Arming future veterinarians against an ever-adaptable foe: Inspired parasitology curriculum and resources that capture the beauty (and terror) of parasites in the tropics.

OVERVIEW: CONTEXT AND SUMMARY OF CONTRIBUTION

Parasitology has traditionally been considered by students as a dense, complex, and boring subject that is not easy to learn and enjoy. Over the last **six years**, I have defied this preconception by producing original and unique parasite images, case studies, and props that not only inspire learning but also ensure a deep and lasting appreciation of these important parasites by our veterinary graduates. My name is Constantin (Con) Constantinoiu and I am fortunate to work in one of the most exciting and important areas of veterinary science—veterinary parasitology. This is the study of fleas, flies, lice, ticks, worms, and protozoa that can have devastating impacts on our livestock and pets and, often, even humans.

Unlike metropolitan veterinary schools in Australia that have 3-4 expert parasitologists, I am the sole expert teaching parasitology to veterinary students at undergraduate and postgraduate levels at James Cook University (JCU). Within the JCU Bachelor of Veterinary Science degree, parasitology is a core discipline in which I am privileged to teach across **three subjects**: *Integrated Animal Structure and Function*, *Transitions from Health to Disease* and *Veterinary Clinical and Professional Practice*. Across the subjects, students have to absorb and apply a vast amount of new information on morphology, life cycles, and control measures for more than 250 species of parasites, so the method of teaching and delivery becomes paramount. Australian lecturers in veterinary parasitology have always faced the dilemma of how to marry the effective teaching of the subject as a useful and practical discipline with the breadth of information (Arundel and Rickard, 1983).

My multidimensional approach to curricula design invigorates student learning through five key strategies: (i) the use of visually beautiful and shocking images, (ii) incorporating research expertise as foundational to curriculum, (iii) delivering entertaining stories in interactive lectures to stimulate student thinking and recall, (iv) the use of authentic case studies, and (v) the creation of innovative engagement resources, such as parasitology suits. This comprehensive approach results in highly knowledgeable and capable students, equipped with both an appreciation of the hidden beauty of parasites and the necessity of combating them in a challenging tropical environment.

CRITERION 2. DEVELOPMENT OF CURRICULA, RESOURCES OR SERVICES THAT REFLECT A COMMAND OF THE FIELD.

I began work at JCU in 2009, one of few universities located in the tropics and deeply involved in assuring animal health in the region. The constant evolution of parasites presents significant challenges to parasite control, but this is especially significant in the tropics where the favourable yearlong climate allows parasites' lifecycles to continue year round, making control programs extremely difficult, and where drug resistance is widespread. In 2010, I designed, developed and implemented new, authentic, and highly successful subjects to allow students to gain a deep understanding of essential knowledge required to diagnose, treat and control parasitic diseases.

(i) INTERNATIONALLY RECOGNISED UNIQUE VISUAL RESOURCES THAT BRING PARASITES TO LIFE

Bringing parasitology to life by making the individual parasites beautiful, interesting and relevant to the veterinary profession brings me joy as they stand out of the crowd of ugly and boring creatures. My passion and patience, along with expertise in special microscopy and tissue processing techniques, turns parasites interacting with a host into beautiful technicolour images that are unique in Australia and worldwide (Fig. 1). They not only enrich our scientific knowledge, but enchant the eye as well. I have been asked by domestic and international researchers to help or teach them my techniques: *'I have read your work and observed the fantastic immunofluorescence images from skin biopsies… Do you have interest in collaborating with my work and accept me in your laboratory'* (Dr. Thiago Malardo, 2015, Faculdade de Medicina de Ribeirão Preto/USP, Brazil); *'...Ian Colditz at CSIRO, Armidale suggested that I make contact with you for help. Would it be possible to talk to you to discuss my technical problems?'* (Grant Smolenski, 2013, Waikato

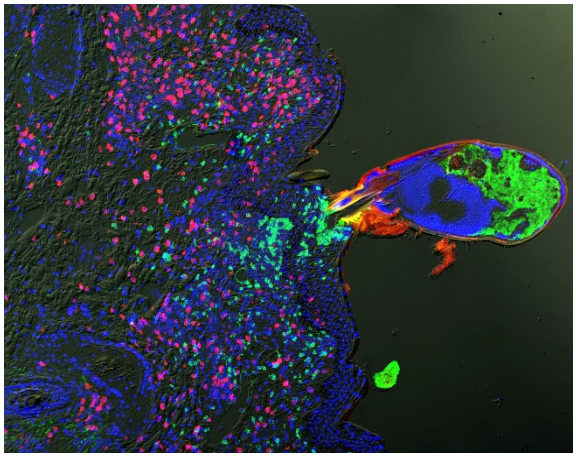

Fig. 1 Winning image, Bioscapes Olympus competition, showing a tick feeding on the host
http://www.olympusbioscapes.com/gallery/photographer/constantin-constantinoiu

University, New Zealand). My photos of parasites have been featured in books, *Australasian Animal Parasites Inside & Out* (25 images) and *Principles of Veterinary Parasitology* (2 images), and on the covers of books and scientific journals (*International Journal for Parasitology; Biotechniques; Parasite immunology* - twice). My unique images have won microscopy image awards both regionally (North Queensland Festival of Life Sciences, JCU 2009 & 2013) and internationally (Fig. 1, Olympus, 2008 Bioscapes). One of my parasite pictures was even made into a greeting card!

The use of these images in my teaching practice engages students and leaves them with memorable experiences that illustrate the relevant information. My teaching evaluation results (Fig. 2-4 show the results for the main subject, *Transitions from Health to Disease*, percentage response rates 36 to 48%) and comments demonstrate the success of visual tools to enhance learning: *'Thank you for making a potentially boring subject entertaining and interesting. I love your jokes and pictures but you have ruined my life in some ways, rice noodles look like tapeworms and I'm slightly traumatised by the mouthparts of several parasites'* (Student Evaluation, 2012); *'your slides are great with all the text and pictures'* (Student Evaluation, 2013). The use of beautiful, suggestive, and gruesome pictures that impress and shock the students improves their learning and helps them distinguish individual parasites, by attaching relevance and meaning to information.

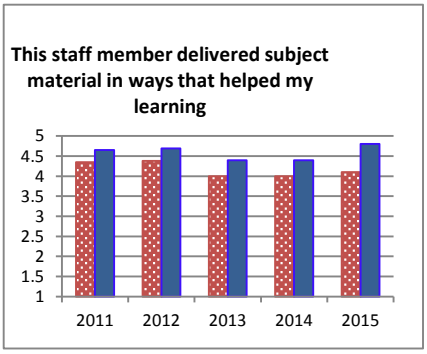

Fig. 2 Delivery of subject material in ways that help learning.

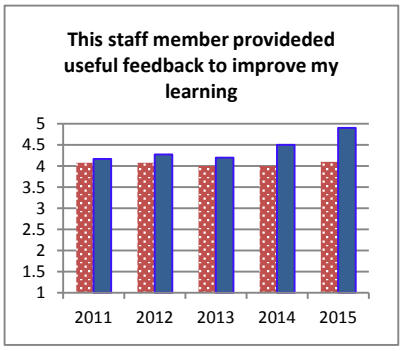

Fig. 3 Feedback provided to the students to improve their learning.

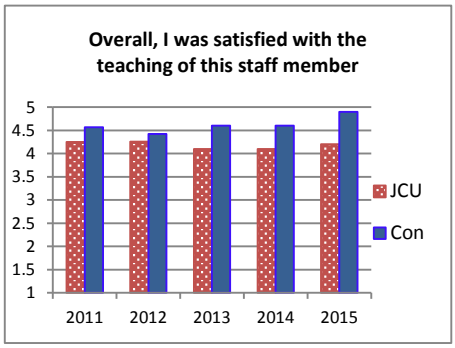

Fig. 4 Student overall satisfaction.

(ii) RESEARCH EXPERTISE GUIDING CURRICULUM AND RESOURCE DEVELOPMENT

The students recognise my knowledge in the field and it motivates and gives them confidence: *'Con is an expert at what he teaches us'* (Student Evaluation, 2014); *'the extent of his knowledge is inspiring'* (Student Evaluation, 2014); *'Con is extremely knowledgeable and approachable'* (Student Evaluation, 2013). Since 2010 I have published 12 papers in peer-reviewed journals, contributed chapters to two books, discovered drug resistance in the most important parasite of small ruminants, and discovered two new species of lice on native rodents in the tropics. The findings of my research drive and greatly enhance my teaching. In a formal review of my teaching, A/Professor Jeffrey Warner (Associate Dean Research & Education) wrote, *'Con lets his research inform his teaching. Of the teaching material I observed, much of the data he presented to demonstrate an important point was as a consequence of his research. Students identify Con as an expert in the field and are more likely to engage with this material and they benefit from cutting edge and contemporary material'* (2013). My expertise in the field is further demonstrated by the uptake of my scholarly work beyond JCU. In 2012, as evidence of peer recognition of my knowledge at a national level, I was invited to contribute to *Australasian Animal Parasites Inside and Out*, the parasitology reference book for schools of Veterinary Sciences in Australia (Traub, Brown, Coleman, Constantinoiu, O'Handley, & Slapeta, 2014; Pomroy, Beveridge, Constantinoiu, Emery, & Woodgate, 2014). In addition, I contributed to the preferred reference book in Romania, *Veterinary Parasitology* (Constantinoiu, 2014a; 2014b). These outputs are unique resources for conquering students' misconceptions that parasitology is 'dry' and 'boring'. My expertise in the field, my own learning in undertaking a Graduate Certificate of Education, along with humour and reflection are instrumental in my curriculum design and delivery.

(iii) INTERESTING AND INTERACTIVE LECTURES FOR EASY LEARNING

I use a variety of strategies in the development of teaching materials to enhance lectures, including the incorporation of vivid examples, engaging them as mnemonic devices to reduce the cognitive load on students' working memory and improve long-term retention and retrieval of information (Stewart, 2012). I develop analogies of famous characters or formidable animals: parasites that feed on blood during the night

are contemporary Draculas, parasites that are always coupled are modern Romeos and Juliets whose love even Shakespeare could not fathom, and hookworms that have very sharp teeth and feed on large amounts of blood are sharks of the intestine. These, complemented by visual images and case studies, become significant features of my teaching, enhancing its design and clarity. My teaching evaluation comments indicate that my lecture notes are outstanding, make study easier and they can be used as a reference after students graduate: *'His lecture notes are some of the BEST in circulation. They are simple, easy to follow, and make for a great reference resource. The important bits are highlighted, the important parasites are repeated. Fundamentals of teaching are great'* (Student Evaluation, 2015), *'Very good lecture notes'* (Student Evaluation, 2014), *'Absolutely love seeing your cartoon pictures to make lectures more interesting'* (Student Evaluation, 2014).

The presentation of lectures is interactive and engaging for students, incorporating interactive questioning as a formative assessment technique to stimulate students to learn rather than promoting anxiety (Brown and Race, 2012). Questions such as: 'How do you reckon the parasite will cause pathology?' and 'How would you treat animals infected with this parasite?' help students focus during the lectures, remember more and is greatly appreciated by both students and peers: *'The way he constantly asks people questions in class makes you pay more attention and want to know everything well'* (Student Evaluation, 2013); *'He asks questions to students directly, this helped me learn because if I got a question wrong, I remembered the answer'* (Student Evaluation, 2014); *'Fantastic questions that helped grasp the concept'* (Student Evaluation, 2014). A/Professor Jeffrey Warner wrote, *'His performance in class constantly challenges the students. He regularly asks questions of them to ensure they are focused. He regularly reiterates the learning objectives so the students know and are reminded of what they must get from the lecture'* (Formal Peer Review, 2013).

(iv) CASE STUDIES FOR AUTHENTIC DEVELOPING OF PROBLEM SOLVING AND DECISION MAKING SKILLS

One of my most significant contributions to the new parasitology curriculum has been demonstrating the relevance of parasites in a clinical context by using over 70 case studies in practical classes and lectures. These simulate real-life situations faced by veterinarians and make the study of parasites more engaging. Students are then immersed in the life of veterinarians that have to diagnose animals suffering from infections with various parasites and make decisions on control and prevention. This requires not only knowledge of parasites but also judgement, inquisition, and responsibility. Thus, learning becomes active and self-directed, and fosters key skills of problem-solving, communication, researching, acquiring and transferring knowledge to new situations (Brodie, 2012). *'Practical sessions complemented the lecture content perfectly'* (Student Evaluation, 2013), *'using real life examples in terms of parasites'* (Student Evaluation, 2014), *'there were multiple opportunities to investigate the parasites on a practical level, with several classes and Con nearly bending over backwards to give us extra chances. I always felt like he actually "wanted" us to learn and wasn't just going through the motions, it was great'* (Student Evaluation, 2013), *'the practicals are extremely helpful and support the lecture material well'* (Student Evaluation, 2013). The case studies ensure high levels of engagement and professional readiness as evidenced by one student experience. In 2015, while on placement in a usually dry area of New South Wales, one of my students helped diagnose and control a severe outbreak of haemonchosis, which is caused by *Haemonchus contortu*, the most important worm of sheep and goats in the tropics. This parasite is extremely rare in dry areas; however, unusual heavy rain and high temperatures had created a tropical environment. The student's knowledge of the parasite and the contextual conditions led to an accurate and astute diagnosis.

Fig. 5 Students wearing the suits with painted organs and parasites in front of stations with information on parasites and fixed parasites in jars.

(v) INNOVATIVE AND 'OUT OF THE BOX' IDEAS TO SPUR STUDENTS' INTEREST AND PROMOTE PARASITOLOGY TO THE GENERAL PUBLIC

In 2014, I was awarded a grant from JCU that involved painting anatomically positioned human organs and their common parasites on lycra suits (Fig. 5). The suits are worn by 2-3 students during the first lectures of Parasitology and at university promotional events to spur the interest of the students for parasitology. The parasites on the suits are identified by numbers that are matched with scary but beautiful images and information on the parasites. Students and

the general public find the suits extremely interesting and love them. Professor Glen Coleman, head and professor of Parasitology at the University of Queensland, called the painted suits *'really brilliant'* while Linda Jones, Executive Officer of the Australian Society for Parasitology (ASP), said the suits were *'amazing'*, inviting me to take part with them in ASP's World Science Festival in Townsville in September 2016.

RECOGNITION FROM FELLOW STAFF, THE INSTITUTION AND/OR THE BROADER COMMUNITY

In addition to endorsement for specific areas of my curriculum and resource development, I have received wide-ranging recognition for my work. In a formal peer review, a colleague, A/Professor John Cavalieri, wrote, *'It was clear that Con had detailed knowledge of this area and provided students with information that was relevant to their field. Detailed notes were supplemented with excellent pictures'* (2013). As further internal recognition of the outstanding quality of my curriculum and resource development, I have received two institutional awards, the Dean's *Certificate of Recognition of Excellence in Teaching* and a *JCU Citation for Outstanding Contribution to Student Learning* in 2016.

Externally, my work has also been circulated and discussed. Ian Beveridge, Professor of Parasitology from the School of Veterinary Science, University of Melbourne on reviewing over 100 of my photographs that accompanied keys for identification of Australian native fleas wrote *'I really like your pictures of features used in the Dunnett & Mardon key!'* (unsolicited email, 2016). Dr. Brown Besier, Principal Veterinary Parasitologist with Animal Health Laboratories, Western Australia on seeing my work mentioned to a colleague that he was *'impressed by the presentation and quality of the work and pictures'* (in conversation, 2015).

Feedback from numerous scholarly education sessions I conduct beyond JCU are also very favourable. Dr Jim Pollock wrote that participant feedback sheets from a workshop I presented on parasitology and microbiology for the Australian Wildlife Rehabilitation Conference suggested that *'the workshop has raised the bar on what can be presented at future Conferences'* (unsolicited email, 2012). Similarly, Dr Karen Gerber, from JCU wrote that *'the quality of the lecture notes and the material presented were amazing'* (2013) after a workshop for veterinarians on diagnosis and control of parasitic diseases in small animals. Furthermore, the activities I present to high school students are also well appreciated: *'Please pass on our thanks to Con… students had a blast learning about parasites, bacteria and microscopes'* (Ms Kate Kachel and Ms Gemma Bauman, unsolicited email, 2014, Science Experience event organisers).

CONCLUSION

Parasitology is one of the most important but toughest areas of veterinary science, especially for vets in the tropics. The overwhelming number of clever and ever-adapting parasites is daunting for students that initially find the study of parasitology difficult, monotonous, and boring. Through an authentic approach to curriculum development using fascinating imagery, realistic case studies, and passion for the subject, I succeed in captivating the students' interest, inspiring them to learn and making the study of parasites an enjoyable learning experience. As one student said, *'I felt we were (con)ned into learning the parasites!'* (Student Evaluation, 2014). My multi-faceted and research-led approach assures highly qualified veterinarians, who are cognisant of—and enthusiastic about—overcoming the terrors of parasitology. As noted by industry partners, *'JCU students on placement and JCU graduates know Parasitology very well, better than graduates from other schools in Australia'* (Dr Strohfeldt, Bell Vet Clinic Services, 2016).

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