Institution:
UNIVERSITY OF LIVERPOOL

Unit of Assessment:
UOA6 - Agriculture, Veterinary and Food Science

Title of case study:
Global Reduction in Equine Colic through a Novel Tapeworm Infection Test

1. Summary of the impact

Research at the University of Liverpool (UoL) has demonstrated the importance of intestinal tapeworm infection as an important and hitherto unrecognised risk factor for a major life-threatening acute intestinal disease (colic) in the horse. A novel serological test for exposure to the tapeworm infection was developed at UoL to provide a diagnostic tool for research and clinical applications. As a result, "best practice" equine preventive healthcare programmes now include anti-helminth and tapeworm control protocols and anti-tapeworm anthelmintics are licensed for use in the horse and marketed throughout the world. This research has had a major impact on equine health resulting in welfare and economic benefits for horses, their owners, veterinary practices and industry.

2. Underpinning research

Historically, tapeworm infection was not considered a threat to equine health until surgical observation suggested that some forms of intestinal disease were associated with heavy tapeworm infection. However, tapeworm infection was difficult to diagnose by coprological methods, thus hampering investigation of the host-parasite relationship.

UoL epidemiological research by Professor Chris Proudman and colleagues in the 1990s [1,2] identified the equine tapeworm *Anoplocephala perfoliata* as a significant cause of intestinal disease. This work won two awards [1]. As part of the work a novel serological diagnostic test (ELISA) was then developed to detect *A. perfoliata* infection and demonstrated a highly significant association between tapeworm infection and two specific types of equine intestinal disease. A dose-response relationship was also reported indicating increased risk of intestinal disease with increasing tapeworm infection intensity; this feature of the diagnostic test has proven critical to its use in disease prevention.

Colic is a major health issue with horses and is responsible for a quarter of horse deaths and costs over $120m in the USA alone, with 66% of that loss associated with horse death. Proudman showed that the diseases associated with tapeworm infection were (i) "spasmodic colic," a low mortality, high morbidity disease, and (ii) ileal impaction colic, a low incidence but high morbidity condition. The incidence of spasmodic colic is high, estimated at 1 case per 10 horse years at risk, and thus effective prevention or intervention would have significant clinical impact. The high morbidity of ileal impaction colic also indicates potentially high impact of effective interventions.

Since the original UoL research, a number of field-based clinical studies led by Proudman, in conjunction with Verbac Animal Health and the Universities of Glasgow and Pisa, have explored the use of the serological tapeworm diagnostic test in populations of horses [3-6]. Specifically, they have identified a clear reduction in colic risk associated with anti-tapeworm anthelmintic use, investigated adverse drug reactions following the use of anti-tapeworm anthelmintics and have described the dynamics of post-treatment antibody responses which are key to clinical interpretation of test results.

3. References to the research

1. **Proudman CJ, French NP**, and **Trees AJ**. (1998) Tapeworm infection is a significant risk factor for spasmodic colic and ileal impaction colic in the horse. *Equine Veterinary Journal* **30**, 194-199. Citations: 88 Impact Factor: 2.286

   Awarded the Urquhart Prize (British Association for Veterinary Parasitology) 1998.
   Awarded the Equine Veterinary Journal Open Award 1998.

2. **Proudman CJ**, and **Trees AJ**. (1999) Tapeworms as a cause of intestinal disease in horses. *Parasitology Today* **15**, 156-159. Citations: 35 Impact Factor: 2.35

3. Barrett EJ, **Farlam J**, and **Proudman CJ**. (2004) Field trial of the efficacy of a combination of ivermectin and praziquantal in horses infected with roundworms and tapeworms. *Veterinary Record*. **154**, 323-5. Citations: 9 Impact Factor: 1.803

4. Barrett EJ, Blair CW, **Farlam J**, **Proudman CJ**. (2005) Post-dosing colic and diarrhoea in horses with serological evidence of tapeworm infection. *Veterinary Record* **156**, 252. Citations: 9 Impact Factor: 1.803

5. Traversa D, Fichi G, Campigli M, Rondolotti A, Iorio R, **Proudman CJ**, Pellegrini D and Perrucci S (2008) A comparison of coprological, serological and molecular methods for the diagnosis of horse infection with Anoplocephala perfoliata (Cestoda, Cyclophyllidea). *Veterinary Parasitology* **152**, 271-277. Citations: 9 Impact Factor: 2.381

6. Abbott JB, Mellor DJ, Barrett EJ, **Proudman CJ**, and Love, S. (2008). Serological changes observed in horses infected with Anoplocephala perfoliata after treatment with praziquantel and natural reinfection. *Veterinary Record* **162**, 50-53. Citations: 9 Impact Factor: 1.803

Key Grants

1993 – 1996. **Horserace Betting Levy Board** Research Training Scholarship awarded to Proudman. “An epidemiological investigation of the role of the equine tapeworm *Anoplocephala perfoliata* in intestinal disease” £60k.

2007 – 2008. **U Live Enterprises** (University of Liverpool). Development of a novel recombinant antigen ELISA for equine tapeworm serological diagnosis, £50k.

2010 – 2012. **Technology Strategy Board** Knowledge Transfer Partnership (KTP007842) with **Equine Pets and Livestock Animalcare Ltd** (Carmarthen, Wales). “Introduce, embed and extend diagnostic services developed outside the company in order to offer sustainable equine worm control.” £142k.

4. Details of the impact

Novel research by Proudman and colleagues at the UoL has significantly improved the way a potentially devastating equine health risk is diagnosed, managed and treated. This research into equine colic has resulted in impacts both domestically and internationally and includes (i) improvements to animal health by way of diagnostic testing, updated healthcare guidelines, and public and industry awareness activities promoting the benefits of anthelmintic use, and (ii) generation of an increased income stream for the animal health industry and pharmaceutical companies by proving the clear benefits of using anti-tapeworm drugs for a major equine problem. Beneficiaries are horses and their owners through improved welfare; veterinarians and testing laboratories through an increased range of services for tapeworm infection detection; and treatment and pharmaceutical companies through additional products and sales.

UoL research linking equine colic to tapeworm exposure has led to the widespread use of anti-tapeworm therapies to treat the two described forms of colic. This has primarily manifested as worldwide changes to recommended protocols for treating equine colic effectively. As a result, Proudman’s research findings and conclusions have been incorporated (2010 – 2012) into equine healthcare guidelines and widely adopted in the UK and internationally.

Diagnosis and preventative treatment

The development by the UoL of a serological test for tapeworm infection has given veterinary surgeons and researchers a risk assessment tool and which has become a key diagnostic assay that is in routine use in equine medicine. The University of Liverpool operates a commercial

diagnostic service for the test (branded as "Diagnosteq"). This service is widely used by vets in the UK and Europe. During the period 2008 to 2012, the service tested 19,887 samples for clinicians to guide worm control programmes. The serological test for equine tapeworm infection is unique to this laboratory. The 'Diagnosteq' service has also undertaken serological testing for epidemiological research purposes on samples from 15 different countries, including the USA, Canada, Australia, Japan, France, Germany, Sweden, Norway, The Netherlands and Italy.

Proudman's research showed a clear reduction in colic risk when anti-tapeworm anthelmintics were used. The launch of anti-tapeworm anthelmintics has been accompanied by extensive public engagement activities, including websites [e.g. 14] and CPD courses for equine surgeons [15] to raise public and industry awareness of the value of their usage to prevent life threatening colic in horses.

Awareness raising

The importance of equine tapeworm control is now embedded in undergraduate veterinary curricula, CPD programmes for practising veterinary surgeons and training of lay prescribers of anthelmintic drugs (Suitably Qualified Persons) [8] and sources of professional information [9].

Increased awareness of intestinal tapeworms as a risk to horse health, plus the knowledge and products to implement effective tapeworm control is now widely available to the general public of horse owners [e.g. 7,10,11,12].

Equine anthelmintic market

Recognising the significance of Proudman's research to equine healthcare programmes, several international animal health pharmaceutical companies have applied for marketing authorisation and launched anti-tapeworm anthelmintics for use in horses citing the UoL research as indicating a need for tapeworm control in horses. Veterinary sales clearly indicate significant growth in the anti-tapeworm sector of the equine anthelmintic market. During the impact qualifying period (2008 – 2012), five pharmaceutical companies (Elanco, Intervet, Merial, Pfizer and Virbac) were marketing between 15 – 17 anti-tapeworm products with £9.7m sales in 2010. This compares to a market of 5 products produced by 2 companies and annual sales of just £3.9m in 2001; a 250% increase in sales. Veterinary practise sales represent only 15-20% of total veterinary anthelmintic sales, the remainder being sold directly to horse-owners. Some companies use serological testing for risk screening [13].

5. Sources to corroborate the impact

Each source listed below provides evidence for the corresponding numbered claim made in section 4 (details of the impact).

7. The British Horse Society. Advice on Worm Control. http://www.bhs.org.uk/~/media/BHS/Files/PDF%20Documents/Worm%20Control.ashx

8. Proudman, C.J. (2009) Intestinal parasitism. In: The Equine Acute Abdomen, second edition. Ed. Mair, T.S. and White, N.A.. Lea and Febiger, Philadelphia

9. Reinemeyer C, and Lloyd S. Tapeworm Infection. Vetstream http://www.vetstream.com/equis/Content/Disease/dis00740

10. Better Equine Worm Control. Farmers Guardian (2011) http://www.farmersguardian.com/home/equestrian/equestrian-features/better-equine-worm-control/37861.article (Article aimed at lay audience in UK, includes use of ELISA test for monitoring)

11. Tapeworms. Intelligent Worming. http://www.intelligentworming.co.uk/doyouknow-aboutworms-tapeworm.asp (Information site for commercial provider of worm control for horses in UK)

12. Worm Control in Horses. Horse & Hound (2006) http://www.horseandhound.co.uk/horse-care/horse-care-tips/worm-control-in-horses/

13. Zoetis. https://online.zoetis.com/GB/EN/Conditions/Pages/WormControl.aspx (see page on testing)

14. Q&A's – Ask our vet Callum. Virbac. http://www.3dworming.co.uk/ask-our-vet.html (information for horse owners about tapeworms and colic based on Prof Proudman's research)

15. Rossdales Colic Surgery Course (2013). http://www.rossdales.com/downloads/colic_2013_progr.pdf (CPD for equine surgeons including dissemination by Prof Proudman).