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Veterinary Parasitology Teaching at London – Meeting the 'Day-One Competency' Needs of New Veterinarians

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ABSTRACT

Over the past four decades, there has been an exponential increase in veterinary parasitology knowledge, coinciding with the advent of molecular biology in research. Therefore, it is unrealistic for teachers to expect students to graduate with an encyclopaedic knowledge of the subject. As a result, a new curriculum was introduced at The Royal Veterinary College (University of London) in 2007, designed to meet the needs of our new graduates, i.e. RCVS Day-One Competences. The aims of this curriculum are, *inter alia,* to ensure that new graduates have an up-to-date body of core knowledge and are able to apply such knowledge and newly-acquired information to scientific and clinical problem-solving. Veterinary parasitology is taught primarily in Year 2, following a brief introduction in Year 1; clinical aspects are covered in Year 3, with original research projects undertaken in Years 4 and 5. Parasitology is taught in parallel with other subjects, enabling both horizontal and vertical integration. Core material is provided in lectures supplemented by directed learning (DL) in small groups and interactive, clinical scenario-based practical classes. Student learning is supported by Moodle 3.2 (Virtual Learning Environment [VLE], RVC Learn) which provides access to an on-line study guide (annotated using Adobe Reader), PowerPoint presentations with synchronized lecturer commentary (Echo Active Learning Platform [ALP]), detailed feedback for DL and practical classes, parasite 'potcasts' and CAL packages, and a Clinical Skills Centre. A parasitology textbook has also been published recently to support courses taught at the College. Assessment of student learning is achieved using a variety of written formats (essay, problem-solving questions [PSQ], multiple choice questions [MCQ] and extended matching questions [EMQ]), integrated oral examinations and objective structured clinical examinations (OSCE).

Keywords: Assessment, Curriculum, London, Problem-solving, Teaching

1. Introduction

Over the past four decades, there has been an exponential increase in veterinary parasitology knowledge coinciding with the advent of molecular biology in research (Hide and Tait, 1991; van Borm et al*.,* 2015). The emphasis of veterinary parasitology teaching has also changed, moving away from students being able to recite, for example, long lists of parasites found in the alimentary tract of ruminants to a greater understanding of the basic principles underlying the epidemiology of parasitic gastro-enteritis. It is also clearly unrealistic for teachers to expect students to graduate with an encyclopaedic knowledge of the subject. As a result, a new veterinary curriculum was introduced at The Royal Veterinary College in 2007 designed to meet the needs of our prospective graduates in line with the UK Royal College of Veterinary Surgeons (RCVS) Day One Competences (RCVS, 2017).

2. Old curriculum

Prior to the introduction of the new curriculum, veterinary parasitology teaching comprised a much longer course, contributing to the London five-year degree programme (BVetMed) that amounted to 93.5 contact hours (in Years Three and Four) up to the late 1980s (comprising 70 lectures and 41 practical classes, the latter including many films on parasite topics, the development of diagnostic skills and a problem-solving session). An internal review of the parasitology course that

focussed on links between parasitology, pathology, epidemiology and clinical teaching, coupled with the need for a lecture-free final year, resulted in a marked reduction in didactic teaching in the 1990s. This led to a 38.2% drop in student contact time to 57.8 h (comprising 41 lectures, 15 practical classes and eight directed learning (or problem-solving) classes).

3. New curriculum

3.1 Overview

A further reduction (25.6%) in student contact time to 43 h (comprising 30 lectures, ten practical classes and seven directed learning classes), coupled with the move of veterinary parasitology teaching to Years 1 and 2, accompanied the introduction of the new curriculum in 2007. Of course, student contact time represents that experienced by the individual student; staff teaching time may, in many cases, be significantly longer where large classes are divided and directed learning or practical classes repeated several times. The overall aims of this curriculum were to ensure that prospective graduates had an up-to-date body of core knowledge, and were able to use such knowledge and newly acquired information in scientific and clinical problem solving. For the first time, students were not expected to graduate with an encyclopaedic knowledge but to have a good understanding of basic principles and apply these to solve problems that they had not encountered before.

More specifically, students completing the parasitology module should be able to (1) define the importance of parasites to agricultural economics, animal welfare

and/or public health; (2) briefly describe the main clinical features associated with infection; (3) explain how host, parasite and environment interact to cause and regulate disease; (4) show how this knowledge may be applied in the design of effective parasite control strategies; and (5) demonstrate the presence of parasites in an infected animal.

3.2 Course organisation

3.2.1 BVetMed programme

To support these aims, the organisation of the veterinary course was changed and subjects taught in long, systems-based 'strands' from one year to the next. This teaching format enables both horizontal integration (with related subjects in the same year) and vertical integration (with other parasitology and clinical topics in later years) of newly acquired knowledge by the students (May and Silva-Fletcher, 2015). For example, ectoparasites are now taught in parallel with the anatomy and physiology of the skin during the early stages of the course. Basic knowledge is reinforced in later years when students acquire clinical experience and prescribe drugs for treatment and control whilst working in clinics.

Veterinary parasitology is introduced to students towards the end of Year 1 when the main parasite groups (helminths, arthropods and protozoa) are presented on a taxonomic basis (Table 1). The abomasal nematode *Ostertagia ostertagi* is then taught in detail to illustrate our general approach to the teaching of individual parasites, i.e. importance (agricultural economics and animal welfare), main clinical features, parasite recognition, life cycle, epidemiology (how parasite, host and

environment interact) and how this knowledge may be used to design control strategies. Teaching bovine ostertagiosis just after alimentary tract anatomy and physiology, and alongside ruminant nutrition and grassland management, provides the students with an opportunity for horizontal integration of directly-related topics. In addition, all Year 1 students undertake their first research project designed to develop the skills needed for experimental design, data collection and statistical analysis, and writing a scientific report. Whilst this report may be either a literature- or data analysis-based project, for a small proportion of students it is parasitology-related.

The majority of veterinary parasitology is taught during Year 2, primarily by organ system and then, within the alimentary and respiratory tracts, on a host species basis. The order in which particular parasites are taught mirrors the parallel teaching of organ systems by basic science colleagues.

During Year 3, students are taught clinical aspects of particular parasitic maladies, such as lungworm disease in companion and food animals, coupled with anthelmintics and anthelmintic resistance, and faecal examination as an aid to diagnosis.

During Years 4 and 5, all students are expected to undertake a second research project, which occupies two, four-week blocks whilst the students are on rotations. The expectation of this project is that it is set at a higher academic level than their first project and requires students to play a leading role in initiating and running original research. Whilst only a small proportion of the class undertake parasitology research projects, the results of a significant proportion are accepted for publication in peer-reviewed journals. Combining the output from multiple research projects has proven a particularly effective approach, providing students with experience of the

preparation, peer review and publication of scientific data. Typically, these involve studies of the epidemiology, molecular genetics and/or control of parasite infections in domestic and wild animals, and human beings (Table 2).

3.2.2 Graduate accelerated BVetMed programme

The College also offers a four-year, fast-track programme designed for graduates who already hold a biological sciences degree. These students are given a truncated parasitology course totalling 16.3 contact hours (comprising 13 lectures, two practical classes and three directed learning classes) during their introductory year before entering the BVetMed five-year programme at the start of Year 3 (additional seven contact hours; Table 3).

3.3 Course delivery

Core material is provided to students in lectures (45 min) which are supplemented by directed learning (DL; problem-based learning lasting 1.5 h) classes in small groups and interactive, clinical scenario-based practical classes (1 h each).

DL classes provide students with an opportunity to work on key parasite problems in small groups (6-8 students) with written and internet resources. Such classes are designed to reinforce student understanding of, for example, parasite epidemiology and use that as a basis for the design of parasite control programmes. Not all topics are supported by DL classes, rather carefully selected examples that include bovine ostertagiosis, bovine coccidiosis, hydatid disease, cat and dog fleas and vaccination against ticks in Years 1 and 2, and bovine parasitic bronchitis and

anthelmintic resistance in Year 3. As an example, in the case of flea control, students are required to extract key information from drug data sheets and/or commercial literature that they are provided with, consider the importance of speed of kill and duration of action, consider whether drug resistance could become a problem in the UK and, using the information that they have collected, design flea control programmes for three very different clinical scenarios.

Apart from helping students integrate basic scientific and clinical knowledge, DL classes also encourage the development of a range of generic skills, including problem-solving skills, self-directed learning, communication and interpersonal skills, self- and peer-assessment skills, team working and also promote deep learning and high-order thinking skills (Lane 2008).

Over the last two years, the format of the majority of practical classes has been changed. In such classes, students are now given a series of clinical scenarios to work through. Each scenario takes the student through a case history that is accompanied by parasite specimens (e.g., bottled worms, museum specimens, histological slides) and laminated colour pictures. This approach ensures that students are encouraged to think like clinicians as they consider the parasites that might have been associated with the clinical signs. Practical classes are therefore used to develop skills in parasite identification, reinforce concepts covered in core lectures and encourage informal staff-student communication.

The increase in student numbers seen over the last 30 years has had a major effect on how parasitology teaching is delivered. Whilst lecture theatres on both campuses (London and Hertfordshire) can accommodate whole classes, with class sizes now approaching 300 students, DL and practical classes are divided into four with different groups running concurrently to ensure best use of student time and

efficient use of teaching accommodation (small-group teaching rooms and main teaching laboratory).

3.4 Learning support

3.4.1 Learning technology

Technology-enhanced learning plays an increasingly important role in the way students study today. Instead of relying solely on didactic lectures and hard copy handouts, they are now able to access a wealth of additional resources online. These resources include a range of high quality teaching materials, including parasitology (e.g. National Center for Veterinary Parasitology, http://www.ncvetp.org/), that are shared by other institutions, often as free Open Education Resources (OERs). However, there is some concern that students may spend a disproportionate amount of time browsing the web and accessing content that is neither peer reviewed nor directly relevant to the curriculum. Therefore, the College has developed a site called Learning Links, currently available only to RVC students, which has a selection of more than 700 veterinary education web links that have all been reviewed by students and may be searched, filtered and bookmarked, and help students make good use of their time.

3.4.2 Virtual Learning Environment

The majority of universities now use a Virtual Learning Environment (VLE), or on-line management system, to host digital curriculum content. At the RVC, VLE

(supported by Moodle 3.2) has gradually grown over the years, and now provides comprehensive resources that students can continue to access even after they have graduated. Students also play an important part in fashioning the design and structure of VLE to ensure it matches the way they prefer to study.

One of the most popular developments in learning technology at the RVC in the last 10 years, and hosted by VLE, has been lecture capture. The College uses a cloud-based software tool, Echo Active Learning Platform, which is scheduled to capture every lecture and small group teaching session. Students are able to watch PowerPoint presentations with synchronized lecturer commentary, ideal for those that have missed particular classes or wish to revise topics.

Since the quality of these recordings is a key factor that determines their level of use, the College now employs Student Learning Technologists in each class to ensure quality recording. The fact that all current and archived lectures are captured has had a significant, perhaps surprising, impact on student attendance in lectures. A minority (4.3% students) now choose to view lectures on-line rather than in the lecture theatre; this may in part be due to a proportion of students living off-campus preferring to save the cost of travel to college. Whilst this drop in attendance is of concern to academics, students are adamant that recorded lectures form an important part of their approach to learning.

In addition to lecture capture, the VLE also hosts an on-line (previously hard copy) two-volume study guide (which the students can annotate during lectures using Adobe Reader) that contains (a) learning outcomes for each lecture, DL and practical class; (b) detailed illustrated lecture notes; and (c) instruction and question sheets for DL and practical classes. The guide also provides an overview of parasites that are of importance in tropical climates and in North America, since a

significant number of our students, wishing to work there upon graduation, will need to sit the North American Veterinary Licencing Examination (NAVLE). Graduate Accelerated BVetMed students are provided with a shortened, on-line study guide during their introductory year and, later, access to the full study guide when joining Year 3 of the BVetMed course. Other online resources include animated parasite 'pot casts' created by staff which provide a dynamic video with audio description of parasitology specimens (accessible on any mobile device for students to work through at their own pace), and a parasitology diagnostic techniques website, developed in conjunction with the FAO (http://www.rvc.ac.uk/Review/Parasitology/Index/Index.htm).

The VLE also provides a platform for feedback (for directed learning and practical classes) and assessment (see Section 3.5). Using digital technology, it has been possible to provide more flexible modes of delivering both formative and summative assessments. Assessment can be through use of online multiple-choice questions (MCQs), flashcards or short answer questions which can also incorporate feedback. In addition, on-line marking has proved an efficient way of streamlining double-blind marking and providing reliable and rapid results.

3.4.4 Other resources

Other resources include (1) a Clinical Skills Centre (available for use by students in Years 3 to 5 to practice basic parasitological techniques, such as, McMaster faecal egg counting, examination of skin and blood smears, etc.); (2) veterinary and medical parasite collections of international importance that act as a unique resource, not only as a source of teaching material for practical classes but also for collaborative research; and (3) a parasitology textbook, written by four past and

present teachers at the RVC and published recently to support courses taught at the College (Jacobs et al., 2016).

3.5 Assessment

Assessment of student learning is achieved using a variety of written formats (essay, problem-solving question [PSQ], multiple-choice question [MCQ] and extended matching question [EMQ]), integrated oral examinations and objective structured clinical examinations (OSCEs); the format of each is chosen to be the most appropriate for the knowledge and skills being assessed. For example, essay questions may be used to asses student understanding of concepts, PSQs their ability to interpret data and apply their findings to a clinical problem, MCQs core knowledge, EMQs clinical reasoning, integrated oral examinations their ability to integrate knowledge across subject boundaries and OSCEs their skill at performing practical tasks, such as the preparation of a blood smear and examination of a skin scraping. Students are also given on-line access to past examination papers (previous year only) in order to familiarise themselves with the format and types of questions that they are likely to be given.

4. Future developments

Since 2008, there have been cuts in government-funded tuition income and in the funding available to support university infrastructure in the UK. Whilst such cuts might be off-set, to a greater or lesser extent, by increased student fees, to be sustainable, education establishments must identify additional income streams

including increases in research funding, clinical activities, benefaction and, in particular, student numbers. Progressive increases in student numbers inevitably influence the way that veterinary parasitology is taught. Whilst the availability of learning resources might match increased class sizes in the short term, it is likely that there will be a growth in on-line and off-campus pre-clinical (Years 1 and 2) learning in the medium to long-term – lectures might be replaced by webinars, enabling student interaction with the lecturer in real time; DL classes with Skype group video calls and practicals using three dimensional (3D) imaging software, enabling the student to 'examine' parasitology exhibits remotely. Furthermore, increased reliance on on-line provision will almost inevitably lead to greater sharing of educational resources between teaching establishments.

Irrespective of future changes in the delivery of veterinary parasitology teaching, it will be the responsibility of university academics to ensure the highest quality of educational provision to help students achieve their learning outcomes and graduate with the essential skills that they need to embark upon their careers.

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References

Aher, A.M., Caudill, D., Caudill, G., Butryn, R.S., Wolf, D. Fox, M.T., Blake, D.P., Cunningham, M.W., 2016. Occurrence, distribution and ecological factors associated with heartworm (*Dirofilaria immitis*) infection in wild coyotes (*Canis latrans*) from Florida, USA. J. Wild. Dis. 52, 785-792.

Barkway, C.P., Pocock, R.L., Vrba, V., Blake, D.P., 2011. Loop-mediated isothermal amplification (LAMP) assays for the species-specific detection of *Eimeria* that infect chickens. BMC Vet. Res. 7, 67.

Barkway, C.P., Pocock, R.L., Vrba, V., Blake, D.P., 2015. Loop-mediated isothermal amplification (LAMP) assays for the species-specific detection of *Eimeria* that infect chickens. J. Vis. Exp. 96, e52552.

Hide, G., Tait, A., 1991. The molecular epidemiology of parasites. Experientia 47, 128-142.

JACOBS, D.E., FOX, M.T., GIBBONS, L.M., HERMOSILLA, C., 2016. Principles of Veterinary Parasitology. Wiley, pp. 400.

Kalema-Zikusoka, G., Rothman, J.M., Fox, M.T., 2005. Intestinal parasites and bacteria of Mountain Gorillas *(Gorilla beringei beringei)* in Bwindi Impenetrable National Park, Uganda. Primates 46, 59-63.

Kirk, L., Limon, G., Guitian, J., Hermosilla, C., Fox, M.T., 2014. *Angiostrongylus vasorum* in United Kingdom mainland – a nationwide postal questionnaire survey. Vet. Rec. 175, 118-123.

Lane, E.A., 2008. Problem-based learning in veterinary education. J. Vet. Med. Educ. 35, 631-636.

May, S.A., Silva-Fletcher, A., 2015. Scaffolded active learning: nine pedagogical principles for building a modern veterinary curriculum. J. Vet. Med. Educ. 42, 332-339.

Morgan, E.R., Tomlinson, A., Hunter, S., Nichols, T., Roberts, E., Fox, M.T., Taylor, M.A., 2008. A*ngiostrongylus vasorum* and *Eucoleus aerophilus* in foxes (*Vulpes vulpes*) in Great Britain. Vet. Parasitol. 154, 48-57.

Noronha, M., Tennant, K., Prior, R., Woolley, S., Fox, M.T., 2006. Survey of eyeworm (*Thelazia* species) in wild deer in southern England. Vet. Rec. 159, 318-319.

Patel, Z., Gill, A.C., Fox, M.T., Hermosilla, C., Backeljau, T., Breugelmans, K., Keevash, E., McEwan, C., Aghazadeh, M., Elson-Riggins, J.G., 2014. Molecular identification of novel intermediate host species of *Angiostrongylus vasorum* in Greater London. Parasitol. Res. 113, 4363-4369.

RCVS (2017) RCVS Day One Competences. www.rcvs.org.uk/document.../day.../day-one-competences-updated-26-march-2014.pdf (Accessed on 12 July 2017)

Tweedle, D.M., Fox, M.T., Gibbons, L.M., Tennant, K. 2005. Change in prevalence of the bovine eyeworm, *Thelazia* spp., in England. Vet. Rec. 157, 555-556.

Upjohn, M., Cobb, C., Monger, J., Geurden, T., Claerebout, E., Fox, M.T., 2010. Prevalence, molecular typing and risk factor analysis for *Giardia duodenalis*

infections in dogs in a central London rescue shelter. Vet. Parasitol. 172, 341-346.

van Borm, S., Belák, S., Freimanis, G., Fusaro, A., Granberg, F., Höper, D., King, D.P., Monne, I., Orton, R., Rosseel, T., 2015. Next-generation sequencing in veterinary medicine: how can the massive amount of information arising from high-throughput technologies improve diagnosis, control, and management of infectious diseases? Methods Mol. Biol. 1247, 415-436.

TABLES

Table 1

Veterinary parasitology classes (BVetMed course)

Table 1

Veterinary parasitology classes (BVetMed course)

Lectures

Year 1

1 Introduction to Parasitology
2 Introduction to Arthropods
3 Introduction to Protozoa
4 Introduction to Helminths
5 Bovine parasitic gastro-enteritis (PGE)

Year 2

6 Small ruminant PGE
7 Equine PGE
8 Porcine and avian PGE
9 Small animal PGE
10 Cestodes and alimentary myiasis
11 Avian coccidiosis
12 Mammalian coccidiosis
13 Other protozoa
14 Ruminant, equine and porcine lungworm
15 Hydatid disease
16 Liver fluke
17 Fleas and lice
18 Nuisance and biting flies
19 Warble and blowfly
20 Ticks
21 Mites
22 Babesiosis, leishmaniosis and dirofilariosis
23 Toxoplasmosis and neosporosis
24 *Sarcocystis* and *Taenia* (muscle)
25 *Trichinella*
26 *Taenia* and *Encephalitozoon* (CNS)

Year 3

27 Food animal lungworm
28 Companion animal lungworm
29 Anthelmintics

30 Anthelmintic resistance

Practical classes

Year 1

1 Introduction to Parasite Groups

Year 2

2 Digestive system (helminths 1)
3 Digestive system (helminths 2 and arthropods)
4 Digestive system (protozoa)
5 Respiratory system
6 Liver
7 Skin (fleas, lice, myiasis)
8 Skin (ticks and mites)
9 Circulatory System

Year 3

10 Faecal examination

Directed Learning (or problem-solving) classes

Year 1

1 Bovine PGE: Epidemiology and Control

Year 2

2 Mammalian coccidiosis
3 Hydatid control
4 Flea control
5 Tick control

Year 3

6 Bovine lungworm vaccination
7 Anthelmintic resistance

Table 2

Examples of parasite-host studies resulting in peer-reviewed publications (RP2 projects

Table 2

Examples of final year veterinary student research projects resulting in peer-reviewed publications.

Host	**Parasite(s)**	**Location**	**Reference**
Mountain Gorillas	Intestinal helminths	Uganda	Kalema-Zikusoka *et al.* (2005)
Cow	*Thelazia* spp.	England	Tweedle *et al.* (2005)
Deer	*Thelazia* spp.	England	Noronha *et al.* (2006)
Red fox	*Angiostrongylus, Eucoleus*	UK	Morgan *et al.* (2008)
Dog	*Giardia*	London	Upjohn *et al.* (2010)
Chicken	*Eimeria*	London	Barkway *et al.* (2011)
Dog	*Angiostrongylus*	UK	Kirk *et al.* (2014)
Slugs	*Angiostrongylus*	London	Patel *et al.* (2014)

Chicken	*Eimeria*	London	Barkway *et al.* (2015)
Coyote	*Dirofilaria*	Florida	Aher *et al.* (2016)

Table 3

Veterinary parasitology classes (AccBVetMed course)

Table 3

Veterinary parasitology classes (AccBVetMed course)

Lectures

Introductory Year (AccBVetMed)

31 Introduction to Parasitology
32 Alimentary tract (nematode, ostertagiosis)
33 Alimentary tract (protozoa 1, coccidiosis
34 Alimentary tract (protozoa 2, *Cryptosporidium* and *Giardia*)
35 Alimentary tract (trematode, fasciolosis)
36 Respiratory tract (nematode, lungworms)
37 Parasites of the cardiovascular system)
38 Ectoparasites (fleas and lice)
39 Ectoparasites (nuisance flies and myiasis)
40 Ectoparasites (ticks and mites)
41 Parasitic zoonoses 1
42 Parasitic zoonoses 2
43 Emerging parasitic diseases

Year 3 (BVetMed)

14 Food animal lungworm
15 Companion animal lungworm
16 Anthelmintics
17 Anthelmintic resistance

Practical classes

Introductory Year (AccBVetMed)

1 Alimentary tract parasitism (faecal samples)
2 Parasites of veterinary importance

Year 3 (BVetMed)

3 Faecal examination

Directed Learning (or problem-solving) classes

Introductory Year (AccBVetMed)

1 Bovine PGE: Epidemiology and Control
2 Flea control
3 Tick vaccination

Year 3

8 Bovine lungworm vaccination
9 Anthelmintic resistance