ovis* metacestode. The *T ovis* cysticercus in the heart on the right in (b) has been incised and can be seen to be calcified

The *Taenia* species and *E granulosus* are all epidemiologically distinct and the differences need to be considered when applying control strategies and attempting eradication programmes. Among the more important are the differing host specificities. The major definitive host for *T ovis*, *T hydatigena* and *T multiceps* is the dog, while *E granulosus* can establish patent infection in the red fox (*Vulpes vulpes*) as well, albeit at a lower level than in dogs (Clarkson and Walters 1991).

All *Taenia* species seem to cause the development of immunity in the sheep, which prevents repeated infection, and there appears to be a degree of cross-protection between *T ovis* and *T hydatigena* (Gemmell and others 1987). Passive immunity from colostrum is also thought to occur (Herbert and others 1984). Evidence regarding protective immunity to *E granulosus* following natural infection in sheep is unclear. The number of hydatid cysts increases with age in sheep in endemic areas (Lahmar and others 1999); the number of *Taenia* metacestodes appears to plateau with increasing host age. The percentage of all metacestodes that are fertile decreases with time. The epidemiological effects of this are compounded by the period to maturity of the metacestode, which is substantially longer in *E granulosus* than the *Taenia* species.

The biotic potential of adult *Taenia* tapeworms is immense, with a single *T hydatigena* producing on average 76,000 eggs per day compared to 42 eggs per day from a single adult *E granulosus* (Gemmell and others 1987).

Although more *Echinococcus* adults may be present in the dog's intestine than *Taenia* tapeworms, the reproductive rate of *E granulosus* is estimated to be close to 1 (ie, one adult worm gives rise to one adult worm), while that of the *Taenia* species, in the absence of any control measures, is much higher and these species are then constrained by host immunity. Thus, any control measures are more likely to be successful in reducing the reproductive rate of *E granulosus* to below 1 than that of the *Taenia* species (Gemmell and others 1986). It is this difference that has led to the successful eradication of *E granulosus* from several

countries including Iceland and New Zealand (despite both the persistence of *T hydatigena* and emergence of *T ovis* in New Zealand).

Dispersal of eggs from the faecal mass can occur by a variety of routes and flies and birds can act as vectors; hence, metacestodes may periodically be detected in individual animals on farms where no carcase/offal feeding of dogs occurs, where there is regular praziquantel treatment of farm dogs, and where other dogs and foxes are absent.

The eggs of all tapeworms can survive temperatures in the range of -20°C to 30°C for prolonged periods and will not be killed by the most commonly used disinfectants; however, they are susceptible to desiccation and UV light (Willis and Herbert 1984, Veit and others 1995). The metacestodes can be killed by freezing (-10°C for 10 days) or cooking (>72°C).

## Impact of tapeworm infections

The economic impact of dog tapeworms on sheep production is often considered negligible by farmers in comparison to other ovine parasitic infections. Control of parasitic gastroenteritis (PGE) and *Fasciola hepatica* are key components of flock health planning, but the potential impact of cestode infections is frequently unappreciated.

While the economic impact of liver fluke and PGE are routinely acknowledged (EBLEX estimates PGE costs £10 per lamb and ADAS has estimated the cost of liver fluke to be £3-5 per ewe), the cost of meat rejections and the morbidity



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