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 **T H E H O R S E T R U S T**

**Registered Charity 231748**

**APPLICATION FOR A RESEARCH GRANT**

1. **1st Applicant’s title, name and qualifications:**

 Professor Jacqueline Matthews BVMS PhD MRCVS

1. **Current job title:** Deputy Director/Principal Veterinary Parasitologist
2. **Department, institute and address:**

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**4. Source of Salary:** Moredun Research Institute

**1. 2nd Applicant’s title, name and qualifications:**

 Dr Jane Hodgkinson, BSc PhD

1. **Current job title:** Senior Lecturer in Veterinary Parasitology
2. **Department, institute and address:** School of Veterinary Science, Institute of Infection & Global Health, University of Liverpool, IC2, 146 Brownlow Hill, L3 5RF

 **Tel:** 0151 795 0223 **Fax:**

 **E-mail address:**jhodgkin@liv.ac.uk

**4. Source of Salary:** University of Liverpool (HEFCE)

**1. 3rd Applicant’s title, name and qualifications:**

Dr Eric Morgan MA VetMB PhD DipEVPC MRCVS

1. **Current job title:** Senior Lecturer in Veterinary Parasitology
2. **Department, institute and address:**

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**4. Source of Salary:** University of Bristol (HEFCE)

**1. 4th Applicant’s title, name and qualifications:**

 Dr Tim Mair BVSc PhD DEIM DESTS DipECEIM AssocECVDI MRCVS

**2. Current job title:** Director

**3. Department, institute and address:**

Bell Equine Veterinary Clinic, Mereworth, Maidstone, Kent, ME18 5GS

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1. **Source of Salary:**

Bell Equine Veterinary Clinic

**1. 5th Applicant’s title, name and qualifications:**

 Dr Stewart Burgess BSc (Hons), PhD

**2. Current job title:** Senior Scientist

**3. Department, institute and address:**

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**4. Source of Salary:** Moredun Research Institute

1. **Title of project:**

*Taking evidence-based parasite control into the field to mitigate helminth-associated disease in horses*

1. **Declarations**
2. **Applicants**

I/we have read the guidance notes and terms and conditions under which The Horse Trust welfare grants are awarded and, if this application is successful, I/we shall be actively engaged in the day-to-day control of the work.

Signature(s): Date: 19 Mar14



1. **Head of Department**

I confirm that I have read this application, it has been authorised by the Institute Senior Management Group and I agree to this work being carried out in my department.

Name: Date:

Signature:

1. **Secretary of Institute/Finance Officer**

If a grant is made I will ensure that the funds provided are used for the purpose for which they have been given and in accordance with the terms and conditions. I confirm that it is our intention to maintain our support for this department during the period for which this grant is requested and that this institution will meet all indirect costs arising from the conduct of the work herewith described. I also confirm that the finances of this institution, including research grants, are subject to periodic audit.

Name: Date:

Signature:

Position: Institution:

1. **Aims and objectives: - 300 words**

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| *Anthelmintic resistance is a major threat to equine welfare*. Many worm populations have been subjected to selection pressure for drug resistance because of previous frequent anthelmintic exposure. Fenbendazole resistance is rife in cyathostomins worldwide, with reduced pyrantel efficacy common in some areas, and macrocyclic lactone resistance emerging in a number of countries. These issues are compounded by lack of efficacy of ivermectin against *Parascaris equorum* and *Oxyuris equi.* For these reasons, evidence-based (i.e. targeted) methods of control have been advocated. This has meant a radical change in how worm control should be delivered in the field. There has been some degree of uptake of targeted deworming in the UK; however, there remain important caveats that need addressing if this type of strategy is to be implemented more widely. For example, will concomitant reductions in anthelmintic treatment frequency impact the prevalence/distribution of different helminth species? Could this result in re-emergence of pathogenic worm species reduced previously by interval treatment protocols? For these reasons, the *impact* of targeted deworming programmes must be monitored to identify potential adverse sequelae associated with reductions in anthelmintic use. Furthermore, evidence-based protocols require robust diagnostic tools that inform accurately and with high sensitivity on the parasites present and their sensitivity to the anthelmintics tested. Thus, in the proposed project we aim to:* Undertake questionnaire analyses to measure uptake of targeted deworming programmes to quantify the extent of change in attitudes and behaviours;
* Compare prevalence/distribution of all major helminth species and levels of AR on yards that follow traditional interval *versus* targeted deworming programmes to quantify the impact of these changes;
* Road-test recently optimised diagnostic tools (FEC, ELISA) for practice and commercial laboratory settings to ensure that they have practical utility and are robust;
* Develop knowledge transfer tools to support evidence-based control in the field.
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1. **Scientific summary of research project - 300 words**

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| Anthelmintic resistance in horse nematodes is effectively out of control. Should resistance levels worsen, there will be few options left. Recently, we screened 1000’s of equine faecal samples for nematode eggs and demonstrated that excretion amongst horses was highly over-dispersed, providing compelling evidence that targeted deworming will impact transmission with a consequential reduction in anthelmintic use. On the flip-side, a recent study indicated a rise in *Strongylus vulgaris* prevalence where targeted therapy was delivered over a several years, suggesting that longterm modifications to deworming programmes might affect health risk. Here, we will address these issues by undertaking:A. Questionnaire analyses to explore delivery of worm control across the UK. Statistics will be performed to illustrate behaviour frequency, supported by univariate/multivariate models to determine significance of the observed trends.B. Helminth prevalence studies on yards using interval *versus* targeted deworming protocols. From A, we will identify yards where interval treatments are applied and those where targeted deworming is performed. We will quantify impact of control procedure followed by examining helminth FEC/distribution across farms employing the two protocols. Prevalence, shedding and *k* values will be incorporated into analyses of questionnaire outputs (A) to determine risk factors for shedding and the presence of particular species. C. Ivermectin/moxidectin-FEC reduction tests and nematode egg reappearance period studies. The latter is acknowledged as an early measure of resistance. These parameters will identify effectiveness of the most commonly used anthelmintics. The data will be incorporated into analysis of questionnaire outputs (A) to determine potential risk factors for resistance. D. A study of the utility of a cyathostomin encysted larvae (EL) diagnostic ELISA in a commercial setting. E. Based on outputs of A-D, we will develop diagnostic and knowledge-based tools that will support all equine stakeholders in making anthelmintic treatment decisions.  |

1. **Lay summary of research: - 300 words**

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| Previous studies demonstrate that worms are present in *all* UK horse populations and that dewormer resistance in some species is common-place. Multi-drug resistance has been identified, making *sustainable control a priority area in equine disease management*. This is pertinent because no new equine dewormers are being developed in the medium term and once resistant, worms are not thought to revert to sensitivity, even when not exposed to a particular drug for years. Because of the threat of resistance, control programmes have been promoted that rely on reduced dewormer use. These take into account the uneven distribution of worms amongst horses. Recently, we screened 1000’s of dung samples for worm eggs and demonstrated that, on stud farms, only 11% horses excreted 80% eggs counted, whilst in ‘leisure’ horse populations, 15% excreted 80% eggs counted. These figures provide strong evidence that targeted deworming of high ‘shedders’ will substantially reduce transmission with concomitant reductions in drug usage. This must be balanced against the fact that in one Danish study, where dewormer use had been substantially reduced, a rise in detection of pathogenic *Strongylus vulgaris* worm was detected. For these reasons, we need to quantity the impact of changes in equine deworming protocols in the UK. To do this, we will select premises where horses are subjected to targeted deworming and those where they are administered dewormers on an interval basis. We will measure the impact of the two types of programme on the level/type/drug sensitivity of worms excreted by horses managed under each programme so that we can *quantify risk* and, therefore, modify advice for horse owners accordingly. To support future diagnostics, we will bring forward new tools to robustly inform treatment decisions. *The principal outputs will be the generation of knowledge and diagnostics that will advance safe, evidence-based worm control*. |

1. **What is the likely impact of your work and how will it improve equine welfare? - 300 words**

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| Roundworms are ubiquitous in all breeds and age of horses world-wide. When present in high burdens in individuals, these worms can cause serious disease and can be fatal. Three broad spectrum anthelmintic classes are available to control these parasites; however, increasing levels of anthelmintic resistance represent a threat to sustainable control. Nowhere is this more evident than in the UK, where there has been a long history of indiscriminate deworming in interval-based programmes. Recently, we measured multi-drug resistance in a number of populations, with resistance identified in two types of common roundworm (cyathostomins, *Parascaris equorum*), both of which have the potential to be fatal if not controlled adequately. Because of the issue of resistance, horse owners need to engage in control protocols that rely less on anthelmintic use. These protocols involve the strategic application of broad spectrum anthelmintics in the appropriate season to kill pathogenic stages that are undetectable by conventional (i.e. faecal egg count, FEC) means. This needs to be combined with targeted treatments (based on FEC analysis) to reduce egg contamination into the environment. Our aim is to build on our previous research by measuring the impact (including positive and negative sequelae) of evidence-based deworming across the UK and to extend our studies on the immediate threat of emerging resistance to ivermectin and moxidectin, by far the most commonly used dewormers worldwide. We will also road test, in a commercial laboratory setting, a diagnostic ELISA that we have developed to detect immature cyathostomin larvae. Using a combination of data from our questionnaire analyses, classical parasitology studies, molecular biology experiments, ELISA validation and statistical modeling, we will develop accessible diagnostic and knowledge tools for owners/managers and those who advise on deworming (veterinarians, veterinary pharmacists and suitably qualified persons) to provide an evidence-based platform for sustainable control for the future.  |

1. **How does this research proposal relate to current work being undertaken in your group(s)? - 300 words**

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| *Matthews*: to early 2014, projects include a study to optimise sensitive FEC-based tools to support evidence-based worm control (Pilkington Trust). Matthews shares a HBLB scholarship with Hodgkinson (PI) to monitor worm control methods on Thoroughbred studs and is PI on a DEFRA/VMD project comparing UK anthelmintic prescribing channels (ruminants, pigs and horses). Matthews’ other concurrent projects are ruminant nematode-based and involve many methodologies to be used in the proposed project. The ruminant projects span subunit vaccine development for control of teladorsagiosis (sheep) and investigations of deworming strategies and anthelmintic efficacy (cattle). This project is a natural extension of earlier Horse Trust projects; especially, first steps in development of the ELISA described in the proposed project. *Hodgkinson:* since 1999, Jane has focussed on increasing knowledge of how parasites become drug-resistant and how drug use can be rationalised to mitigate resistance. Projects include development of tools for evidence-based control, investigation of resistance. Current work includes HBLB-funded scholarship to examine worm control on studs, a BBSRC project to investigate resistance in liver fluke and academic leadership of the equine parasite diagnostic service, Diagnosteq (<http://www.liv.ac.uk/diagnosteq/>). *Morgan* works on dynamic interactions between hosts and parasites and its manipulation to achieve sustainable control. Projects include practical diagnosis, epidemiology and use of mathematical models as tools for evidence-based control. *Mair* is Director of a large first opinion/referral practice with hospital. Research projects include investigations of anthelmintic resistance in the catchment area and documentation of clinical features/pathological changes in parasite-related diseases.*Burgess* is a senior scientist working on development of novel vaccines and diagnostic tools for parasites of ruminants. The group recently developed and validated a diagnostic ELISA for detection of sheep scab, which is currently being commercialised. This test is also being deployed as part of a large-scale disease eradication campaign on the Isle of Mull. |

1. **Identify any ethical issues associated with this proposed research: - 300 words**

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| 1. Regarding use of animals, there are no invasive studies specified in this project. All faecal samples will be collected after excretion and we will only use serum samples archived or submitted for diagnostic purposes to practice laboratories and to the commercial service, Diagnosteq (http://www.liv.ac.uk/diagnosteq/) at Liverpool, where Jane Hodgkinson is the academic lead. For submitted samples, we will request owner permission to use faeces in our analyses and the serum aliquots in the cyathostomin EL ELISA. As we have done previously, with submitted samples, FEC and ELISA results will be fed back directly to the attending veterinary surgeon to inform management of the case and for them to liaise with the owner regarding current and future parasite control options. 2. Regarding the questionnaire component, all data submitted will be anonymised and subjected to strict data management practices that we have used previously (please see relevant publications in our reference lists in the cv section).  |

1. **External Referees (List the name and contact details of 4 potential referees for this application)**

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| --- |
| Dr Martin Nielsen, Gluck Equine Research Center Department of Veterinary Science University of Kentucky Lexington, KY 40546-0099, USAE-mail:martin.nielsen@uky.edu Professor Ray M Kaplan, Department of Infectious Diseases, College of Veterinary Medicine, University of Georgia, Athens, GA 30602-7387, USAEmail: rkaplan@uga.edu Dr Eva Osterman Lind, National Veterinary Institute, Department of Virology, Immunobiology and Parasitology, Section for Parasitological Diagnostics, SE-751 89 Uppsala, SwedenEmail: eva.osterman-lind@sva.seDr Deborah van Doorn, Department of Infectious Diseases and Immunology, Utrecht University, P.O Box 80125, 3508 TC Utrecht, The NetherlandsEmail: D.C.K.vanDoorn@uu.nl  |

**15. SUPPORT FROM OTHER SOURCES**

**a) Is this or a related application currently being submitted elsewhere? NO**

IF YES:

To which organisation? NA

By what date is a decision expected? NA

**b) Has this, or a similar application been submitted elsewhere over the past two years?**

**NO**

IF YES:

To which organisation?

What was the result?

**16. PREVIOUS APPLICATIONS TO THE HORSE TRUST**

**a) Is this the principal applicant’s first application to The Horse Trust? NO**

IF NO:

Please give details of applications made to The Horse Trust in the last seven years and their outcome.

2008. Horse Trust. An investigation into moxidectin resistance in the Cyathostominae. With JE Hodgkinson (Liverpool). Three year project. £241,822. Funded.

2009. Horse Trust. Clinical scholarship . A study of anthelmintic efficacy in yards in Scotland. With BC McGorum (PI, Edinburgh). Three year scholarship with parasitology MSc project (clinical scholar: C Stratford). Funded.

2010. Elise Pilkington Trust PhD project, administered by the Horse Trust. WormTrust: a decision support system for sustainable parasite control (PhD student: HE Lester). With ER Morgan (Bristol), JE Hodgkinson (Liverpool). £73,404. Funded.

**17. ANIMAL EXPERIMENTATION**

Does this project require a Home Office Licence? NO

IF YES, have appropriate personal and project Licences been obtained?

IF NO, has application for such Licence(s) been made?

**18. FINANCIAL SUMMARY**

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| --- | --- | --- | --- | --- |
|  | **Year 1** | **Year 2** | **Year 3** | **TOTAL** |
| Staff costs | 40,879 | 41,697 | 42,531 | 125,107 |
| Consumables | 9,300 | 19,300 | 28,500 | 57,100 |
| Livestock | - | - | - | - |
| Travel expenses | 1,400 | 3,300 | 4,500 | 9,200 |
| Equipment | 1,250 | - | - | 1,250 |
| Total | **52,829** | **64,297** | **75,531** | **192,657** |

**19. DETAILED DESCRIPTION OF SCIENTIFIC PROJECT (MAXIMUM 5 PAGES, 11 FONT, 2CM MARGINS)**

**Background**

Gastrointestinal helminths are omnipresent in horses worldwide. In equines that graze contaminated pasture and which are not treated appropriately, large numbers of these worms can accumulate. For example, substantial burdens (several million) of immature cyathostomin larvae can encyst in the large intestine for long periods; these larvae are relatively insensitive to most anthelmintics [1]. The larvae usually encyst in autumn/winter (in the UK) and can comprise up to 90% of the total cyathostomin burden [2]. Encysted larvae (EL) can then re-emerge from the gut wall in large numbers leading to a fatal colitis known as larval cyathostominosis [3]. In addition to these highly ubiquitous nematodes, large strongyle species (for example, *Strongylus vulgaris)* and the tapeworm, *Anoplocephala perfoliata*, can cause serious disease in horses if not adequately controlled [4]. In youngsters, *Parascaris equorum* can be a substantial threat [4] and *Dictyocaulus arnfieldi* [5] and *Fasciola hepatica* [6] can cause disease, especially when horses are co-grazed with, or graze pastures recently populated by, more permissive hosts.

For many years, equine parasite control followed interval-dosing regimens involving regular anthelmintic administration to all horses, with treatment timings based on strongyle egg reappearance period (ERP) defined for each anthelmintic at licensing [7]. Interval programmes resulted in substantial reductions in strongyle-associated disease, but made considerable contributions to anthelmintic resistance (AR) in cyathostomins [8]. Cyathostomin resistance to fenbendazole and pyrantel is now widespread [reviewed in 1,8,9] and reduced efficacy of ivermectin and moxidectin (measured primarily as reduced ERP) is emerging [10,11]. Ivermectin resistance has also been commonly detected in *P. equorum* [12]. These problems are compounded by reports of lack of efficacy of macrocyclic lactone (ML) compounds against *Oxyuris equi* infection [13], a chronic and debilitating condition in affected horses. Should AR levels worsen, there will be no options left as *no* new anthelmintic classes are under development for use in horses in the short to medium term. Furthermore, based on comparative studies in sheep nematodes [14], reversion to drug sensitivity is unlikely to occur in resistant populations.

For these reasons, more sustainable, evidence-based methods of parasite control have been advocated. These programmes are based on a requirement to treat horses predisposed to large burdens, particularly, high levels of (undetectable) immature larvae, balanced with a need to reduce anthelmintic treatment frequency to preserve efficacy. Our work [15,16] and that of others [17,18] has demonstrated that faecal egg count (FEC) excretion in horses is highly over-dispersed, with <20% of a given population likely to contribute to >80% of nematode egg excretion at any given point in time. By exploiting these observations, targeted deworming based on FEC analysis can substantially impact transmission with consequent reductions in drug use. However, a recent Danish study indicated a rise in *S. vulgaris* prevalence where targeted therapy had been delivered over a number of years [19]. The latter study highlights that the impact of targeted deworming programmes on helminth species prevalence and distribution needs to be monitored.

In the UK, there has been a reasonable uptake of targeted deworming in the leisure horse-owning sector [20], with slower translation in the Thoroughbred breeding industry [21]. With alterations in control protocols, it is important to scrutinise the impact of changes in practice on parasite species prevalence and distribution as well as the effect on anthelmintic efficacy. These studies are warranted as there are worrying trends in anthelmintic sensitivity profiles across the UK. Our recent research demonstrated that fenbendazole was not effective in reducing cyathostomin eggs in any population tested [11,16,22] and pyrantel efficacy was highly variable [11,16,22]. Although ML treatment generally led to mean FEC reductions of >95% [11,16,22], in the small number of instances where strongyle ERP was measured, this was shorter compared to periods reported in the mid-late 1990’s [11,23,24]. These findings reflect those in other countries [25-28] and highlight the real threat of multi-drug resistance in cyathostomin populations and the requirement for control programmes that rely less on global anthelmintic treatments. In 2010, DEFRA estimated that there are ~600,000-1.2 million horses in the UK. Many of these may still receive regular blanket anthelmintic treatments with no attention paid to efficacy. A lack of uptake of targeted treatments may be due to the perceived complexity involved in integrating these ‘new’ methods. In the UK, Animal Medicines Training Regulatory Authority-registered Suitably Qualified Persons (SQPs), licensed to sell anthelmintics, handle the bulk of the equine anthelmintics trade and may not have the requisite knowledge of anthelmintic resistance and/or have restricted access to the sort of diagnostic tests (e.g. FEC) required to support decision-making.

**Objective**

Based on the aforementioned issues, the objectives of the proposed project are to:

* Undertake questionnaire analyses to extend information on the uptake of targeted deworming programmes to quantify extent of change in attitudes to parasite control across the UK and to highlight gaps in knowledge in the end-user;
* Compare the prevalence and distribution of helminth species and levels of anthelmintic resistance on yards that follow interval *versus* targeted deworming programmes to quantify the impact of control protocol followed;
* Develop sensitive and robust diagnostic tools (FEC, ELISA) for practice and commercial laboratory settings to underpin evidence-based parasite control.

The data and tools generated will be exploited to build decision support systems and information packages designed to facilitate evidence-based protocols for the future.

**Methodologies to be used in the project**

**1. Questionnaire analyses**

We will contact > 1000 horse owners, yard managers or stud farm owners. Representative yards will be targeted using our existing database, via the British Horse Society, the Thoroughbred Breeders Association and veterinary practices that we have previously collaborated with. Owners will be contacted directly by email or post (if no email address available). Sampling frame will be stratified according to region, yard size and previous interaction with our group (specified as: no interaction, partial interaction [questionnaire completed but no FEC/efficacy testing done], full interaction [questionnaire completed, FEC/efficacy testing done]. We anticipate a 40-50% response rate. We will explore previous/current control measures (chemical [for example, treatment regimes, dosing protocols, anthelmintics used], environmental measures [for example, dung removal, rotational grazing, stocking density]), use of diagnostics (FEC, tapeworm blood test), as well as attitudes to anthelmintic use and prescribing practices. Questionnaires will be piloted using a cohort of owners identified through Bell Equine and Diagnosteq and questions designed along successful formats that we published previously [20,21]. Briefly, the questionnaires will have a majority of close-ended multiple choice questions, with some open-ended questions and an opportunity for respondents to include additional comments. Microsoft Excel will used for data analysis and descriptive statistics. Relationships will be explored using multiple linear regression, conducted in PASW 18.0 (SPSS). Relationships between management factors will be assessed using Spearman rank correlation. Bonferroni correction will be applied to adjust the critical P value to compensate for multiple tests, by dividing α=0.05 by the number of comparisons made. Only ordinal and scale variables will be included in the analyses. We will compare the outputs here to those from previous studies [20,21] to examine if attitudes and behaviours have changed, and if they have not, what the barriers to change might be. We will also use the information volunteered on types of deworming programme used at each site to inform the selection of the yards to be used in the prevalence and efficacy studies below.

**2. Prevalence/distribution of helminth species on yards following different types of deworming programme**

There is limited published data relating to how targeted deworming might affect the distribution of FEC amongst horses or how it might impact prevalence of particular worm species. As mentioned above, a recent study indicated a rise in *S. vulgaris* prevalence in populations where targeted therapy was delivered compared to populations where treatments were not based on FEC, with *S. vulgaris* occurrence significantly associated with most recent dewormings occurring >6 months previously [29]. Here, we will quantify possible risks associated with reduced anthelmintic treatment frequency in practical terms by examining nematode FEC levels, distribution of FEC and species present across yards employing different types of deworming protocol. Yards will be selected based on questionnaire responses in (1). We aim to recruit 10-15 yards in each of the two groups (a. targeted protocol followed; b. interval treatment protocol followed) for comparison. Horses (>20 per yard) will be selected for FEC monitoring over 2 seasons. We will select horses over a range of egg shedding values; assessed following two screening samplings. Faecal samples, collected and handled as described in [16], will be assessed for strongyle and *P. equorum* FEC using a centrifugal flotation method sensitive down to 1 EPG. Aggregation parameter, *k* [30]*,* will be established for each yard cohort over time. Eggs will be harvested from individual samples, DNA extracted and subjected to *S. vulgaris*-specific polymerase chain reaction using primers described in [29]. Values for prevalence, shedding and *k* will be incorporated into analysis of the questionnaire data outputs to determine risk factors for shedding level and presence of particular species, and will be used to inform decision support modeling (see 5).

**3. ML efficacy on yards following different types of deworming protocol**

Here, we will undertake ML FEC reduction tests following methods published previously [16]. We will extend the sampling frame to monitor ERP after IVM or MOX administration [11]. These studies will be performed on a minimum of 20 yards: >10 employing targeted and >10 employing interval treatment protocols. Horses whose FEC reduction is >95% 2 weeks after IVM or MOX administration will be monitored weekly or 2-weekly for strongyle and *P. equorum* egg excretion up to 15 weeks after treatment. We will assess ERP by calculating % reduction in FEC for a group to define a threshold for efficacy [11]. Efficacy values (FEC reduction, ERP) will be established for each yard. Estimated values for both will be incorporated into analysis of the questionnaire outputs to determine risk factors for AR, and used to inform decision support modeling (see 5).

**4. Road testing a diagnostic ELISA for cyathostomin encysted larvae (EL) burdens**

Patent strongyle infections can be detected using FEC; however, FEC analysis does not provide any measure of immature stages, in the case of cyathostomins, EL in the gut wall. No diagnostic method is commercially available to accurately measure EL burden. Over the last decade, our group has developed a recombinant protein-based ELISA designed to detect cyathostomin EL-specific antibody in blood from infected horses [2,31,32]. This test has high specificity for cyathostomins and significant correlations between serum IgG(T) responses to recombinant proteins included in the test and total mucosal EL burden have been demonstrated [33]. The test can provide information to support differential diagnosis of larval cyathostominosis or identify horses with high burdens at risk of parasite-associated colitis. The test could also be exploited to inform on EL burden for targeting MOX larvicidal treatments to individuals, thus reducing selection pressure for ML resistance. Here, we will take the research laboratory-based protocol and establish its value in a commercial setting (Diagnosteq). These experiments will include batch production testing of all reagents and generation of a large consignment of control sera to be used in the evaluation of intra- and inter-assay variability. Once these are established, stability testing of the reagents (including pre-coated plates) over a 1 year period (1, 3, 6 and 12 months) will be performed. Assay performance (sensitivity and specificity) will be assessed across a range of positivity thresholds for burden estimations using receiver operator characteristic (ROC) curve analysis with archived and submitted sera. Once final validation is complete, the test will be launched commercially with promotion via our extensive links with equine veterinary practices.

**6. Evidence based parasite control tools**

A critical outcome is to deliver tools to facilitate implementation of evidence-based control. An electronic system, that would guide decisions for deworming treatments for veterinary surgeons, SQPs and informed horse owners, could offer a solution to the complexity of making targeted protocols accessible. By generating data on FEC test parameters and efficacy analysis, we have established the groundwork for a decision support system [16,34-36]. Here, we will examine risk factors identified (above) relating to species prevalence, egg shedding*, k* and AR and build these into a decisions support system (DSS). For advice pertaining to FEC testing we will include estimates for over-dispersion between horses and statistical variance introduced by laboratory methods [37,38]. We will develop an easy-to-use FEC reduction calculator to provide accessible, robust methodology to calculate efficacy. The DSS will be developed as an online tool freely accessible through Moredun’s Knowledge Transfer and Exchange Hub (http://www.moredun.org.uk/webfm\_send/613) and/or a Horse Trust website portal.

To expedite knowledge transfer we will run several workshops for horse owners and yard managers, as well as those who prescribe anthelmintics (veterinary surgeons, SQPs, veterinary pharmacists). We will invite participants from relevant stakeholder groups (e.g. BHS, NEWC, BEVA, TBA, AMTRA). Each workshop will involve up to 40 participants and will last a day. These will take place at the Horse Trust, Liverpool, Bell Equine and Moredun. To encourage participation, workshops will be semi-structured. In addition to being a knowledge transfer exercise, workshops will provide vital information on potential barriers to engagement/implementation of evidence-based control which will be used to inform the DSS. Finally, the information generation from this and previous projects will be summarized to provide a set of Guidelines for Equine Parasite Control similar to those delivered by the COWs (of which Matthews is a Strategy Board member: http://www.cattleparasites.org.uk/) and SCOPs (http://www.scops.org.uk/) initiatives.

**Project management** The project will be based at Moredun Research Institute where Matthews will supervise the post-Doc on a daily basis. This scientist will deliver the questionnaire research, perform the parasitology and the molecular studies. The work on modelling parasite distribution will be conducted in collaboration with Bristol and facilitated by meetings in Bristol and at Moredun (Co-I Morgan has regular contact with the Moredun/Liverpool groups as part of separate projects). Liverpool will facilitate the questionnaire distribution through Diagnosteq and will also develop the ELISA to a commercial setting in collaboration with Co-I Burgess at Moredun. All applicants will meet 2 times per year to discuss milestones and will be in regular email contact regarding short term objectives. Matthews will lead the knowledge transfer activities with support from the post-Doctoral scientist, Hodgkinson and Morgan.

JM to add milestones and deliverables chart**20. REFERENCES (MAXIMUM 2 PAGES, 11 FONT 2CM MARGINS)**

* 1. Matthews JB 2008. An update on cyathostomins: Anthelmintic resistance and worm control. Eq. Vet. Ed. 20: 552-60.
	2. Dowdall SMJ, Matthews JB, Murphy D, Love S, Proudman CJ. 2002. Antigen-specific IgG(T) responses in natural and experimental cyathostomin infection. Vet Parasitol. 106: 225-42.
	3. Giles CJ, Urquhart KA, Longstaffe JA. 1985. Larval cyathostomiasis (immature trichonema-induced enteropathy): a report of 15 clinical cases. Equine Vet J. 17, 196-201.
	4. Reinemeyer CR, Nielsen MK. 2009. Parasitism and colic. Vet Clin North Am Equine Pract. 25:233-45.
	5. MacKay RJ, Urquhart KA. 1979. An outbreak of eosinophilic bronchitis in horses possibly associated with *Dictyocaulus arnfieldi* infection. Equine Vet J. 11:110-2.
	6. Owen JM. 1977. Liver fluke infection in horses and ponies. Equine Vet J. 9:29-31.
	7. Kaplan, R.M. and Nielsen, M.K. (2010) An evidence-based approach to equine parasite control: It ain't the 60s anymore. *Equine vet Educ* 22, 306-316.
	8. Kaplan RM. 2002. Anthelmintic resistance in nematodes of horses. Vet. Res. 33:491-507.
	9. Matthews JB. 2014. The future of helminth control in horses. Equine Vet J. 46:10-1.
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	22. Stratford CH, Lester HE, Pickles KJ, McGorum BC, *Matthews JB*. 2014. An investigation of anthelmintic efficacy against strongyles on equine yards in Scotland. Equine Vet J. 46:17-24
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	33. McWilliam HEG, Nisbet AJ, Dowdall SMJ, Hodgkinson JE, Matthews JB. 2010. Identification and characterisation of a potential immunodiagnostic marker for larval cyathostominosis. Int J Parasitol. 40:265-75
	34. Lester HE, Bartley DJ, Morgan ER, Hodgkinson JE, Matthews JB. 2012. The spatial distribution of strongyle eggs in horse faeces. J Eq Vet Sci32:S33-4.
	35. Lester HE, Matthews JB. 2014. Faecal worm egg count analysis for targeting anthelmintic treatment in horses: points to consider. Equine Vet J. 46:139-45.
	36. Lester HE, Bartley DJ, Morgan ER, Hodgkinson JE, Stratford CH, Matthews JB. 2013. A cost comparison of faecal egg count-directed anthelmintic delivery versus interval programme treatments in horses. Vet Rec.173:371.
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Other refs to read and use

von Samson-Himmelstjerna, G., Traversa, D., Demeler, J., Rohn, K., Milillo, P., Schurmann, S., Lia, R., Perrucci, S., di Regalbono, A.F., Beraldo, P., Barnes, H., Cobb, R. and Boeckh, A. (2009) Effects of worm control practices examined by a combined faecal egg count and questionnaire survey on horse farms in Germany, Italy and the UK. *Parasit Vectors* 2 Suppl 2, S3.

Fritzen, B., Rohn, K., Schnieder, T. and von Samson-Himmelstjerna, G. (2010) Endoparasite control management on horse farms-lessons from worm prevalence and questionnaire data. *Equine Vet J* 42, 79-83.

Comer, K.C., Hillyer, M.H. and Coles, G.C. (2006) Anthelmintic use and resistance on thoroughbred training yards in the UK. *Vet Rec* 158, 596-598.

**21. FINANCIAL DETAILS**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Cost heading** | **Year 1** | **Year 2** | **Year 3** | **TOTAL** |
| **i) Staff costs** |  |  |  |  |
| Post Doc Scientist (MRi) | 40,879 | 41,697 | 42,531 | **125,107** |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
| SUB-TOTAL | 40,879 | 41,697 | 42,531 | **125,107** |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Cost heading** | **Year 1** | **Year 2** | **Year 3** | **TOTAL** |
| **ii) Consumables** | 9,300 | 19,300 | 28,500 | 57,100 |
| Parasitology reagents | 1,500 | 1,500 | 1,500 | 4,500 |
| Molecular reagents (S. vulgaris PCR, recombinant protein expression for ELISA) | 4,800 | 8,800 | 9,500 | 23,500 |
| Costs for FECRT and ERP analysis (anthelmintics, postage) | 1,500 | 1,500 | 1,500 | 4,500 |
| Basic biochemicals | 500 | 500 | 500 | 1,500 |
| ELISA reagents | NA | 7,000 | 7,500 | 14,500 |
| DSS construction (consultancy) |  |  | 8,500 | 8,500 |
|  |  |  |  |  |
| SUB-TOTAL | 9,300 | 19,300 | 28,500 | 57,100 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Cost heading** | **Year 1** | **Year 2** | **Year 3** | **TOTAL** |
| **iii) Livestock**Number required (clinical) p.a.:Number required (non-clinical) p.a:Purchase costs:Maintenance costs *(please specify):*SUB-TOTAL |  |  |  |  |
| 1. **Travel expenses** (please specify)**:**

a. Group meetings (Liv-Bristol-Kent-Edinburgh)b. Travel of post-Doc to Bristol to develop modelling b. KE activities (workshops/seminars: Edinburgh, Kent, Liverpool, Bristol, Home of Rest for Horses)SUB-TOTAL |  1,400 1,400 |  1,4001,2008003,300 |  1,4001,2001,9004,500 |  4,2002,4002,7009,200 |
| **v) Equipment** *(please list each item separately)***:**Two sets of Gilsen Pipettes: 1. For molecular work at MRI, 2. For ELISA work at LiverpoolSUB-TOTAL | 1,2501,250 | -- | -- | 1,2501,250 |

**22. JUSTIFICATION FOR SUPPORT REQUESTED**

*(On this page, please justify all costs under the following headings: staff; consumables; livestock, travel and equipment maximum 1 page of A4, 11 font 2CM margins)*

**Salaries**

Budget is sought to a support suitably qualified post-Doctoral scientist to work full-time to undertake day-to-day benchwork/analysis at MRI. This is a very labour intensive project which will require an individual with a number of different skills (parasitology with molecular biology and/or immunochemistry and/or modelling expertise) and hence the request for a post-Doctoral scientist. This person will perform all of the questionnaire and parasitological studies based at MRI, as well as prepare recombinant proteins for the ELISA and undertake the *S. vulgaris* PCR experiments. All of the above activitied will be supervised and supported by Matthews and Burgess at MRI, with practical aspects of the sampling supported by Mair at Bell Equine. The appointee will also undertake the downstream statistical analyses (trained and supported by Morgan at Bristol) and will liaise closely with the technical support team at Liverpool to transfer the ELISA technology and recombinant proteins to the diagnostic laboratory (supported and facilitated by Hodgkinson at Liverpool). The appointed individual will also help to write the parasite control guidelines, develop the online support tools, write scientific/enduser articles and present training workshops at various sites with support and guidance from Matthews, Mair, Hodgkinson and Morgan.

**Consumables**

Budget is requested to support the parasitology, molecular biology and immunochemistry benchwork at MRI. This includes costs for basic biochemicals, reagents for parasitology laboratory (FEC/FECRT) studies, materials for molecular work (PCR and gel reagents, protein expression/purification reagents, etc.) and for ELISA (plates, conjugates, substrates, etc). Costs are also requested to cover the financial implications of the field work involved in FEC testing, and undertaking FECRT and ERP analyses (Bell Equine). Consumable costs are also required for the ELISA development work at Liverpool to road test the ELISA. Finally a budget is sought for the software and consultancy costs for the modeling and DSS development work at Bristol. The latter will include consultancy from a computer programmer based in Bristol.

**Equipment**

Our laboratories are very well equipped and hence we only request dedicated pipettes for the molecular biology (PCR) work (at MRI) and for the ELISA development (at Liverpool).

**Travel**

Budget is requested to support inter-institute/practice progress meetings for every year of the project. We also request funds to support the post-Doctoral scientist’s visits to Bristol to undertake the modelling work and the DSS development. Finally, we request a budget for all of the Knowledge Exchange activities (workshops and seminars) to be delivered (at Moredun, Liverpool, Bell, HoRH) in Years 2 and 3 of the project.

**23. STAFF TIME***(please provide details of financial and staff support for this project from other sources. Include percentages of total working time for all principal and co-applicants, collaborators, technical and animal staff for whom salaries are not requested in this application).*

Professor JB Matthews, MRI – 7%

Dr JE Hodgkinson, Liverpool – 5%

Diagnosteq staff member, Liverpool - 5%

Dr ER Morgan, Bristol – 5%

Dr T Mair, Bell Equine – 2%

Dr STG Burgess, MRI – 4%**24. Curriculum Vitae (For each applicant)**

**SURNAME:** Matthews **FORENAMES:** Jacqueline

**CONTACT DETAILS:**

Moredun Research Institute, Pentlands Science Park, Edinburgh EH26 0PZ

jacqui.matthews@moredun.ac.uk 0131 445 5111

**QUALIFICATIONS:** BVMS PhD MRCVS

**CURRENT POSITION:** Deputy Director & Principal Veterinary Parasitologist (since 2011)

**CONTRACT END DATE:** Open ended contract

**PREVIOUS POSITIONS (LAST THREE POSITIONS):**

2008-11 Chair of Veterinary Immunobiology, Royal (Dick) School of Veterinary Studies, University of Edinburgh

2004-08 Principal Veterinary Parasitologist, Moredun Research Institute

1998-04 Lecturer, Equine Medicine, Faculty of Veterinary Science, Liverpool University

**CURRENT GRANTS:**

*Matthews principal investigator (PI) unless otherwise stated*

2014-16 **BBSRC**. Technical development of a novel vaccine vehicle for cattle pathogens. With Matthews (PI, Edinburgh). £301,483. 3% time.

2013-15 **DEFRA/VMD**. A study to consider prescribing groups and distribution channels to ensure appropriate use of anthelmintics in the UK. With Hodgkinson & Pinchbeck (Liverpool), Bartley & Hotchkiss (Moredun). £266,364. 10% time.

2013-15 **Donkey Sanctuary.** Development and quantitative validation of improved sustainable donkey parasite control programmes: creation and validation of a general monitoring and control system for donkey endoparasites. With Love & Denwood (PI, Glasgow). £50,000. 3% time.

2013-16 **NERC (CASE) PhD Scholarship**. A roadmap to better anthelmintic resistance control in UK cattle: underpinning knowledge on how resistance is spread amongst populations. With Paterson (PI, Liverpool), Donachie (Moredun Scientific). ~£70,000. 3% time.

2013-16 **Horserace Betting Levy Board**. Research Training Scholarship. Development of tools to promote best practice parasite control on UK Thoroughbred studs. With Hodgkinson (PI, Liverpool). £122,465. 3% time.

2011-16 **Scottish Government RESAS.** Core Projects: 1. Development of a subunit vaccine for control of teladorsagiosis in sheep (co-PI with Nisbet, Moredun). 2. Anthelmintic resistance in cattle: definition of resistance in populations and tools to quantify resistance (with Bartley, Moredun). 20% time.

**LIST UP TO 3 PREVIOUS GRANTS RELEVANT TO THIS APPLICATION:**

*Matthews PI unless otherwise stated*

2011-13 **Horserace Betting Levy Board**. Further development of a diagnostic immunoassay for larval cyathostomins. £123,232. With Handel (Edinburgh), Hodgkinson (Liverpool). £123,232.

2009-12 **Horserace Betting Levy Board**. An investigation into the status of anthelmintic resistance in breeding Thoroughbreds in the UK. With Hodgkinson (Liverpool) & Morgan (Bristol). £303,000.

2007-10 **Horserace Betting Levy Board**. Development of a diagnostic assay for larval cyathostominosis. With JE Hodgkinson (Liverpool). £258,000.

**PUBLICATIONS (UP TO 20 RELEVANT PUBLICATIONS):**

*Relevant equine parasitology publications*

1. Matthews JB. 2014. The future of helminth control in horses. Equine Vet J. 46:10-1.
2. Relf VE, Lester HE, Morgan ER, Hodgkinson JE, Matthews JB. 2014. Anthelmintic efficacy on UK Thoroughbred stud farms. Int. J Parasitol. In press.
3. Stratford CH, Lester HE, Morgan ER, Pickles KJ, Relf V, McGorum BC, Matthews JB. 2014. A questionnaire study of equine gastrointestinal parasite control in Scotland. Equine Vet J. 46:25-31.
4. Stratford CH, Lester HE, Pickles KJ, McGorum BC, Matthews JB. 2014. An investigation of anthelmintic efficacy against strongyles on equine yards in Scotland. Equine Vet J. 46:17-24.
5. Corbett CJ, Love S, Moore A, Burden FA, Matthews JB, Denwood MJ. 2014. The effectiveness of faecal removal methods of pasture management to control the cyathostomin burden of donkeys. Parasites & Vectors 7:48.
6. Lester HE, Matthews JB. 2014. Faecal worm egg count analysis for targeting anthelmintic treatment in horses: points to consider. Equine Vet J. 46:139-45.
7. Lester HE, Bartley DJ, Morgan ER, Hodgkinson JE, Stratford CH, Matthews JB. 2013. A cost comparison of faecal egg count-directed anthelmintic delivery *versus* interval programme treatments in horses. Vet Rec.173:371.
8. Cwiklinski K, Merga Y, Lake SL, Hartley C, Matthews JB, Paterson S, Hodgkinson JE. 2013. Transcriptome analysis of a parasitic clade V nematode: comparative analysis of potential molecular anthelmintic targets in Cylicostephanus goldi. Int J Parasitol. 43:917-927.
9. Lanz S, Gerber V, Marti E, Rettmer H, Klukowska-Rötzler J, Matthews JB, Pirie S, Hamza E. 2013. Effect of hay dust extract and cyathostomin antigen stimulation on cytokine expression by PBMC in horses with recurrent airway obstruction. Vet Immunol and Immunpathol. 155:229-237.
10. Matthews JB, Burden F. 2013. Common helminth infections of donkeys and their control. Eq. Vet. Ed. 25, 461–467.
11. Lester HE, Spanton J, Stratford CA, Bartley DJ, Morgan ER, Hodgkinson JE, Coumbe K, Mair T, Swane B, Lemone G, Cookson R, Matthews JB. 2013. Anthelmintic efficacy against cyathostomins in horses in England. Vet Parasitol. 197:189-196.
12. Relf VE, Morgan ER, Hodgkinson JE, Matthews JB. 2013. Helminth egg excretion with regard to age, gender and management practices on UK Thoroughbred studs. Parasitology. 140:641-652.
13. Wood E, Matthews JB, Stephenson S, Slote M, Nussey DH. 2013. Variation in faecal egg counts in horses managed for conservation purposes: individual egg shedding consistency, age effects and seasonal variation. Parasitology 140:115-128.
14. Relf VE, Morgan ER, Hodgkinson JE, Matthews JB. 2012. A questionnaire study on parasite control practices on UK breeding Thoroughbred studs. Equine Vet J. 44:466-71.
15. Cwiklinski K, Kooyman FNJ, van Doorn DCK, Matthews JB, Hodgkinson JE. 2012. New insights into sequence variation in the IGS region of 21 cyathostomin species and the implication for molecular identification. Parasitology. 139:1-11.
16. Matthews JB, McArthur C, Robinson A, Jackson F. 2012. The in vitro diagnosis of anthelmintic resistance in cyathostomins. Vet. Parasitol. 185:25-31.
17. Stratford CA, McGorum BC, Pickles KJ, Matthews JB. 2011. An update on cyathostomins: anthelmintic resistance and diagnostic tools. Equine Vet. J. 43:133-139.
18. Matthews JB. 2011. Facing the threat of equine parasitic disease. Equine Vet. J. 43: 126-132.
19. McWilliam HEG, Nisbet AJ, Dowdall SMJ, Hodgkinson JE, Matthews JB. 2010. Identification and characterisation of a potential immunodiagnostic marker for larval cyathostominosis. Int J Parasitol. 40:265-275.
20. Lake S, Matthews JB, Kaplan RM, Hodgkinson JE. 2009. Molecular diagnostics for benzimidazole resistance in the Cyathostominae: detection of resistance alleles in field populations. Parasit Vectors. Sep 25;2 Suppl 2:S6.

NB: A further 80+ peer reviewed publications in veterinary helminthology and in last 5 years, 40+ invited seminars, workshops and plenary lectures on sustainable helminth control in ruminants and horses. Full details available on request.

**Relevant patents issued or pending**

Cyathostomin encysted larvae detection (indirect recombinant protein ELISA). JB Matthews (PI), with Hodgkinson & Proudman (Liverpool)

US Patent granted: application reference 13/260,935

EU Patent application in progress, PCT stage: PCT/GB2010/112836

Also in process in Canada and Australia.

**SURNAME:** Hodgkinson **FORENAMES:** Jane

**CONTACT DETAILS:**

Veterinary Parasitology, School of Veterinary Science/Institute for Infection and Global Health, University of Liverpool, Liverpool Science Park IC2 building, 146 Brownlow Hill

L3 5RF. Tel: 0151 795 0223 Email: jhodgkin@liv.ac.uk

**QUALIFICATIONS:** BSc PhD SQP (number: QE8430)

**CURRENT POSITION:** Senior Lecturer, Veterinary Parasitology

**CONTRACT END DATE:** Open ended contract

**PREVIOUS POSITIONS (LAST THREE POSITIONS):**

# 2002-2011 Lecturer in Veterinary Parasitology, Dept Infection Biology, Institute of Infection and Global Health, University of Liverpool.

1999-2001 Postdoctoral Research Scientist, Equine Studies Division, Department of Veterinary, Clinical Sciences and Animal Husbandry. Project: “Molecular studies on cyathostomin species”, funded by the Horserace Betting Levy Board.

1997-1999 Grade B Clinical Scientist, Dept. Clinical Haematology, Central Manchester Healthcare Trust.

**CURRENT GRANTS:**

NB: JH principal investigator (PI) unless otherwise stated

2013-17 **BBSRC**. Control of liver fluke in cattle in the UK. £992,460. With Williams (PI, Liverpool).

2013-15 **DEFRA/VMD**. A study to consider prescribing groups and distribution channels to ensure appropriate use of anthelmintics in the UK. With Matthews (PI, Moredun) & Pinchbeck (Liverpool), Bartley & Hotchkiss (Moredun). £266,364.

2013-16 **Horserace Betting Levy Board**. Development of tools to promote best practice parasite control on UK Thoroughbred studs. With Matthews (Moredun). £122,465.

2013-14 **Petplan Charitable Trust** The role of P-glycoproteins in ivermectin resistance in the Cyathostominae, £9,820.

2010-14 **BBSRC**. Mapping triclabendazole resistance in *Fasciola hepatica* using next generation sequencing technologies, £700,013. With Williams & Paterson (Liverpool).

**LIST UP TO 3 PREVIOUS GRANTS RELEVANT TO THIS APPLICATION:**

2008-11 **Horse Trust**.An investigation into moxidectin resistance in the Cyathostominae. With Matthews (PI, Moredun). £241,822.

2006-07 **Horse Trust** (Home of Rest for Horses). Preliminary phenotypic and genotypic characterisation of moxidectin resistance in the Cyathostominae, £60,429. With Matthews (Moredun).

2009-13 **Horserace Betting Levy Board**. An investigation into the status of anthelmintic resistance in breeding Thoroughbreds in the UK. With Matthews (PI, Moredun) & Morgan (Bristol). £303,000.

**PUBLICATIONS (UP TO 20 RELEVANT PUBLICATIONS):**

1. Lester HE, Bartley DJ, Morgan ER, Hodgkinson JE, Stratford CH, Matthews JB. 2013. A cost comparison of faecal egg count-directed anthelmintic delivery versus interval programme treatments in horses. Vet Rec.173:371.
2. Cwiklinski K, Merga Y, Lake SL, Hartley C, Matthews JB, Paterson S, Hodgkinson JE. 2013. Transcriptome analysis of a parasitic clade V nematode: comparative analysis of potential molecular anthelmintic targets in *Cylicostephanus goldi*. Int J Parasitol. 43:917-927.
3. Lester HE, Spanton J, Stratford CA, Bartley DJ, Morgan ER, Hodgkinson JE, Coumbe K, Mair T, Swane B, Lemone G, Cookson R, Matthews JB. 2013. Anthelmintic efficacy against cyathostomins in horses in England. Vet Parasitol. 197:189-196.
4. Relf VE, Morgan ER, Hodgkinson JE, Matthews JB. 2013. Helminth egg excretion with regard to age, gender and management practices on UK Thoroughbred studs. Parasitology. 140:641-52.
5. HodgkinsonJ, CwiklinskiK, BeesleyNJ, Paterson S, Williams DJL. 2013.Identification of putative markers of triclabendazole resistance by a genome-wide analysis of genetically recombinant *Fasciola hepatica*. Parasitology 140:1523-1533.
6. Relf VE, Morgan ER, Hodgkinson JE, Matthews JB. 2012. A questionnaire study on parasite control practices on UK breeding Thoroughbred studs. Equine Vet J. 44:466-471.
7. Cwiklinski K, Kooyman FNJ, van Doorn DCK, Matthews JB, Hodgkinson JE. 2012. New insights into sequence variation in the IGS region of 21 cyathostomin species and the implication for molecular identification. Parasitology. 139:1-11.
8. McWilliam HEG, Nisbet AJ, Dowdall SMJ, Hodgkinson JE, Matthews JB. 2010. Identification and characterisation of a potential immunodiagnostic marker for larval cyathostominosis. Int J Parasitol. 40:265-275.
9. van Doorn DCK, Kooyman FNJ, Eysker M, JE Hodgkinson, JA Wagenaar, HW Ploeger. 2010. In vitro selection and differentiation of ivermectin resistant cyathostomin larvae. Veterinary Parasitology, 174:292-299.
10. Lake SL, Matthews JB, Kaplan RM, Hodgkinson JE. 2009.Determination of genomic DNA sequences for beta-tubulin isotype 1 from multiple species of cyathostomin and detection of resistance alleles in third-stage larvae from horses with naturally acquired infections**.** Parasites & Vectors 2(Suppl 2):S6.
11. Hodgkinson JE, Clark HJ, Kaplan RM, Lake SL, Matthews JB. 2008. The role of polymorphisms at beta tubulin isotype 1 codons 167 and 200 in benzimidazole resistance in cyathostomins. Int J Parasitol. 38:1149-1160.
12. Clark HJ, Kaplan RM, Matthews JB, Hodgkinson JE. 2005. Isolation and characterisation of a beta tubulin isotype 2 gene from two cyathostomin species. Int. J. Parasitol. 35:349-358.
13. Hodgkinson JE, FreemanKL, LichtenfelsJR, PalfremanS, Love S, Matthews JB. 2005. Identification of strongyle eggs from anthelmintic treated horses using a PCR-ELISA based on intergenic DNA sequences. Parasitol. Res. 95:287-292.
14. Hodgkinson JE. 2006. Molecular Diagnosis and Equine Parasitology. Vet Parasitol. 136,109-116.
15. DavidsonAJ, Hodgkinson JE, Proudman CJ, MatthewsJB. 2005. Cytokine responses to Cyathostominae larvae in the equine large intestinal wall. Res Vet Sci. 78, 169-176.
16. Matthews JB, Hodgkinson JE, Dowdall SM, Proudman CJ. 2004. Recent developments in research into the Cyathostominae and *Anoplocephala perfoliata*. Vet Res. 35:371-381.
17. Ramsey YH, Christley RM, Matthews JB, Hodgkinson JE, McGoldrick J, Love S. 2004. Multi-level multivariable linear regression models for assessment of seasonal development of *Cyathostominae* larvae on pasture. Vet Parasitol. [119:](http://www.sciencedirect.com/science?_ob=IssueURL&_tockey=%23TOC%235191%232004%23998809995%23480146%23FLA%23display%23Volume_119,_Issue_4,_Pages_261-345_(6_February_2004)%23tagged%23Volume%23first%3D119%23Issue%23first%3D4%23Pages%23first%3D261%23last%3D345%23date%23(6_February_2004)%23&_auth=y&view=c&_acct=C000053675&_version=1&_urlVersion=0&_userid=1553878&md5=0e36ed56be8a364176bfe9789971b217) 307-318.
18. Coles GC, Eysker M, Hodgkinson J, Matthews JB, Kaplan RM, Klei TR, Sangster NC. 2003. Anthelmintic resistance and use of anthelmintics in horses. Vet Rec. 153:636.
19. Hodgkinson JE, Lichtenfels, JR, Mair TS, Cripps P, Freeman KL, Ramsey YH, Matthews JB. 2003. A PCR-ELISA for the identification of cyathostomin fourth-stage larvae obtained from clinical cases of larval cyathostominosis. International Journal for Parasitology,33:1427-1435.
20. Hodgkinson JE, Love S., Lichtenfels JR, Ramsey YR, Palfreman S, Matthews JB. 2001. Evaluation of the specificity of five oligoprobes for identification of cyathostomin species from horses. Int J Parasitol. 31: 197-204.

**Relevent patents issued or pending**

Cyathosotmin immunodiagnostics (see above). With JB Matthews (PI), & Proudman

**Academic Lead for Diagnosteq**

Diagnosteq <http://www.liv.ac.uk/diagnosteq/> is a service set up by the Equine Division of Liverpool University's Veterinary Faculty to give veterinary surgeons access to expert interpretation of test results performed at Diagnosteq and advice on all aspects of parasite control.

**SURNAME:** Morgan **FORENAMES:** Eric

**CONTACT DETAILS:**

University of Bristol, Bristol Life Sciences Building, 24, Tyndall Avenue, Bristol BS8 1TQ eric.morgan@bristol.ac.uk 01179 287485

**QUALIFICATIONS:** MA VetMB PhD DipEVPC MRCVS

**CURRENT POSITION:** Senior Lecturer in Veterinary Parasitology (since 2007)

**CONTRACT END DATE:** Open ended contract

**PREVIOUS POSITIONS (LAST THREE POSITIONS):**

2003-07 Lecturer, Veterinary Parasitology, School of Biological Sciences, University of Bristol

2001 Veterinary Officer, MAFF/Defra, Foot and mouth disease control, UK

1999 Veterinary Officer, Royal Army Veterinary Corps, NATO SFOR mission, Balkans

**CURRENT GRANTS:**

2013-16 **TSB-BBSRC**. Rapid diagnostics of endemic disease in animals. AutoFEC: pen-side faecal egg counting in grazing ruminants for decision support. Co-PI with Fisher (Ridgeway Research) and Fletcher (Arrow Labs). £618,219.

2013-14 **BBSRC** Sparking Impact Award (via University of Bristol). Applying targeted parasite control on smallholder farms in Botswana using a mobile phone-based decision-support system. £14,720.

2011-14 **EC FP7 STREP**. GLOWORM: Global change and sustainable control of helminth infections in grazing livestock. Co-ordinator Vercruysse (Gent). €210,000 of €3M.

**LIST UP TO 3 PREVIOUS GRANTS RELEVANT TO THIS APPLICATION:**

2009-13 **Horserace Betting Levy Board**. An investigation into the status of anthelmintic resistance in breeding Thoroughbreds in the UK. With Matthews (PI, Moredun) and Hodgkinson (Liverpool) £303,000.

2009-11. **Defra** (UK Department for the Environment, Food and Rural Affairs). The detection of anthelmintic resistance in cattle. Co-I with Coles (Bristol). £161,882.

2006-09. **EU FP6 STREP**, food quality and safety. PARASOL: Novel solutions for the sustainable control of nematodes in ruminants. €163,000. Co-PI.

**PUBLICATIONS (UP TO 20 RELEVANT PUBLICATIONS):**

1. Lester HE, Bartley DJ, Morgan ER, Hodgkinson JE, Stratford CH, Matthews JB. 2013. A cost comparison of faecal egg count-directed anthelmintic delivery versus interval programme treatments in horses. Vet Rec.173:371.
2. Stratford CA, Lester HE, Morgan ER, McGorum BC, Pickles KJ, Relf VE, Matthews JB. 2013. A questionnaire study of equine gastrointestinal parasite control in Scotland. Eq Vet J. x.
3. Lester HE, Spanton J, Stratford CA, Bartley DJ, Morgan ER, Hodgkinson JE, Coumbe K, Mair T, Swane B, Lemone G, Cookson R, Matthews JB. 2013. Anthelmintic efficacy against cyathostomins in horses in England. Vet Parasitol. Vet Parasitol. 197:189-196.
4. Stratford CA, Lester HE, Morgan ER, McGorum BC, Pickles KJ, Relf VE, Matthews JB. 2013. An investigation of anthelmintic efficacy against strongyles on equine yards in Scotland. Eq Vet. J. x.
5. Relf VE, Morgan ER, Hodgkinson JE, Matthews JB. 2013. Helminth egg excretion with regard to age, gender and management practices on UK Thoroughbred studs. Parasitology. 140:641-52.
6. Relf VE, Morgan ER, Hodgkinson JE, Matthews JB. 2012. A questionnaire study on parasite control practices on UK breeding Thoroughbred studs. Equine Vet J. 44:466-71.
7. Morgan ER, van Dijk J. 2012. [Climate and the epidemiology of gastrointestinal nematode infections of sheep in Europe](http://www.bris.ac.uk/vetscience/people/eric-r-morgan/pub/8407943). Vet. Parasitol. 189: 8-14.
8. Morgan ER, Hosking BC, Burston S, Carder KM, Hyslop AC, Pritchard LJ, Whitmarsh AK, Coles GC. 2012. [A survey of helminth control practices on sheep farms in Great Britain and Ireland](http://www.bris.ac.uk/vetscience/people/eric-r-morgan/pub/7188594). Vet. J. 192: 390-397.
9. Wall R, Rose H, Ellse L, Morgan ER. 2011. Livestock ectoparasites: Integrated management in a changing climate. Vet. Parasitol. 180: 82-89.
10. Bennema SC, Vercruysse J, Morgan E, Stafford K, Höglund J, Demeler J, von Samson-Himmelstjerna, Charlier J. 2010. Epidemiology and risk factors for exposure to gastrointestinal nematodes in dairy herds in northwestern Europe. Vet. Parasitol. 173: 247-254.
11. Morgan ER, Coles GC. 2010. Nematode control practices on sheep farms following an information campaign aiming to delay anthelmintic resistance. Vet. Rec. 166, 305-307.
12. Morgan ER, Wall R. 2009. Climate change and parasitic disease: farmer mitigation? Trends Parasitol. 25, 308-313.
13. Stafford KA, Morgan ER, Coles GC. 2009. Weight-based targeted selective treatment of gastrointestinal nematodes in a commercial sheep flock. Vet. Parasitol. 164: 59-65.
14. Van Dijk J, David GP, Baird G, Morgan ER. 2008. Back to the future: developing hypotheses on the effects of climate change on ovine parasitic gastroenteritis from historical data. Vet. Parasitol. 158: 73-84.
15. Morgan ER, Hetzel N, Povah C, Coles GC. 2005. Prevalence and diagnosis of parasites of the stomach and small intestine in horses in south-west England. Vet. Rec. 156: 597-600.
16. Presland SL, Morgan ER, Coles GC. 2005. Counting nematode eggs in equine faecal samples. Vet. Rec. 156: 208-210.

**SURNAME:** Mair **FORENAMES:** Timothy

**CONTACT DETAILS:**

Bell Equine Veterinary Clinic, Mereworth, Maidstone, Kent, ME18 5GS

**QUALIFICATIONS:** BVSc PhD DEIM DESTS DipECVDI MRCVS

**CURRENT POSITION:** Director (since 2005)

**CONTRACT END DATE:** Open ended contract

**PREVIOUS POSITIONS (LAST THREE POSITIONS):**

1989-2005 Assistant, Bell Equine Veterinary Clinic

1986-1989 Wellcome Trust Lecturer in equine medicine, University of Bristol

1982-1986 Horserace Betting Levy Board Research Training Scholar, University of Bristol

**CURRENT GRANTS:**

**LIST UP TO 3 PREVIOUS GRANTS RELEVANT TO THIS APPLICATION:**

**PUBLICATIONS (UP TO 20 RELEVANT PUBLICATIONS):**

1. Lester HE, Spanton J, Stratford CA, Bartley DJ, Morgan ER, Hodgkinson JE, Coumbe K, Mair T, Swane B, Lemone G, Cookson R, Matthews JB. 2013. Anthelmintic efficacy against cyathostomins in horses in England. Vet Parasitol. 197:189-196.
2. Dowdall SMJ, Proudman CJ, Klei TR, Mair TS, Matthews JB. 2004. Characterisation of specific IgG(T) responses to two larval antigen complexes in horses naturally- and experimentally-infected with cyathostomins. Int J Parasitol. 34:101-108.
3. Hodgkinson JE, Lichtenfels JR, Mair TS, Cripps P, Freeman KL, Ramsey YH, Love S, Matthews JB. 2003. A PCR-ELISA for the identification of cyathostomin fourth-stage larvae from clinical cases of larval cyathostominosis. Int J Parasitol. 33:1427-1435.
4. Dowdall SMJ, Matthews JB, Mair TS, Murphy D, Love S, Proudman CJ. 2002. Antigen specific IgG(T) responses in natural and experimental cyathostomin infection in horses. Vet. Parasitol. 106**:**225-242.
5. Mair TS, Sutton DGM, Love S. 1999. Caeco-caecal and caeco-colic intussusceptions associated with larval cyathostomosis in four young horses. Equine Vet. J.Suppl32***:***77-80.
6. Mair TS. 1994. Observations on an outbreak of larval cyathostomiasis among a group of yearling and two year old horses. Vet. Rec. 135:598-600
7. Reid SWJ, Mair TS, Hillyer MH, Love S. 1994. Epidemiological risk factors associated with a diagnosis of clinical cyathostomiasis in the horse. Equine Vet. J. 27:127-130.
8. Mair TS, Pearson, GR. 1994. Multi-focal non-strangulating intestinal infarction associated with larval cyathostomiasis in a pony. Equine Vet. J. 27:154-155.
9. Mair TS. 1993. Recurrent diarrhoea in aged ponies associated with larval cyathostomiasis*.* Equine Vet J. 25:161-163.
10. Mair TS, Cripps PJ, Ricketts SW. 1993. Diagnostic and prognostic value of serum protein electrophoresis in horses with chronic diarrhoea. Equine Vet J. 25:324-326

**T H E H O R S E T R U S T**

**Registered Charity 231748**

**SURNAME:** Burgess **FORENAMES:** Stewart Thomas George

**CONTACT DETAILS:** Moredun Research Institute, Edinburgh. EH26 0PZ.

**QUALIFICATIONS:** BSc (Hons), PhD

**CURRENT POSITION:** Senior Scientist

**CONTRACT END DATE:** Open ended contract

**PREVIOUS POSITIONS:**

Aug 2012 – Present: Senior Research Scientist, Moredun Research Institute, Edinburgh.

Aug 2007- July 2012: Postdoctoral Researcher, Moredun Research Institute, Edinburgh.

Sep 2005-July 2007: Postdoctoral Research Associate, Division of Pathway Medicine, University of Edinburgh.

**CURRENT GRANTS:**

2013-2016 **Defra.** Further work on the host:parasite interaction in sheep scab, focusing on protective mechanisms and immune evasion to identify and develop novel methods of control based on immunoprophylaxis. Principle Investigator. **Funded: £785,086.**

2012-2015 **Perry Foundation** PhD Studentship (Edward Marr). The development and use of RNAi technology for selective gene silencing and vaccine candidate identification in the sheep scab mite *Psoroptes ovis*. PI and primary supervisor. **Funded: £30,000.**

2013-2016 **Moredun Scientific Ltd/Moredun Research Institute**. MSL PhD Scholarship. Development of paper-based, Penside, Diagnostic Devices for Veterinary Diseases. **Funded: £60,000.**

**PREVIOUS GRANTS RELEVANT TO THIS APPLICATION:**

2010-2013 **Defra.** Analysis of the host:parasite interaction in sheep scab, to further develop diagnostic tools and identify and assess novel vaccine candidates. Principle Investigator. **Funded: £838,000.**

2009-2012 **QMS/EBLEX/HCC PhD studentship scheme**. Identification of novel biomarkers for the detection of sheep scab. PI and principal supervisory contact. **Funded: £60,000.**

2011-2012 **Genecom Orphans Fund** project with ReactivLab Ltd assessing potential of acute phase proteins as diagnostic biomarkers for sheep scab. PI. **Funded: £15,000.**

**PUBLICATIONS:**

1. Smith CL, Dickinson P, Forster T, Khondoker M, Craigon M, Ross A, Storm P, Burgess STG, Lacaze P, Stenson BJ, Ghazal P (2007). Quantitative assessment of human whole blood RNA as a potential biomarker for infectious disease. *The Analyst*. 132(12):1200-9.

2. O'Looney N, Burgess STG, Kwan MC, Ross AJ, Robb J, Forster T, Beattie JS, Ghazal P, Petrik J, Campbell CJ. (2008). Evaluation of a protein microarray method for immuno-typing erythrocytes in whole blood. *Journal of Immunoassay and Immunochemistry*. 29(2):197-209.

3. Burgess STG, Kenyon F, O'Looney N, Ross AJ, Kwan MC, Beattie JS, Petrik J, Ghazal P, Campbell CJ. (2008). A multiplexed protein microarray for the simultaneous serodiagnosis of human immunodeficiency virus/hepatitis C virus infection and typing of whole blood. *Analytical Biochemistry*. 382(1):9-15.

4. Watkins C, MacKellar A, Frew D, Mackie C, George A, Hopkins J, Burgess STG, McNeilly T, Huntley JF. 2009. Gene Expression Profiling of Ovine Keratinocytes stimulated with *Psoroptes ovis* mite antigen - a preliminary study. *Parasite Immunology*. 31(6): 304-11.

5. Burgess STG, Frew D, Nunn F, Watkins C, McNeilly TN, Nisbet AJ, Huntley JF. (2010). Transcriptomic analysis of the temporal host response to skin infection with the ectoparasitic mite *Psoroptes ovis*. *BMC Genomics*. 11: 624.

6. Nunn F, Burgess STG, Nisbet AJ, Bates P, Sargison N, Huntley JF. 2011. Development of a diagnostic test for the detection of sheep scab. *Molecular and cellular probes*. 25(5-6):212-8.

7. Burgess STG, Innocent G, Nunn F, Frew D, Kenyon F, Nisbet AJ, Huntley JF. 2011. The use of a *Psoroptes ovis* diagnostic ELISA for the analysis of a natural outbreak of sheep scab. *Parasites & Vectors*. 5:7.

8. Athanasiadou S, Jones LA, Burgess STG, Kyriakis I, Pemberton AD, Houdijk JGM, Huntley JF. 2011. Genome-wide transcriptomic analysis of intestinal tissue to assess the impact of nutrition and a secondary nematode challenge in lactating rats. *PLoS One*. 6(6).

9. Knight PA, Griffith SE, Pemberton AD, Brown JK, Pate JM, Talbot RT, Smith S, Waddington D, Fell M, Archibald AL, Burgess STG, Smith WD, Miller HRP, Morrison IW. 2011. Novel gene expression responses in the ovine abomasal mucosa to infection with the gastric nematode *Teladorsagia circumcincta*. *Vet Res.* 42:78.

10. Burgess STG, Nisbet AJ, Kenyon F, Huntley JF. 2011. Generation, analysis and functional annotation of expressed sequence tags from the ectoparasitic mite *Psoroptes ovis*. *Parasites & Vectors*. 22:145.

11. Burgess STG, McNeilly TN, Watkins CA, Nisbet AJ, Huntley JF. 2011. Host transcription factors in the immediate pro-inflammatory response to the parasitic mite *Psoroptes ovis. PLoS One*. 6(9):e24402.

12. Wells E, Burgess STG, McNeilly TN, Huntley JF, Nisbet AJ. 2011. Recent developments in ectoparasite diagnosis: understanding host response and parasite biology for better diagnostics. *Mol Cell Probes*. Oct 1 2011.

13. Mounsey KE, Willis C, Burgess STG, Holt DC, McCarthy J, Fischer K. 2011. Quantitative PCR-based genome size estimation of the astigmatid mites *Sarcoptes scabiei, Psoroptes ovis* and *Dermataphagoides pteronyssinus*. *Parasites & Vectors.* 5:3

14. Burgess STG, Downing A, Watkins CA, Marr EJ, Nisbet AJ, Kenyon F, McNair C, Huntley JF. 2011. Development and validation of a cDNA microarray to measure gene expression in the sheep scab mite *Psoroptes ovis*. *Parasites & Vectors*. 5:30

15. Holt DC, Burgess STG, Reynolds SL, Mahmood W, Fischer K. 2012. Intestinal proteases of free living and parasitic astigmatid mites. Invited Review – *Cell Tissue Res*. Published Online First DOI: 10.1007/s00441-012-1369-9.

16. Burgess STG, Greer A, Frew D, Wells B, Marr EJ, Nisbet AJ, Huntley JF. 2012. Transcriptomic analysis of host circulating leukocytes reveals novel aspects of the systemic inflammatory response to sheep scab. *PLoS One* 7(8):e42778.

17. Stoeckli M, McNeilly TN, Frew D, Marr EJ, Nisbet AJ, van den Broek A, Burgess STG. 2013. The effect of *Psoroptes ovis* infestation on ovine epidermal barrier function. *Vet Res*. 44:11.

18. Wells B, Burgess ST, Nisbet AJ. 2013. Characterization of the ovine complement 4 binding protein-beta (C4BPB) chain as a serum biomarker for enhanced diagnosis of sheep scab. *Mol Cell Probes*. doi:pii: S0890-8508(13)00017-0. 10.1016/j.mcp.2013.03.003.

19. Carmichael SN, Bron JE, Taggart JB, Ireland JH, Bekaert M, Burgess STG, Skuce PJ, Nisbet AJ, Gharbi K, Sturm A. 2013. Salmon lice (Lepeophtheirus salmonis) showing varying emamectin benzoate susceptibilities differ in neuronal acetylcholine receptor and GABA-gated chloride channel mRNA expression. *BMC Genomics*. 14:408.

20. Wells B, Innocent G, Eckersall D, McCulloch E, Nisbet AJ, Stewart TG Burgess. 2013. Two major ruminant acute phase proteins, haptoglobin and serum amyloid A, as serum biomarkers in an improved diagnostic test for sheep scab. *Veterinary Research.* Manuscript Under Review.

**20. COLLABORATION ON A GRANT**

*(Collaborators ie scientific/clinical colleagues who are associated with a proposal but are not co-applicants, are asked to complete this form)*

  **Name of principal applicant**:

 **Address of department and institution**:

  **Name of collaborator**:

**Full address of collaborator**:

**Email**:

 **Extent and nature of collaboration**:

**I confirm that I am willing to collaborate as stated above with (principal applicant) on the project entitled:**

**Signed:**

**Date:**