NEW VISTAS IN VETERINARY PARASITOLOGY

AAV 61st Annual Meeting Proceedings
August 6 – 9, 2016 • San Antonio, TX
www.AAVP.org
Anne Zajac was born and raised in Lansing, Michigan, the daughter of Robert and Joan Zajac. Her mother is a World War II British war bride and Anne looked forward to summer trips to see relatives in south Wales. Anne had no interest in science or veterinary medicine growing up—she preferred literature and theatre—but by the time she started as an undergraduate at the University of Michigan her interests were expanding. She took an Experimental Psychology course and discovered biology, which led to her first laboratory experience—assisting a psychology graduate student—and she shifted her major to Psychology. But psychology wasn’t “sciencey” enough and Anne changed again to Zoology. An Invertebrate Zoology course was a dramatic revelation. Anne was accepted into an entomology PhD program at Notre Dame University, but the summer after graduation she traveled to the UK and her strong attachment to that country led to the decision to defer graduate school and stay, at least temporarily. By the greatest good luck she found a laboratory job that allowed her to get a work permit. That position was at the Wellcome Laboratories for Experimental Parasitology at the University of Glasgow where Anne discovered that the best invertebrates are parasites while working for Dr. Adrian Hopkins on the immune response to the rodent tapeworm *Hymenolepis diminuta*.

After two years in Glasgow, Anne decided to reapply for graduate school, but this time to work on tapeworms. She returned to the U.S. for a MS program in the laboratory of Dr. Jeffrey Williams at Michigan State University. The Williams lab was full of energetic and enthusiastic graduate students and postdocs from around the world, including Tim Geary, George Conder, Bruce Hammerburg and Roger Cook. Anne’s MS work was on the host / parasite relationship of the rodent schistosome *Schistosomatium douthitti* and the dramatic differences between the response of laboratory mice and voles to the parasite. Jeff’s lab was in the veterinary college at MSU, and seeing the possibilities of veterinary medicine and veterinary parasitology were another enormous revelation. While at MSU Anne also earned a DVM before moving to another Big 10 school, Ohio State University, to enroll as a PhD student under the direction of Dr. Rupert Herd, an Australian parasitologist who was one of the first to apply the concepts of strategic
parasite control in the U.S. Anne’s dissertation, like her MS thesis, again dealt with differences in host responses to parasites—this time differences in the response of hair and wool sheep breeds to the amazing nematode *Haemonchus contortus*. Important sources of support at OSU were her office mates Craig Reinemeyer and Glenn Frank, not to mention her future husband, Gareth Moore, a Canadian veterinarian doing a clinical pharmacology residency at OSU, who won Anne’s heart by helping place jugular catheters in sheep for round the clock sampling in January in northern Ohio.

After completing their time in Ohio, Anne and Gareth were married and became faculty at the Virginia-Maryland Regional College of Veterinary Medicine at Virginia Tech in one of the loveliest parts of the U.S, the mountains of southwestern Virginia. Anne and Gareth purchased a small farm in nearby Giles County and were soon joined by a daughter (Isabel) and son (Alistair) and a small flock of parasite resistant sheep. Anne’s first parasitology colleague at VT was Jorgen Hansen, a delightful and accomplished Danish parasitologist, who was also interested in ruminant nematodes. However, for most of Anne’s time at VT, her primary partner in parasitology has been David Lindsay who joined the faculty several years after Anne. They have been colleagues in research ever since and provided the parasitology instruction and diagnostics at the veterinary college ever since.

One of the best parts of Anne’s job at VT has been the opportunity to share the fascination of parasites with undergraduate, graduate and veterinary students. Anne has served on a number of graduate committees and advised or co-advised students both MS and PhD students including Maxine Kellman, Alexa Rosypal and Aaron Lucas. With Jorgen Hansen and David Lindsay, Anne has contributed to infecting other VT students with the parasitology bug including AAVP members Susan Little, Ray Kaplan, Sheila Mitchell and Alice Houk.

During her career at VT, Anne has conducted research in several areas, but her greatest interest has been the gastrointestinal nematodes of ruminants. She has continued work in genetic variation in resistance. More recently she has become involved in research on the use of plant and microbial products as anthelmintics including orange oils, cranberry proanthocyanidins and birdsfoot trefoil. She is a member of the American Consortium for Small Ruminant Parasite Control and has been active in outreach to small ruminant producers. Her work with *H. contortus* has led to collaborations with a number of excellent scientists including Katherine Petersson (University of Rhode Island), Dave Notter and Scott Greiner (VT), Stephan Wildeus (Virginia State University) and numerous colleagues in ACSRPC and the USDA. Another area of interest for a number of years has been *Giardia* infections in small animals, which has recently led to another successful collaboration with Joel Herbein and his colleagues (TechLab, Inc).

In 2010 Anne became one of the charter diplomates of the Parasitology specialty in the American College of Veterinary Microbiologists and she has served on the exam committee since that time. She was recently elected to the Board of Governors of ACVM. She has been an active member of AAVP during her parasitology career, serving on a number of committees and as AAVP president in 2001-2002. In the early 1990’s Iowa State University Press offered AAVP the opportunity to assume responsibility for an updated edition of *Veterinary Clinical Parasitology* by Margaret Sloss and Russell Kemp, since both authors were deceased. The AAVP Executive Board asked Anne if she would be interested in taking on the project of updating the book. She agreed and with the assistance of many members of AAVP the 6th edition appeared in 1994. Subsequently, Gary Conboy joined her as co-author for the all color 7th edition (2006) and updated 8th edition (2012). The 9th edition of the textbook is now in preparation.
AMERICAN ASSOCIATION OF VETERINARY PARASITOLOGISTS

AWARDS HISTORY

AAVP-Merial Distinguished Veterinary Parasitologist Award

1985  Jitender P. Dubey
1986  Norman D. Levine
1987  E. J. Lawson Soulsby
1988  Jeffrey F. Williams
1989  K. Darwin Murrell
1990  William C. Campbell2, 3
1991  Jay Hal Drudge and Eugene T. Lyons
1992  Gilbert F. Otto
1993  Thomas R. Klei
1994  Peter M. Schantz
1995  James C. Williams
1996  T. Bonner Stewart
1997  J. Owen D. Slocombe
1998  J. Ralph Lichtenfels
1999  Roger K. Prichard
2000  Edward L. Roberson
2001  Byron L. Blagburn
2002  Sidney A. Ewing
2003  Louis C. Gasbarre
2004  David S. Lindsay
2005  Jorge Guerrero
2006  John W. McCall
2007  Ronald Fayer
2008  Dwight D. Bowman
2009  Ellis C. Greiner
2010  George A. Conder
2011  Thomas M. Craig
2012  James E. Miller
2013  Dante Zarlenga
2014  Timothy G. Geary
2015  Michael W. Dryden

1National Academy of Sciences 2010
2National Academy of Sciences 2002
3Noble Prize in Physiology or Medicine 2015

2016 AAVP-Merial Distinguished Veterinary Parasitologist Award Winner

Anne M. Zajac
Dr. William (Bill) Campbell is one of three scientists sharing this year’s Nobel Prize in Physiology or Medicine. Dr. Campbell (PhD Wisconsin) is sharing half of the award with Japan’s Satoshi Omura, for the discovery of avermectin which affects nematodes, and China’s Youyou Tu received the other half of the award for her discovery of artemisinin, which is highly effective against the malaria parasite.

Dr. Campbell was born in Northern Ireland, graduated from Trinity College (Dublin), before moving to the United States where he completed his PhD at the University of Wisconsin. He then went to work with the Merck Institute for Therapeutic Research, where he began his collaboration with Dr. Omura.

Omura was studying a group of soil bacteria called *Streptomyces*, and he selected about 50 isolates that showed promise. From this group of isolates, Dr. Campbell discovered that a specific bacterium, *Streptomyces avermitilis*, produced avermectin, a potent anthelmintic. Avermectin was refined into ivermectin, and this drug revolutionized control of many parasites in animals and of filarial in humans.

In addition to being a long-time American Association of Veterinary Parasitologists member, Dr. Campbell, was recognized with the AAVP-Merial Distinguished Veterinary Parasitologist Award in 1990, and was elected to the National Academy of Sciences in 2002. Currently, Dr. Campbell is a Research Fellow Emeritus at Drew University.
AAVP Distinguished Service Award

1976  Rurel R. Bell
1983  Terance J. Hayes
1987  Norman F. Baker
1988  Donald E. Cooperrider
1994  S. D. “Bud” Folz
1997  Honorico Rick Ciordia
2006  Raffaele “Raf” Roncalli
2008  Anne M. Zajac

AMERICAN ASSOCIATION OF VETERINARY PARASITOLOGISTS

AWARDS HISTORY

Hoechst-Roussel Agri-Vet Company Graduate Student Research Award

1987  Lora G. Rickard
1988  Debra A. Cross
1989  Stephen C. Barr
1990  Jim C. Parsons
1991  Carlos E. Lanusse
1992  David G. Baker
1993  Rebecca A. Cole
1994  Ray M. Kaplan
1995  Scott T. Storandt
1996  A. Lee Willingham III
1997  Carla C. Siefker
1998  Ryan M. O’Handley
1999  John S. Mathew
2000¹  Sheila Abner
2001  Andrew Cheadle
2002  No recipient
2003  Mary G. Rossano
2004  Andrea S. Varela
2005  Alexa C. Rosypal
2006  Sheila M. Mitchell
2007  Martin K. Nielsen
2008²  Heather D. Stockdale
2009  Kelly E. Allen
2010  Stephanie R. Heise
2011  Aaron S. Lucas
2012³  Flavia A. Girao Ferrari
2013  Lindsay A. Starke
2014  Alice Che Yu Lee
2015  Anne Barrett

¹2000, award renamed the “AAVP/Intervet Graduate Student Research Award”
²2008, award renamed the “AAVP/Schering-Intervet Graduate Student Research Award”
³2012, award renamed the “AAVP/Merck Animal Health Graduate Student Research Award”

2016 AAVP/Merck Animal Health Graduate Student Research Award
Rachel Curtis-Robles
AAVP-Companion Animal Parasite Council (CAPC) Graduate Student Award in Zoonotic Disease

2008    David G. Goodman
2009    Stephanie R. Heise
2010    Sriveny Dangoudoubiyam
2011    Jessica Edwards
2012    Lindsay Starkey
2013    Gail M. Moraru
2014    Anne Barrett
2015    Alice Che Yu Lee

2016 AAVP-CAPC Graduate Student Award in Zoonotic Disease

Brian H. Herrin
# Officers 2015-2016

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<tr>
<th>Position</th>
<th>Name</th>
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<td>Ray M. Kaplan</td>
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<td>Andrew S. Peregrine</td>
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<td>Guelph, ON, Canada</td>
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2015-2016 AAVP Committee Chairs and Members (Term Date)


**Archives:** Tom Nolan, Chair (2015), Miguel Suderman (2016), Raf Roncalli (2018)


**Constitution and Bylaws:** Tom Kennedy, Chair (2016), Adrian Wolstenholme (2017), Alexa Rosypal (2018), Joe Camp (2018), Andy DeRosa (2019)


**Finance:** Andrew Moorhead, Chair (2017), Jim Miller (2018), Bob Storey (2016), Ashley McGrew (2018), Pete Hann (2018)


**Student Representatives:** Meriam Saleh (2016), Jessica Jacobs (2017)

**Past Presidents:** Andrew Peregrine, Chair (2018), Dwight Bowman (2017), Alan Marchiondo (2016)

**Ad Hoc List Serve Manager:** Bert Stromberg (2016)
PAST PRESIDENTS OF THE
AMERICAN ASSOCIATION OF
VETERINARY PARASITOLOGISTS

1956-1958  L. E. Swanson
1958-1960  Fleetwood R. Koutz
1960-1962  Wendell H. Krull
1962-1964  Saeed M. Gaafar
1964-1966  E. D. Besch
1966-1968  George C. Shelton
1968-1970  John H. Greve
1970-1972  Harold J. Griffiths
1972-1973  Donald E. Cooperrider
1973-1975  Demetrice L. Lyles
1975-1977  Harold J. Smith
1977-1979  Norman F. Baker
1979-1981  Edward L. Roberson
1981-1983  Jeffrey F. Williams
1983-1985  John B. Malone
1985-1986  Robert M. Corwin
1986-1987  K. Darwin Murrell
1988-1989  Harold C. Gibbs
1989-1990  Bert E. Stromberg
1990-1991  Roger K. Prichard
1992-1993  Ronald Fayer
1993-1994  George A. Conder
1994-1995  Charles H. Courtney
1995-1996  Byron L. Blagburn
1996-1997  Peter M. Schantz
1997-1998  James C. Williams
1998-1999  Louis C. Gasbarre
2000-2001  Thomas J. Kennedy
2001-2002  Anne M. Zajac
2003-2004  Craig R. Reinemeyer
2004-2005  Linda S. Mansfield
2005-2006  Ann R. Donoghue
2006-2007  Daniel E. Snyder
2007-2008  David S. Lindsay
2008-2009  Susan E. Little
2009-2010  Lora R. Ballweber
2010-2011  Karen Snowden
2011-2012  Patrick F.M. Meeus
2012-2013  Alan A. Marchiondo
2013-2014  Dwight D. Bowman
2014-2015  Andrew S. Peregrine
2015-2016  Ray M. Kaplan
PAST SECRETARY-TREASURERS OF THE
AMERICAN ASSOCIATION OF VETERINARY PARASITOLOGISTS

Wendell H. Krull 1956-1959
Edward G. Batte 1960
Donald E. Cooperrider 1961-1969
Rurel Roger Bell 1969-1977
Terence J. Hayes 1978-1983
Vassilios J. Theodorides 1983-1986
Thomas J. Kennedy 1993-1998
Daniel E. Snyder 1998-2004
Alan A. Marchiondo 2004-2010
Robert G. Arther 2010-2014
Doug Carithers 2014- Present

PAST AAVP ANNUAL MEETINGS

1956 1st Annual Meeting – SAN ANTONIO, TX 16 OCT
1957 2nd Annual Meeting – COLUMBUS, OH 17 AUG
1958 3rd Annual Meeting – PHILADELPHIA, PA 18 AUG
1959 4th Annual Meeting – KANSAS CITY, MO 23 AUG
1960 5th Annual Meeting – DENVER, CO 14 AUG
1961 6th Annual Meeting – WEST LAFAYETTE, IN 20 AUG
1962 7th Annual Meeting – MIAMI BEACH, FL 12 AUG
1963 8th Annual Meeting – NEW YORK CITY, NY 28 JUL
1964 9th Annual Meeting – CHICAGO, IL 19 JUL
1965 10th Annual Meeting – PORTLAND, OR 11 JUL
1966 11th Annual Meeting – LOUISVILLE, KY 13-14 JUL
1967 12th Annual Meeting – DALLAS, TX 9 JUL
1968 13th Annual Meeting – BOSTON, MA 21 JUL
1969 14th Annual Meeting – MINNEAPOLIS, MN 13 JUL
1970 15th Annual Meeting – LAS VEGAS, NV 22 JUN
1971 16th Annual Meeting – DETROIT, MI 18 JUL
1972 17th Annual Meeting – NEW ORLEANS, LA 17 JUL
1973 18th Annual Meeting – PHILADELPHIA, PA 15 JUL
1974 19th Annual Meeting – DENVER, CO 21 JUL
1975 20th Annual Meeting – ANAHEIM, CA 13 JUL
1976 21st Annual Meeting – CINCINNATI, OH 19 JUL
1977 22nd Annual Meeting – ATLANTA, GA 11 JUL
1978 23rd Annual Meeting – DALLAS, TX 17 JUL
1979 24th Annual Meeting – SEATTLE, WA 22-24 JUL
1981 26th Annual Meeting – ST. LOUIS, MO 19-20 JUL
1982 27th Annual Meeting – SALT LAKE CITY, UT 18-19 JUL
1983 28th Annual Meeting – NEW YORK, NY 17-18, JUL
1984 29th Annual Meeting – NEW ORLEANS, LA 15-17 JUL
1985 30th Annual Meeting – LAS VEGAS, NV 22-24 JUL
1986 31st Annual Meeting – ATLANTA, GA 20-22 JUL
1987 32nd Annual Meeting – CHICAGO, IL 19-21 JUL
1988  33rd Annual Meeting – PORTLAND, OR  17-18 JUL
1989  34th Annual Meeting – ORLANDO, FL  16-18 JUL
1990  35th Annual Meeting – SAN ANTONIO, TX  21-24 JUL
1991  36th Annual Meeting – SEATTLE, WA  28-30 JUL
1992  37th Annual Meeting – BOSTON, MA  2-4 AUG
1993  38th Annual Meeting – MINNEAPOLIS, MN  17-20 JUL
1994  39th Annual Meeting – SAN FRANCISCO, CA  9-12 JUL
1995  40th Annual Meeting – PITTSBURGH, PA  6-10 JUL

(Joint meeting with the American Society of Parasitologists)

1996  41st Annual Meeting – LOUISVILLE, KY  20-23 JUL
1997  42nd Annual Meeting – RENO, NV  19-22 JUL
1998  43rd Annual Meeting – BALTIMORE, MD  25-28 JUL
1999  44th Annual Meeting – NEW ORLEANS, LA  10-13 JUL
2000  45th Annual Meeting – SALT LAKE CITY, UT  22-25 JUL
2001  46th Annual Meeting – BOSTON, MA  14-17 JUL
2002  47th Annual Meeting – NASHVILLE, TN  13-16 JUL
2003  48th Annual Meeting – DENVER, CO  19-23 JUL
2004  49th Annual Meeting – PHILADELPHIA, PA  24-28 JUL

(Joint meeting with the American Society of Parasitologists)

2005  50th Annual Meeting – MINNEAPOLIS, MN  16-19 JUL
2006  51st Annual Meeting – HONOLULU, HI  15-18 JUL
2007  52nd Annual Meeting – WASHINGTON, DC  14-17 JUL
2008  53rd Annual Meeting – NEW ORLEANS, LA  19-22 JUL
2009  54th Annual Meeting – CALGARY, CANADA  9-13 AUG

(Joint meeting with the World Association for the Advancement of Veterinary Parasitology and the International Commission on Trichinellosis)

2010  55th Annual Meeting – ATLANTA, GA  31 JUL – 2 AUG
2011  56th Annual Meeting – ST. LOUIS, MO  16-19 JUL

(Joint meeting with the Livestock Insect Workers Conference and the International Symposium of Ectoparasites of Pets)

2012  57th Annual Meeting – San Diego, CA  4-7 AUG
2013  58th Annual Meeting – Chicago, IL  20-23 JUL
2014  59th Annual Meeting – Denver, CO  26-29 JUL
2015  60th Annual Meeting – Boston, MA  11-14 JUL

(Joint meeting with the Livestock Insect Workers Conference and the International Symposium of Ectoparasites of Pets)

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AAVP 61st ANNUAL MEETING
Westin Riverwalk Hotel

REGISTRATION
Navarro A Foyer
Saturday, August 6, 2016, 1:00 PM – 5:00 PM
Sunday, August 7, 2016, 8:00 AM – 2:00 PM

SYMPOSIA / SOCIAL PROGRAMS
Welcoming Reception – Bayer HealthCare, Animal Health
Bayer Symposium - Hidalgo - Saturday, August 6, 2016, 6:30 PM – 7:15 PM
Bayer Social - Hidalgo - Saturday, August 6, 2016, 7:45 PM – 9:45 PM

AAVP Committee-Volunteers Breakfast
(Breakfast only for those volunteering for/on AAVP Committees)
Breakfast Meeting Sponsored by AAVP
Navarro A – Sunday, August 7, 2016, Breakfast 7:15 AM – 7:30 AM,
Committee Meetings 7:30 AM – 8:15 AM

Zoetis Lunch Symposium
Zoetis Lunch Symposium - Navarro A - Sunday, August 7, 2016, 12:00 PM – 1:30 PM

Poster Viewing and Wine Social
Social Sponsored by CEVA Animal Health
Navarro Foyer - Sunday, August 7, 2016, 5:00 PM – 6:00 PM

Merial Symposium / Social
Merial Symposium - Navarro A - Sunday, August 7, 2016, 6:30 PM – 7:30 PM
Merial Social - Navarro Foyer - Sunday, August 7, 2016, 7:30 PM – 9:30 PM

AAVP Members Breakfast
Breakfast sponsored by IDEXX Laboratories, Inc.
Navarro Foyer - Monday, August 8, 2016, 7:45 AM – 8:30 AM

Poster Viewing and Wine Social
Social Sponsored by CEVA Animal Health
Navarro Foyer - Monday, August 8, 2016, 5:00 PM – 6:00 PM

DACVM Meeting
Camino Real – Monday, August 8, 2016, 5:30 PM – 6:30 PM
Elanco Animal Health Symposium / Social
Elanco Symposium - Navarro A – Monday, August 8, 2016, 6:30 PM – 7:30 PM
Elanco Social - Navarro Foyer – Monday, August 8, 2016, 7:30 PM – 9:30 PM

AAVP- National Center for Veterinary Parasitology (NCVP)
Parasitology Clicker Cases
Boxed Lunches Sponsored by NCVP
Navarro B – Tuesday, August 9, 2016, 10:30 AM – 12:30 PM

COFFEE BREAKS
Navarro Foyer, Saturday, August 6, 2016, 4:30 PM – 5:15 PM
Navarro Foyer, Sunday, August 7, 2016, 10:00 AM – 10:30 AM
Navarro Foyer, Sunday, August 7, 2016, 3:00 PM – 3:30 PM
Navarro Foyer, Monday, August 8, 2016, 10:00 AM – 10:30 AM
Navarro Foyer, Monday, August 8, 2016, 3:00 PM – 3:30 PM
Navarro Foyer, Monday, August 9, 2016, 10:00 AM – 10:30 AM

STUDENT FUNCTIONS
AAVP Student Member Meet and Greet
Lunch Sponsored by VIRBAC
Camino Real - Saturday, August 6, 2016, Noon – 1:15 PM

AAVP Students – Lunch, Elections, and Careers in Parasitology
Lunch Sponsored by VIRBAC
Camino Real - Monday, August 8, 2016, Noon – 1:30 PM

AAVP Students – USDA-ARS Knipling-Bushland
U.S. Livestock Insects Research Laboratory Tour in Kerrville, TX
Tuesday, August 9, 2016, 1:45 PM
Students attending the tour of the USDA-ARS Knipling-Bushland U.S. Livestock Insects Research Laboratory in Kerrville should meet in the lobby of the Westin Riverwalk hotel by 1:45 p.m. on Tuesday, August 9. Once in Kerrville, there will be an overview of the work conducted at the Tick and Biting Fly Research Unit and the Screwworm Research Unit and a tour of the facilities. The bus will return to the Comfort Inn at the San Antonio Airport by 9 p.m. on Tuesday, August 9, where rooms are provided.
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²Honorarium for AAVP-CAPC Graduate Student Award – Zoonotic Diseases
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⁴Honorarium for AAVP-Merial Distinguished Veterinary Parasitologist Award

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AAVP Welcome & Social Reception

The Fun Starts Here!

Saturday, August 6, 2016
7:30 pm - 9:30 pm
Hidalgo Ballroom at the Westin Riverwalk

Bayer is sponsoring the AAVP Welcome & Social Reception. Get the word out to your friends and colleagues, and join us for hors d’oeuvres, drinks and networking!
Please join us for lunch and an informative discussion.

**SAROLANER: THE SCIENCE BEHIND THE DISCOVERY OF AN ANIMAL HEALTH ISOXAZOLINE PARASITICIDE**

**Tom L McTier, PhD**

Sunday August 7
12:00-1:00pm

(the presentation is approximately 45 minutes)
the lunch will be in the “Navarro A” lecture hall
Ceva Animal Health is pleased to sponsor the

Wine & Cheese Socials

at the American Association of Veterinary Parasitologists
61st Annual Meeting

Sunday, August 7th, 4:45pm - 6pm
Monday, August 8th, 4:45pm-6pm

Enjoy the Meeting!
Welcome to San Antonio, TX
and the 61st Annual Meeting of the
American Association of Veterinary Parasitologists

Please Join Us
Sunday evening, August 7th 2016
Westin Riverwalk Hotel
Navarro A
6:30 – 7:30 PM
For a Merial-Sponsored Symposium

Merial Reception
Navarro Foyer 7:30 – 9:30 PM
Elanco is the proud sponsor of the presentation

“Heartworm Disease and Macro cyclic Lactones — Where are we today?”

Monday,
August 8th
7:30 p.m.
Ballroom Level
Navarro Atrium
How far does your patients’ heartworm disease prevention go?

Advantage Multi® (imidacloprid + moxidectin) pushes prevention forward

Advantage Multi® not only works reactively to kill heartworm larvae acquired during the previous month, it also goes a step further to proactively prevent heartworm disease by killing newly acquired heartworm larvae all day every day all month long.†

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Indications
Trifexis is indicated for the prevention of heartworm disease (Dirofilaria immitis). Trifexis kills fleas and is indicated for the prevention and treatment of flea infestations (Ctenocephalides felis), and the treatment and control of adult hookworm (Ancylostoma caninum), adult roundworm (Toxocara canis and Toxascaris leonina) and adult whipworm (Trichuris vulpis) infections in dogs and puppies 8 weeks of age or older and 5 pounds of body weight or greater.

Important Safety Information
Serious adverse reactions have been reported following concomitant extra-label use of ivermectin with spinosad alone, one of the components of Trifexis. Treatment with fewer than three monthly doses after the last exposure to mosquitoes may not provide complete heartworm prevention. Prior to administration of Trifexis, dogs should be tested for existing heartworm infection. Use with caution in breeding females. The safe use of Trifexis in breeding males has not been evaluated. Use with caution in dogs with pre-existing epilepsy.

The most common adverse reactions reported are vomiting, lethargy, pruritus, anorexia and diarrhea. To ensure heartworm prevention, dogs should be observed for one hour after administration. If vomiting occurs within one hour, redose. Puppies less than 14 weeks of age may experience a higher rate of vomiting. For product information, including complete safety information, see page XX.


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TRIFEXIS®
(spinosad + milbemycin oxime)
Chewable Tablets

Cautions: Federal ADA law restricts this drug to use by or on the order of a licensed veterinarian. Before using TRIFEXIS chewable tablets, please consult the product insert, a summary of which follows:

Indications:
TRIFEXIS is indicated for the prevention of heartworm disease (Dirofilaria immitis), TRIFEXIS is also indicated for the prevention and treatment of flea infestations (Ommatolcystheus felis), and the treatment and control of adult hookworm (Ankylostoma caninum), adult roundworm (Toxocara canis) and Toxocara (infect) and adult whipworm (Trichuris suis) infections in dogs and puppies 4 weeks of age or older and 3 pounds of body weight or greater.

Dosage and Administration:
TRIFEXIS is given orally, once a month at the minimum dosage of 13.5 mg/lb (30 mg/kg) spinosad and 0.2 mg/lb (0.5 mg/kg) milbemycin oxime body weight. For heartworm prevention, give once monthly for at least 3 months after exposure to mosquitoes (see EFFECTIVENESS).

Contraindications:
There are no known contraindications to the use of TRIFEXIS.

Warnings:
Not for human use. Keep this and all drugs out of the reach of children. Serious adverse reactions have been reported following concomitant extra-label use of ivermectin with spinosad alone, a component of TRIFEXIS (see ADVERSE REACTIONS).

Precautions:
Treatment with fewer than 3 monthly doses after the last exposure to mosquitoes may provide complete heartworm prevention (see EFFECTIVENESS).
Prior to administration of TRIFEXIS, dogs should be tested for existing heartworm infection. At the discretion of the veterinarian, infected dogs should be treated with an antihelminic to remove adult heartworms. TRIFEXIS is not effective against adult D. immitis. While the number of circulating microfilariae may decrease following treatment, TRIFEXIS is not indicated for microfilariae eradication.

MIS lines of sensitivity/resistance manifested as labored respiration, vomiting, salivation, and lethargy, have been noted in some dogs treated with milbemycin oxime carrying a high number of circulating microfilariae. These reactions are presumably caused by release of protein from dead or dying microfilariae.

Use with caution in breeding females. The safe use of TRIFEXIS in breeding males has not been evaluated.

Use with caution in dogs with pre-existing epilepsy (see ADVERSE REACTIONS). Puppies less than 14 weeks of age may experience a higher rate of vomiting.

Adverse Reactions:
In a well-controlled US field study, which included a total of 352 dogs (176 treated with TRIFEXIS and 176 treated with an active control), no serious adverse reactions were attributed to administration of TRIFEXIS. All reactions were regarded as mild.

Over the 180-day study period, all observations of potential adverse reactions were recorded. Reactions that occurred at an incidence >1% (average monthly rate) within any of the 6 months of observation are presented in the following table. The most frequently reported adverse reaction in dogs in the TRIFEXIS group was vomiting.

<table>
<thead>
<tr>
<th>Adverse Reaction</th>
<th>TRIFEXIS Chewable Tablets</th>
<th>Active Control Tablets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vomiting</td>
<td>6.13</td>
<td>3.08</td>
</tr>
<tr>
<td>Purpura</td>
<td>4.00</td>
<td>4.91</td>
</tr>
<tr>
<td>Leukemia</td>
<td>2.63</td>
<td>1.54</td>
</tr>
<tr>
<td>Diarrhea</td>
<td>2.25</td>
<td>1.54</td>
</tr>
<tr>
<td>Dermatitis</td>
<td>1.67</td>
<td>1.45</td>
</tr>
<tr>
<td>Skin reddening</td>
<td>1.37</td>
<td>1.26</td>
</tr>
<tr>
<td>Decrease appetite</td>
<td>1.27</td>
<td>1.35</td>
</tr>
<tr>
<td>Pica reddening</td>
<td>1.18</td>
<td>0.87</td>
</tr>
</tbody>
</table>

In the US field study, one dog administered TRIFEXIS experienced a single mild seizure 21 hours after receiving the second monthly dose. The dog remained enrolled and received four additional monthly doses after the event and completed the study without further incident. Following concomitant extra-label use of ivermectin with spinosad alone, a component of TRIFEXIS, some dogs have experienced the following clinical signs: trembling/shaking, salivation/shaking, seizures, ataxia, mydriasis, blindness and disorientation. Spinosad alone has been shown to be safe when administered concurrently with heartworm preventative at label directions.

In US and European field studies, no dogs experienced seizures when dosed with spinosad alone at the therapeutic dosage range of 13.5-27.3 mg/lb (30-40 mg/kg), including 4 dogs with pre-existing epilepsy. Four epileptic dogs that received higher than the maximum recommended dose of 27.3 mg/lb (60 mg/kg) experienced at least one seizure within the week following the second dose of spinosad, but no seizures following the third and third doses. The cause of the seizures observed in the field studies could not be determined.

For technical assistance or to report suspected adverse drug reactions, contact Elanco Animal Health at 1-888-545-5973. For additional information about adverse drug experience reporting for animal drugs, contact FDA at 1-888-FDA-VETS or http://www.fda.gov/AnimalVeterinary/SafetyHealth

Post Approval Experience (Mar 2012):
The following adverse reactions are based on post-approval adverse drug event reporting. The adverse reactions listed in decreasing order of frequency: vomiting, depression/anhagia, pruritis, anorexia, diarrhea, trembling/shaking, ataxia, seizures, hyperactivity, and skin reddening.

Effectiveness:
Heartworm Prevention:
In a well-controlled laboratory study, TRIFEXIS was 100% effective against induced heartworm infections when administered for 3 consecutive monthly doses. The two consecutive monthly doses did not provide 100% effectiveness against heartworm infection. In another well-controlled laboratory study, a single dose of TRIFEXIS was 100% effective against induced heartworm infection.

In a well-controlled laboratory study conducted with TRIFEXIS, no dogs were positive for heartworm infection as determined by heartworm antigen testing performed at the end of the study and again three months later.

Flea Treatment and Prevention:
In a well-controlled laboratory study, TRIFEXIS demonstrated 100% effectiveness on the first day following treatment and 100% effectiveness on Day 30.

In a well-controlled laboratory study, spinosad, a component of TRIFEXIS, began to kill fleas 30 minutes after administration and demonstrated 100% effectiveness within 4 hours.

For information on null

Pulmonary:
TRIFEXIS is a flavored chewable tablet. In a field study of client-owned dogs where 775 dogs were each offered TRIFEXIS once a month for 6 months, dogs voluntarily consumed 94% of the doses when offered plain as if a treat, and 30% of the doses when offered in or on food. The remaining 13% of doses were administered like other tablet medications.

Elanco, Trifexis and the disparal bar are trademarks owned or licensed by Eli Lilly and Company, its subsidiaries or affiliates.
Detect up to twice as many infections with next-generation intestinal parasite antigen testing

IDEXX Reference Laboratories intestinal parasite antigen testing uses an enzyme-linked immunosorbent assay (ELISA) to identify antigens secreted directly from the infecting hookworm, roundworm, and whipworm parasites. Avoid false negatives and detect worms in their prepatent stages, up to 30 days sooner when compared to fecal ova and parasite testing alone.

To learn more, contact your IDEXX Veterinary Diagnostic Consultant.

Strengthen the bonds.

2. Data on file at IDEXX Laboratories, Inc. Westbrook, Maine USA.

© 2016 IDEXX Laboratories, Inc. All rights reserved. • 109621-00 • All ®/TM marks are owned by IDEXX Laboratories, Inc. or its affiliates in the United States and/or other countries. The IDEXX Privacy Policy is available at idexx.com.
Bravecto kills fleas, prevents flea infestations, and kills ticks (black-legged tick, American dog tick, and brown dog tick) for 12 weeks. Bravecto also kills lone star ticks for 8 weeks.

IMPORTANT SAFETY INFORMATION: The most common adverse reactions recorded in clinical trials were vomiting, decreased appetite, diarrhea, lethargy, polydipsia, and flatulence. Bravecto has not been shown to be effective for 12-weeks’ duration in puppies less than 6 months of age. Bravecto is not effective against lone star ticks beyond 8 weeks after dosing.

References:

You want better compliance. They want better flea & tick protection.

Get it all in 1 easy chew

- Longest length of protection in a chew—up to 12 weeks!* 
- Less frequent dosing for fewer gaps in protection
- Revolutionary technology with proven safety and efficacy

Order vet-exclusive BRAVECTO® for your clinic.
Contact your MERCK Animal Health Rep or distributor partner.
BravectoVets.com

*Bravecto kills fleas, prevents flea infestations, and kills ticks (black-legged tick, American dog tick, and brown dog tick) for 12 weeks. Bravecto also kills lone star ticks for 8 weeks.
BRIEF SUMMARY (For full Prescribing Information, see package insert)

Caution:
Federal (USA) law restricts this drug to use by or on the order of a licensed veterinarian.

Indications:
Bravecto kills adult fleas and is indicated for the treatment and prevention of flea infestations (Ctenocephalides felis) and the treatment and control of tick infestations (Ixodes scapularis (black-legged tick), Dermacentor variabilis (American dog tick), and Rhipicephalus sanguineus (brown dog tick)) for 12 weeks in dogs and puppies 6 months of age and older, and weighing 4.4 pounds or greater.

Bravecto is also indicated for the treatment and control of Amblyomma americanum (lone star tick) infestations for 8 weeks in dogs and puppies 6 months of age and older, and weighing 4.4 pounds or greater.

Contraindications:
There are no known contraindications for the use of the product.

Warnings:
Not for human use. Keep this and all drugs out of the reach of children. Keep the product in the original packaging until use, in order to prevent children from getting direct access to the product. Do not eat, drink or smoke while handling the product. Wash hands thoroughly with soap and water immediately after use of the product.

Precautions:
Bravecto has not been shown to be effective for 12-weeks duration in puppies less than 6 months of age. Bravecto is not effective against Amblyomma americanum ticks beyond 8 weeks after dosing.

Adverse Reactions:
In a well-controlled U.S. field study, which included 294 dogs (224 dogs were administered Bravecto every 12 weeks and 70 dogs were administered an oral active control every 4 weeks and were provided with a tick collar); there were no serious adverse reactions. All potential adverse reactions were recorded in dogs treated with Bravecto over a 182-day period and in dogs treated with the active control over an 84-day period. The most frequently reported adverse reaction in dogs in the Bravecto and active control groups was vomiting.

Percentage of Dogs with Adverse Reactions in the Field Study

<table>
<thead>
<tr>
<th>Adverse Reaction (AR)</th>
<th>Bravecto Group: Percentage of Dogs with the AR During the 182-Day Study (n=224 dogs)</th>
<th>Active Control Group: Percentage of Dogs with the AR During the 84-Day Study (n=70 dogs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vomiting</td>
<td>7.1</td>
<td>14.3</td>
</tr>
<tr>
<td>Decreased Appetite</td>
<td>6.7</td>
<td>0.0</td>
</tr>
<tr>
<td>Diarrhea</td>
<td>4.9</td>
<td>2.9</td>
</tr>
<tr>
<td>Lethargy</td>
<td>5.4</td>
<td>7.1</td>
</tr>
<tr>
<td>Polydipsia</td>
<td>1.8</td>
<td>4.3</td>
</tr>
<tr>
<td>Flatulence</td>
<td>1.3</td>
<td>0.0</td>
</tr>
</tbody>
</table>

In a well-controlled laboratory dose confirmation study, one dog developed edema and hyperemia of the upper lips within 90 minutes of receiving Bravecto. The edema improved progressively through the day and had resolved without medical intervention by the next morning.

For technical assistance or to report a suspected adverse drug reaction, contact Merck Animal Health at 1-800-224-5318. Additional information can be found at www.bravecto.com. For additional information about adverse drug experience reporting for animal drugs, contact FDA at 1-888-FDA-VETS or online at http://www.fda.gov/AnimalVeterinary/SafetyHealth.

How Supplied:
Bravecto is available in five strengths (112.5, 250, 500, 1000, and 1400 mg fluralaner per chew). Each chew is packaged individually into aluminum foil blister packs sealed with a peelable paper backed foil lid stock. Product may be packaged in 1, 2, or 4 chews per package.

Distributed by:
Intervet Inc (d/b/a Merck Animal Health)
Summit, NJ 07901

Made in Austria

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141487 R2
Available by veterinary prescription only.
FLEA AND TICK control
dogs run to, not from...

NexGard® *(afoxolaner)* for dogs is:

**POWERFUL** so it keeps killing fleas
and ticks all month long

**EASY** to give because it’s soft
and beef-flavored

**IMPORTANT SAFETY INFORMATION:** NexGard is for use in dogs only. The most frequently reported adverse reactions included vomiting, dry/flaky skin, diarrhea, lethargy, and lack of appetite. The safe use of NexGard in pregnant, breeding, or lactating dogs has not been evaluated. Use with caution in dogs with a history of seizures. For more information, see full prescribing information or visit www.NexGardForDogs.com.

1 Data on file at Merial.

©2015 Merial, Inc., Duluth, GA. All rights reserved. NEX16TRALED (01/16).
**CAUTION:** Federal (USA) law restricts this drug to use by or on the order of a licensed veterinarian.

**Description:**
Nexgard® (afoxolaner) is available in four sizes of beef-flavored, soft chewables for oral administration to dogs and puppies according to their weight. Each chewable is formulated to provide a minimum afoxolaner dosage of 1.14 mg/lb (2.5 mg/kg).

Afoxolaner has the chemical composition 1-Naphthalenecarboxamide, 4-[3-chloro-5-(trifluoromethyl)-phenyl]-4, 5-dihydro-5-(trifluoromethyl)-3-isoxazolyl-N-[(2,2,2-trifluoroethyl)amino]ethyl). 

**Indications:**
Nexgard kills adult fleas and is indicated for the treatment and prevention of flea infestations (Ctenocephalides felis), and the treatment and control of Black-legged tick (Acaulis scapularis), American dog tick (Dermacentor variabilis), Lone Star tick (Amblyomma americanum) and Brown dog tick (Rhipicephalus sanguineus) infestations in dogs and puppies 8 weeks of age and older, weighing 4 pounds of weight or greater, for one month.

**Dosage and Administration:**
Nexgard is given orally once a month, at the minimum dosage of 1.14 mg/lb (2.5 mg/kg).

**Dosing Schedule:**

<table>
<thead>
<tr>
<th>Weight Range</th>
<th>Afoxolaner Per Chewable (mg)</th>
<th>Chewables Administered</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.0 to 10.0 lbs.</td>
<td>1.1</td>
<td>One</td>
</tr>
<tr>
<td>10.1 to 24.0 lbs.</td>
<td>28.3</td>
<td>One</td>
</tr>
<tr>
<td>24.1 to 60.0 lbs.</td>
<td>68</td>
<td>One</td>
</tr>
<tr>
<td>60.1 to 121.0 lbs.</td>
<td>136</td>
<td>One</td>
</tr>
<tr>
<td>Over 121.0 lbs.</td>
<td>Administer the appropriate combination of chewables</td>
<td></td>
</tr>
</tbody>
</table>

Nexgard can be administered with or without food. Care should be taken that the dog consumes the complete dose, and treated animals should be observed for a few minutes to ensure that part of the dose is not lost or refused. If it is suspected that any of the dose has been lost or if vomiting occurs within two hours of administration, redose with another full dose. If a dose is missed, administer Nexgard and resume a monthly dosing schedule.

**Flea Treatment and Prevention:**
Treatment with Nexgard may begin at any time of the year. In areas where fleas are common year-round, monthly treatment with Nexgard should continue the entire year without interruption.

To minimize the likelihood of flea reinfestation, it is important to treat all animals within a household with an approved flea control product.

**Tick Treatment and Control:**
Treatment with Nexgard may begin at any time of the year (see Effectiveness).

**Contraindications:**
There are no known contraindications for the use of Nexgard.

**Warnings:**
Not for use in humans. Keep this and all drugs out of the reach of children. In case of accidental ingestion, contact a physician immediately.

**Precautions:**
The safe use of Nexgard in breeding, pregnant or lactating dogs has not been evaluated. Use with caution in dogs with a history of seizures (see Adverse Reactions).

**Adverse Reactions:**
In a well-controlled US field study, which included a total of 333 households and 615 treated dogs (415 administered afoxolaner, 200 administered active control), no serious adverse reactions were observed with Nexgard.

Over the 90-day study period, all observations of potential adverse reactions were recorded. The most frequent reactions reported at an incidence of > 1% within any of the three months of observations are presented in the following table. The most frequently reported adverse reaction was vomiting. The occurrence of vomiting was generally self-limiting and of short duration and tended to decrease with subsequent doses in both groups. Five treated dogs experienced anorexia during the study, and two of those dogs experienced anorexia with the first dose but not subsequent doses.

**Table 1: Dogs With Adverse Reactions.**

<table>
<thead>
<tr>
<th>Treatment Group</th>
<th>Afoxolaner</th>
<th>Oral active control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% (n=415)</td>
<td>% (n=200)</td>
</tr>
<tr>
<td>Vomiting (with and without blood)</td>
<td>17</td>
<td>4.1</td>
</tr>
<tr>
<td>Dry/Franky Skin</td>
<td>13</td>
<td>3.1</td>
</tr>
<tr>
<td>Diarrhea (with and without blood)</td>
<td>13</td>
<td>3.1</td>
</tr>
<tr>
<td>Leathy</td>
<td>7</td>
<td>1.7</td>
</tr>
<tr>
<td>Anorexia</td>
<td>5</td>
<td>1.2</td>
</tr>
</tbody>
</table>

1Number of dogs in the afoxolaner treatment group with the identified abnormality.
2Number of dogs in the control group with the identified abnormality.

**Effectiveness:**
In a well-controlled laboratory study, Nexgard began to kill fleas four hours after initial administration and demonstrated >99% effectiveness at eight hours. In a separate well-controlled laboratory study, Nexgard demonstrated 100% effectiveness against adult fleas 24 hours post-inestation for 35 days, and was >93% effective at 12 hours post-inestation through Day 21, and on Day 35. On Day 28, Nexgard was 81.1% effective 12 hours post-inestation. Dogs in both the treated and control groups that were infested with fleas on Day 1 generated flea eggs at 12- and 24-hours post-treatment (0-11 eggs and 11-17 eggs in the Nexgard treated dogs, and 4-80 eggs and 0-118 eggs in the control dogs, at 12- and 24-hours, respectively). At subsequent evaluations post-inestation, fleas from dogs in the treated group were essentially unable to produce any eggs (0-1 eggs) while fleas from dogs in the control group continued to produce eggs (1-141 eggs).

In a 90-day US field study conducted in households with existing flea infestations of varying severity, the effectiveness of Nexgard against fleas on the Day 30, 60 and 90 visits compared with baseline was 98%, 99.7%, and 99.9%, respectively. Collectively, the data from the three studies (two laboratory and one field) demonstrate that Nexgard kills fleas before they can lay eggs, thus preventing subsequent flea infestations after the start of treatment of existing flea infestations.

In well-controlled laboratory studies, Nexgard demonstrated >97% effectiveness against Dermacentor variabilis, >84% effectiveness against Ixodes scapularis, and >93% effectiveness against Rhipicephalus sanguineus; 48 hours post-inestation for 30 days. At 72 hours post-inestation, Nexgard demonstrated >97% effectiveness against Amblyomma americanum for 30 days.

**Animal Safety:**
In a margin of safety study, Nexgard was administered orally to 8 to 9-week-old Beagle puppies at 1, 3, and 5 times the maximum exposure dose (6.3 mg/kg) for three treatments every 28 days, followed by three treatments every 14 days, for a total of six treatments. Dogs in the control group were sham-dosed. There were no clinically-relevant effects related to treatment on physical examination, body weight, food consumption, clinical pathology (hematology, clinical chemistries, or coagulation tests), gross pathology, histopathology or organ weights. Vomiting occurred throughout the study, with a similar incidence in the treated and control groups, including one dog in the 5x group that vomited four hours after treatment.

In a well-controlled field study, Nexgard was used concomitantly with other medications, such as vaccines, anthelmintics, antibiotics (including topicals), steroids, NSAIDs, anesthetics, and antihistamines. No adverse reactions were observed from the concomitant use of Nexgard with other medications.

**Storage Information:**
Store at or below 30°C (86°F) with excursions permitted up to 40°C (104°F).

**How Supplied:**
Nexgard is available in four sizes of beef-flavored soft chewables: 11.3, 28.3, 68 or 136 mg afoxolaner. Each chewable size is available in color-coded packages of 1, 3 or 6.

NADA 141-408, Approved by FDA
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Duluth, GA 30096-4640 USA

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1050-4839-03
Rev. 1/2015
Flea and tick protection that goes on and on and on...all month long

Introducing Simparica

Monthly chewables for dogs that offer persistent protection from fleas and ticks.¹

Simparica acts fast—it starts killing fleas within 3 hours and ticks within 8 hours*—and keeps going strong for 35 days* without losing effectiveness at the end of the month.¹

IMPORTANT SAFETY INFORMATION: Simparica is for use only in dogs, 6 months of age and older. Simparica may cause abnormal neurologic signs such as tremors, decreased conscious proprioception, ataxia, decreased or absent menace, and/or seizures. Simparica has not been evaluated in dogs that are pregnant, breeding or lactating. Simparica has been safely used in dogs treated with commonly prescribed vaccines, parasiticides and other medications. The most frequently reported adverse reactions were vomiting and diarrhea. See full Prescribing Information on the back of this page and at www.zoetisUS.com/SimparicaPI.

*Studies show Simparica starts killing ticks in 8 hours and is ≥96.9% effective for 35 days against weekly reinfestations of Amblyomma americanum, Amblyomma maculatum, Dermacentor variabilis, and Rhipicephalus sanguineus.¹⁶


Fetch more information about Simparica from Zoetis Customer Service at 1-888-ZOETIS-1 or 1-888-963-8471.
FOR ORAL USE IN DOGS ONLY

CAUTION: Federal (USA) law restricts this drug to use by or on the order of a licensed veterinarian.

Description: SIMPARICA is a flavored, chewable tablet for administration to dogs over 6 months of age according to their weight. Each tablet is formulated to provide a minimum sarolaner dosage of 0.91 mg/lb (2 mg/kg) body weight.

Sarolaner is a member of the isoxazoline class of parasiticides and the chemical name is 1-(5’-((5S)-5-(3,5-dichloro-4-fluorophenyl)-5-(trifluoromethyl)-4,5-dihydroisoxazol-3-yl)-3H-spiro(aetidine-3,3’-(2-benzofuran)-1-y)-2-(methylsulfonylethyl)ethaneone. SIMPARICA contains the S-enantiomer of sarolaner. The chemical structure of the S-enantiomer of sarolaner is:

Indications: SIMPARICA kills adult fleas, and is indicated for the treatment and prevention of flea infestations (Ctenocephalides felis), and the treatment and control of tick infestations (Amblyomma americanum (Lone Star tick), Amblyomma maculatum (Gulf Coast tick), Dermacentor variabilis (American dog tick), and Rhipicephalus sanguineus (brown dog tick)) for one month in dogs 6 months of age or older and weighing 2.8 pounds or more.

Dosage and Administration: SIMPARICA is given orally once a month at the recommended minimum dosage of 0.91 mg/lb (2 mg/kg). SIMPARICA can be offered by hand, in the food, or administered like other tablet medications. Care should be taken that the dog consumes the complete dose, and treated animals should be observed for a few minutes to ensure that part of the dose is not lost or refused. If a dose is missed, administer SIMPARICA and resume a monthly dosage schedule. SIMPARICA should be administered at monthly intervals.

Flea Treatment and Prevention: Treatment with SIMPARICA may begin at any time of the year. In areas where fleas are common year-round, monthly treatment with SIMPARICA can continue the entire year without interruption. To minimize the likelihood of flea re-infestation, it is important to treat all dogs and cats within a household with an approved flea control product. Treatment with SIMPARICA can begin at any time of the year (see Effectiveness).

Contraindications: There are no known contraindications for the use of SIMPARICA.

Warnings: Not for use in humans. Keep this and all drugs out of reach of children and pets. For use in dogs only. Do not use SIMPARICA in cats.

SAROLANER should not be used in dogs less than 6 months of age (see Animal Safety).

Precautions: SIMPARICA may cause abnormal neurologic signs such as tremors, decreased conscious proprioception, ataxia, decreased or absent menace, and/or seizures (see Animal Safety). The safe use of SIMPARICA has not been evaluated in breeding, pregnant, or lactating dogs.

Adverse Reactions: SIMPARICA was administered in a well-controlled US field study, which included a total of 479 dogs (315 dogs treated with SIMPARICA and 164 dogs treated with active control once monthly for three treatments). Over the 90-day study period, all observations of potential adverse reactions were recorded. Table 1. Dogs with adverse reactions:

<table>
<thead>
<tr>
<th>Body Weight</th>
<th>SAROLANER per Tablet (mg)</th>
<th>Number of Tablets Administered</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.8 to 5.5 lbs</td>
<td>5</td>
<td>One</td>
</tr>
<tr>
<td>5.6 to 10.0 lbs</td>
<td>10</td>
<td>One</td>
</tr>
<tr>
<td>11.1 to 22.0 lbs</td>
<td>20</td>
<td>One</td>
</tr>
<tr>
<td>22.1 to 44.0 lbs</td>
<td>40</td>
<td>One</td>
</tr>
<tr>
<td>44.1 to 88.0 lbs</td>
<td>80</td>
<td>One</td>
</tr>
<tr>
<td>&gt;88.1 to 132.0 lbs</td>
<td>120</td>
<td>One</td>
</tr>
</tbody>
</table>

SIMPARICA can be offered by hand, in the food, or administered like other tablet medications. Care should be taken that the dog consumes the complete dose, and treated animals should be observed for a few minutes to ensure that part of the dose is not lost or refused. If a dose is missed, administer SIMPARICA and resume a monthly dosage schedule. SIMPARICA should be administered at monthly intervals.

Flea Treatment and Prevention: Treatment with SIMPARICA may begin at any time of the year. In areas where fleas are common year-round, monthly treatment with SIMPARICA can continue the entire year without interruption. To minimize the likelihood of flea re-infestation, it is important to treat all dogs and cats within a household with an approved flea control product. Treatment with SIMPARICA can begin at any time of the year (see Effectiveness).

Contraindications: There are no known contraindications for the use of SIMPARICA.

Warnings: Not for use in humans. Keep this and all drugs out of reach of children and pets. For use in dogs only. Do not use SIMPARICA in cats.

SAROLANER should not be used in dogs less than 6 months of age (see Animal Safety).

Precautions: SIMPARICA may cause abnormal neurologic signs such as tremors, decreased conscious proprioception, ataxia, decreased or absent menace, and/or seizures (see Animal Safety). The safe use of SIMPARICA has not been evaluated in breeding, pregnant, or lactating dogs.

Adverse Reactions: SIMPARICA was administered in a well-controlled US field study, which included a total of 479 dogs (315 dogs treated with SIMPARICA and 164 dogs treated with active control once monthly for three treatments). Over the 90-day study period, all observations of potential adverse reactions were recorded. Table 1. Dogs with adverse reactions:

<table>
<thead>
<tr>
<th>Adverse reaction</th>
<th>sarolaner</th>
<th>sarolaner</th>
<th>active control</th>
<th>active control</th>
</tr>
</thead>
<tbody>
<tr>
<td>N % (n = 315) N % (n = 164)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vomiting</td>
<td>3</td>
<td>0.95% (19)</td>
<td>9</td>
<td>5.50% (9)</td>
</tr>
<tr>
<td>Diarrhea</td>
<td>2</td>
<td>0.63% (12)</td>
<td>2</td>
<td>1.20% (12)</td>
</tr>
<tr>
<td>Lethargy</td>
<td>1</td>
<td>0.32% (3)</td>
<td>2</td>
<td>1.20% (3)</td>
</tr>
<tr>
<td>Inappetence</td>
<td>0</td>
<td>0% (0)</td>
<td>3</td>
<td>1.80% (3)</td>
</tr>
</tbody>
</table>

Additionally, one female dog aged 8.6 years exhibited lethargy, ataxia while posturing to eliminate, elevated third eyelids, and inappetence one day after receiving SIMPARICA concurrently with a heartworm preventative (ivermectin/pyrantel pamoate). The signs resolved one day later. After the day 14 visit, the owner elected to withdraw the dog from the study.
ANIMAL HEALTH
Discovery & Development services include:

- High-Throughput Anti-Parasitic Screening Assays to ID Chemical Series of Interest – Endoparasites (Canine Heartworm, Gastrointestinal Nematodes, Protozoans) – Ectoparasites (Flea, Tick, Biting Fly, Mosquito)
- Unique Parasitology Platform – Over 30 parasite species relevant to animal and human health – Assays & screening paradigms for the progression of compounds to development – in vitro and in vivo models – in vitro ADMET – in vivo DMPK
- Comprehensive Pharmaceutical Development Services – Integrated Bioanalytical Laboratory – Medicinal Chemistry Laboratory – CMC services, Process Formulation, Analytical Development, GMP Manufacturing

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GLP/GCP studies: Parasitology, Microbiology, Animal Production, Safety, PK
E.G. Johnson DVM; Jenifer Edmonds DVM, PhD;
Matthew Edmonds DVM, PhD; Jeff Johnson, CEO
Evin Sharmin, Ph.D., PAS; Kim Ichikawa, M.A.

ENVISION A PARTNER WITH MORE.

When you want more from your CRO, look to MPI Research.

RESEARCH MANAGEMENT GROUP

Contract Monitoring
Protocol Development
Data Management
Report Preparation

Matt Edmonds, DVM, Ph.D
Evin Sharmin, Ph.D., PAS
Kim Ichikawa, M.A.

024007 Hwy 20/26 0 Parma, ID 83660 0 208-722-5829 0 matt.edmonds@rmgvs.com

36
The Westin Riverwalk Floor Plan

**Ballroom Level**

**Lobby Level**
# 2016 AAVP Program

## Oral Presentations

<table>
<thead>
<tr>
<th>Time</th>
<th>Event Description</th>
</tr>
</thead>
</table>
| 8.00-13.15 | AAVP Executive Committee Meeting  
All AAVP officers and committee chairs please plan to attend  
Room: Madero |
| 12.00-13.15| AAVP Student Member Meet and Greet - All Students Please Attend  
Luncheon Sponsored by Virbac  
Room: Camino Real |
| 13.00-17.00| CONFERENCE REGISTRATION (Navarro Foyer)  
Break (no refreshments) |
| 13.15-14.00| PLENARY SESSION: NEW VISTAS IN HOST-PARASITE INTERACTIONS  
Room: Navarro A |
| 14.00-16.30| Opening remarks  
AAVP President: Ray M. Kaplan  
AAVP President-Elect and Program Chair: Timothy G. Geary |
| 14.00-14.15| Opening remarks  
AAVP President: Ray M. Kaplan  
AAVP President-Elect and Program Chair: Timothy G. Geary |
| 14.15-16.30| PLENARY SESSION  
Moderator: Timothy G. Geary  
1. Parasitic nematode functional genomics – fit for purpose?  
   Angela Mousley  
   Queen’s University - Belfast  
2. Parasite microRNAs: key regulators and potential control targets  
   Collette Britton  
   University of Glasgow  
3. Novel synthetic biology approaches to combat drug resistance in parasites of terrestrial and aquatic animals  
   Rick Peterson  
   Intrexon |
| 16.30-17.15| Coffee Break (Navarro Foyer) |
| 17.15-18.30| AAVP AWARDS  
Room: Hidalgo |
| 17.15-17.45| 2016 AAVP-Merck Animal Health Outstanding Graduate Student  
Moderator: Tom McTier  
4. Ecoepidemiology of Trypanosoma cruzi in the US  
Awarded to Rachel Curtis-Robles |
| 17.45-18.30| 2016 AAVP-Merial Distinguished Veterinary Parasitologist  
Moderator: Doug Carithers  
Awarded to Anne Zajac |
| 18.30-19.15| Bayer Symposium  
Room: Hidalgo |
| 19.15-19.30| Break (no refreshments) |
| 19.30-21.30| BAYER OPENING NIGHT SOCIAL  
Room: Hidalgo |
### American Association of Veterinary Parasitologists – 61st Annual Meeting  
**August 6th – 9th 2016, San Antonio, Texas, USA**

#### Sunday August 7, 2016

<table>
<thead>
<tr>
<th>Time</th>
<th>Session 1: Ectoparasites</th>
<th>Session 2: Molecular and Biochemical - 1</th>
<th>Session 3: Heartworm</th>
<th>Session 4: Treatment/Control</th>
</tr>
</thead>
</table>
| 8.30-10.00 | **Room:** Navarro A  
 **Moderators:** M. Reichard, N. Valenzuela | **Room:** Navarro B  
 **Moderators:** J. Gilleard, C. Ballesteros | **Room:** Navarro A  
 **Moderators:** A. Moorhead, J. Evans | **Room:** Navarro B  
 **Moderators:** B. Hayes, J. Scare |
| 8.30-10.00 | 5. Assessment of the onset and residual speed of kill against fleas of a topical Dinotefuran-Fipronil ectoparasiticide on cats over 6 weeks  
 Romain Delcombel  
 Ceva Santé Animale | 11. Identification of semiochemicals attractive to black flies of the Simulium vittatum complex, putative vectors of Onchocerca spp.  
 **Guilherme Verocai**  
 University of Georgia | **Room:** Navarro A  
 **Moderators:** A. Moorhead, J. Evans | 23. Strong immune response and significant parasite burden reduction induced by Cryptosporidium parvum gp45 surface protein: a promising vaccine candidate against bovine cryptosporidiosis  
 **Karina Sonzogni-Desautels**  
 McGill University |
| 8.30-10.00 | 6. Evaluation of fluralaner and afoxolaner treatments to control flea populations, reduce pruritus and minimize dermatologic lesions in naturally infested dogs in private residences in West Central FL, USA  
 **Michael Dryden**  
 Kansas State University | 12. Cystic echinococcosis in cattle slaughtered in Santiago, Chile: Prevalence, distribution, genotype and hydatid cyst fertility.  
 **Felipe Correa**  
 Universidad Andres Bello | **Room:** Navarro A  
 **Moderators:** A. Moorhead, J. Evans | 24. Screening for candidates to block transmission of vector borne apicomplexan parasites  
 **Brian Shiels**  
 University of Glasgow |
| 9.00-10.15 | 7. Therapeutic and residual speed of kill against adult fleas over 1 month of a topical dinotefuran-permethrin-pyriproxyfen combination when used on dogs at the minimal recommended dose  
 **Marie Varloud**  
 Ceva Santé Animale | 13. Investigating the molecular epidemiology of benzimidazole resistance in trichostrongylid nematodes using deep amplicon sequencing of the isotope-1 B-tubulin locus  
 **John Gilleard**  
 University of Calgary | **Room:** Navarro A  
 **Moderators:** A. Moorhead, J. Evans | 25. Larvicidal efficacy against mucosal equine strongyles  
 **Kristen Krebs**  
 University of Kentucky |
 **Byron Blagburn**  
 Auburn University | 14. The use of deep amplicon sequencing to investigate the impact of ivermectin treatment on gastrointestinal nematode communities in Canadian cattle  
 **Russell Avramenko**  
 University of Calgary | **Room:** Navarro A  
 **Moderators:** A. Moorhead, J. Evans | 26. Scanning and transmission electron microscopy of Haemonchus contortus exposed to cranberry vine in vivo  
 **Carly Barone**  
 University of Rhode Island |
| 9.30-10.00 | 9. Update on acaricide resistance in the Southern Cattle Tick (Rhipicephalus microplus) in South America and multiple resistance to acaricides in Southern Brazil: where do we go from here?  
 **Guilherme Klafke**  
 Instituto de Pesquisas Veterinárias “Desiderio Finamor”-FEPAGRO/RS | 15. Deep amplicon sequencing assays to investigate gastro-intestinal nematode species distribution and anthelmintic resistance in Western Canadian sheep flocks  
 **Camila de Queiroz**  
 University of Calgary | **Room:** Navarro A  
 **Moderators:** A. Moorhead, J. Evans | **Room:** Navarro B  
 **Moderators:** B. Hayes, J. Scare |
| 9.45-10.00 | 10. Risk factors associated with multiple drug resistance development in cattle tick populations from Rio Grande do Sul, Brazil, series  
 **Guilherme Klafke**  
 Instituto de Pesquisas Veterinárias “Desiderio Finamor”-FEPAGRO/RS | 16. Identifying and quantifying common GI nematodes of cattle using PCR and high resolution, size fragment analysis  
 **Dante Zarlenga**  
 USDA - Beltsville | **Room:** Navarro A  
 **Moderators:** A. Moorhead, J. Evans | **Room:** Navarro B  
 **Moderators:** B. Hayes, J. Scare |
| 10.00-10.30 | **Coffee Break (Navarro Foyer)** | | **Room:** Navarro A  
 **Moderators:** A. Moorhead, J. Evans | **Room:** Navarro B  
 **Moderators:** B. Hayes, J. Scare |
| 10.30-12.00 | **Session 3: Heartworm**  
 **Room:** Navarro A  
 **Moderators:** A. Moorhead, J. Evans | | **Room:** Navarro B  
 **Moderators:** B. Hayes, J. Scare | **Room:** Navarro B  
 **Moderators:** B. Hayes, J. Scare |
| 10.30-10.45 | 17. Assessment of parasitological and clinical findings in heartworm-infected beagles treated with Advantage Multi® and doxycycline  
 **Molly Savadelis**  
 University of Georgia | | **Room:** Navarro A  
 **Moderators:** A. Moorhead, J. Evans | 24. Screening for candidates to block transmission of vector borne apicomplexan parasites  
 **Brian Shiels**  
 University of Glasgow |
| 10.45-11.00 | 18. Prevention of canine heartworm disease and infection all month long with Advantage Multi® for dogs  
 **Dwight Bowman**  
 Cornell University | | | **Room:** Navarro B  
 **Moderators:** B. Hayes, J. Scare |
| 11.00-11.15 | 19. The safety of milbemycin oxime after administration to heartworm positive microfilaricemic dogs  
 **Daniel Snyder**  
 Elanco | | | **Room:** Navarro B  
 **Moderators:** B. Hayes, J. Scare |
| 11.15-11.30 | 20. Examination of the “susceptibility gap” in the treatment of patent canine heartworm infections  
 **Jason Drake**  
 Elanco | | | **Room:** Navarro B  
 **Moderators:** B. Hayes, J. Scare |
<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
<th>Location</th>
</tr>
</thead>
</table>
| 11.30-11.45  | 21. Blocking of the transmission of *Dirofilaria immitis* L3 (JYD-34 ML resistant strain) from infected mosquitoes to dogs and prevention of infection in dogs treated topically with dinotefuran-permethrin-pyriproxyfen and orally with milbemycin oxime alone or in combination  
*John McCall*
*TRS Labs*  |
|              | 27. In vitro effects of a novel compound (Bedoukian Research) on poultry *Eimeria* spp. development and excystation  
*Vicky Kelly*
*Louisiana State University* |
| 11.45-12.00  | 22. *Dirofilaria immitis*: P-glycoproteins, macrocyclic lactones and resistance to heartworm preventives  
*Roger Prichard*
*McGill University*  |
|              | 28. In vitro and molecular approaches for investigating the pharmacology of larval toxocariasis  
*Jeba Jesudoss*
*Chelladurai*
*Iowa State University* |
| 12.00-13.30  | **Zoetis Lunch Symposium**  
Moderator: Joyce Logan  
**Discovery and dose determination of Sarolaner, a novel isoxazoline ectoparasiticide for dogs**  
**Speaker:** *Tom McTier*  
**Room:** *Navarro A* |
| 13.30-17.00  | **CONCURRENT SCIENTIFIC SESSIONS** |
| 13.30-15.00  | **Session 5: Sarolaner for Ectoparasite Control**  
Room: *Navarro A*  
**Moderators:** G. Conboy, C. Pualski  
**29. Sarolaner (Simparica™) efficacy and speed of kill against adult fleas on dogs**  
*Steven Maeder*
*Zoetis*  |
|              | **30. Evaluation of the effects of sarolaner (Simparica™) on flea reproduction and effectiveness in a simulated infested-home environment**  
*Sara Chapin*
*Zoetis*  |
| 13.30-13.45  | **31. Field efficacy and safety of sarolaner (Simparica™) against fleas on dogs in the United States**  
*Robert Six*
*Zoetis*  |
|              | **32. Efficacy of sarolaner (Simparica™) against adult *Amblyomma americanum*, *A. maculatum*, *Dermacentor variabilis*, *Ixodes scapularis* and *Rhipicephalus sanguineus* on dogs**  
*Steven Maeder*
*Zoetis*  |
| 13.45-14.00  | **33. Parasite dynamics in naturally infected and untreated horse foals**  
*Julia Fabiani*
*University of Kentucky*  |
| 14.00-14.15  | **34. Comparative efficacy of sarolaner (Simparica™) and afoxolaner (NexGard®) against *Ixodes scapularis* infestations on dogs**  
*Robert Six*
*Zoetis*  |
| 14.15-14.30  | **35. Dynamics of Cooperia oncophora establishment in calves**  
*Christian Sauermann*
*AgResearch New Zealand*  |
| 14.30-14.45  | **36. Comparison of fecal egg counting methods in four livestock species**  
*Kelsey Paras*
*University of Georgia*  |
|               | **38. Serological detection of antibodies against Babesia caballi and Theileria equi in Brazilian equids**  
*Bruno Alves*
*Universidade Federal Rural de Pernambuco*  |
| 14.45-15.00  | **39. Immunologic detection of *Giardia duodenalis* in a specific pathogen free captive olive baboon (Papio cynocephalus anubis) colony**  
*Meriam Saleh*
*Virginia Tech*  |
| 15.00-15.30  | **Coffee Break (Navarro Foyer)** |
| 15.30-17.00  | **Session 7: Molecular and Biochemical - 2**  
Room: *Navarro A*  
**Moderators:** G. Zhu, B. Russ  
**40. *Dirofilaria immitis* exhibits sex- and stage-specific differences in excretory/secretory miRNA and protein profiles**  
*Timothy Geary*
*McGill University*  |
| 15.30-15.45  | **Session 8: Novel Cases**  
Room: *Navarro B*  
**Moderators:** A. Zajac, J. Rodriguez  
**44. Immunochemical detection of *Giardia duodenalis* in a specific pathogen free captive olive baboon (Papio cynocephalus anubis) colony**  
*Meriam Saleh*
*Virginia Tech* |
## Sunday August 7, 2016 (continued)

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
<th>Speaker(s)</th>
<th>Affiliation</th>
</tr>
</thead>
</table>
| 15.45-16.00 | 41. Transcriptomic study on ovine immune responses to *Fasciola hepatica* infection  
Yan Fu  
University College Dublin  
47. Detection of circulating *Sarcocystis* sp. in a cat with FIV  
Antoinette Marsh  
Ohio State University | 47. Yan Fu  
University College Dublin  
47. Antoinette Marsh  
Ohio State University |
| 16.00-16.15 | 42. Infection with *Haemonchus contortus* shifts genera diversity of fecal microbiome  
Cody Elkins  
West Virginia University | 48. Cody Elkins  
West Virginia University |
| 16.15-16.30 | 43. Development of microsatellite markers for *Dicrocoelium dendriticum* and their application to investigate parasite epidemiology and transmission  
John Gilleard  
University of Calgary | 49. John Gilleard  
University of Calgary |
| 16.30-16.45 | 44. Investigating changes in trichostrongyloid nematode community composition during cattle fecal coproculture using deep-amplicon “Nemabiome” sequencing  
Russell Avramenko  
University of Calgary | 50. Russell Avramenko  
University of Calgary |
| 16.45-17.00 | 45. RNA-seq reveals differential gene expression in abomasal lymph node during *Haemonchus contortus* infection  
Denzel Middleton  
West Virginia University | 51. Denzel Middleton  
West Virginia University |

### Poster Viewing and Wine Social
Sponsored by Ceva  
Rooms: Navarro Foyer

### Break (no refreshments)

### Merial Symposium
Moderator: Doug Carithers  
Speaker: Josephus Fourie  
Room: Navarro A

### MERAL Sunday Night SOCIAL
Room: Navarro Foyer

## Monday August 8, 2016

### Monday Breakfast
Sponsored by IDEXX  
Navarro Foyer

### CONCURRENT SCIENTIFIC SESSIONS

| Time     | Session 9: Dogs and Cats: Diagnosis  
Room: Navarro A  
Moderators: D. Elsemore, S. Montoya | Session 10: Molecular and Biochemical - 3  
Room: Navarro B  
Moderators: S. Michalski, D. Middleton | 52. Analysis of heat-treated serum from macrocyclic lactone-treated heartworm-positive dogs, a controlled study  
Molly Savadelis  
University of Georgia | 58. *Cryptosporidium parvum* hexokinase: a potential drug target for developing novel therapeutics  
Rana Eltahan  
Texas A&M University |
|----------|--------------------------------------------------------------------------------|---------------------------------------------------------|------------------------------------------------|
| 8.30-10.00 | 53. Do as the humans do: Detecting circulating antigens in dogs infected with *Heterobilharzia americana*  
Jessica Rodriguez  
Texas A&M University | 59. *Cryptosporidium lactate* dehydrogenase is associated with the parasitophorous vacuole membrane and is a potential target for developing therapeutics  
Haili Zhang  
Texas A&M University |
<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
<th>Topic</th>
<th>Speaker</th>
<th>Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.00-9.15</td>
<td>54.</td>
<td>In vivo quantification of <em>Dipylidium caninum</em> and <em>Toxascaris leonina</em> in experimentally infected dogs</td>
<td>Alice Lee</td>
<td>Cornell University</td>
</tr>
<tr>
<td>9.15-9.30</td>
<td>55.</td>
<td>Baermann fecal examination survey of lungworm infection in clinically affected dogs in Ontario and Quebec, Canada.</td>
<td>Gary Conboy</td>
<td>Atlantic Veterinary College</td>
</tr>
<tr>
<td>9.30-9.45</td>
<td>56.</td>
<td>A multicenter study demonstrating the added benefit of coproantigen testing to fecal flotation methods in the diagnosis of canine ascarid, hookworm and whipworm infections</td>
<td>Araceli Lucio-Foster</td>
<td>Cornell University</td>
</tr>
<tr>
<td>9.45-10.00</td>
<td>57.</td>
<td>Teaching Diagnostic Parasitology: Results on <em>Giardia</em> and the Telephone Game</td>
<td>Antoinette Marsh</td>
<td>Ohio State University</td>
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<tr>
<td>10.00-10.30</td>
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<td>Coffee Break (Navarro Foyer)</td>
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<tr>
<td>10.30-12.00</td>
<td></td>
<td>AAVP Business Meeting &amp; Awards</td>
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<td></td>
<td>AAVP Executive Committee, Student Officers, Corporate Sponsor representatives, and Awardees stay for pictures</td>
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<tr>
<td>12.00-13.30</td>
<td></td>
<td>AAVP Students - Lunch, Elections, and Careers in Parasitology</td>
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<td>Luncheon Sponsored by Virbac</td>
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<td>Room: Camino Real</td>
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<tr>
<td>13.30-17.00</td>
<td></td>
<td>CONCURRENT SCIENTIFIC SESSIONS</td>
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<tr>
<td>13.30-15.00</td>
<td>Session 11: Anthelmintic Resistance: Horses</td>
<td>Room: Navarro A</td>
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<td></td>
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<td>Moderators: R. Prichard, K. Paras</td>
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<tr>
<td>13.30-13.45</td>
<td>64.</td>
<td>Combination deworming - a possible solution or source of exacerbation for the disappearing drug classes?</td>
<td>Jessica Scare</td>
<td>University of Kentucky</td>
</tr>
<tr>
<td>13.45-14.00</td>
<td>65.</td>
<td>Drug to target - how you administer an anthelmintic is more important than you might think</td>
<td>Dave Leathwick</td>
<td>AgResearch New Zealand</td>
</tr>
<tr>
<td>14.00-14.15</td>
<td>66.</td>
<td>Anthelmintic resistance in parasites of horses – the need to do better</td>
<td>Martin Nielsen</td>
<td>University of Kentucky</td>
</tr>
<tr>
<td>14.45-15.00</td>
<td>69.</td>
<td>How equine parasitology computer models become handy for both testing and generating hypotheses</td>
<td>Martin Nielsen</td>
<td>University of Kentucky</td>
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<tr>
<td>15.00-15.30</td>
<td></td>
<td>Coffee Break (Navarro Foyer)</td>
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<tr>
<td>Time</td>
<td>Session 13: Immunology: <em>Haemonchus contortus</em></td>
<td>Session 14: Parasitology</td>
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<tr>
<td>15:30-15:45</td>
<td>76. Quantification of <em>Haemonchus contortus</em> larval death after culture with host immune cells by measuring larval ATP Elizabeth Shepherd West Virginia University</td>
<td>82. Advances toward large scale production of <em>Acanthocheilonema viteae</em> Shelly Michalski University of Wisconsin-Oshkosh</td>
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<tr>
<td>15:45-16:00</td>
<td>77. Interleukin-4 and its downstream targets are rapidly upregulated in immune cells of St. Croix sheep exposed to <em>Haemonchus contortus</em> larval antigen in vitro Jessica Jacobs West Virginia University</td>
<td>83. In vitro cultivation of zoonotic Babesia duncani in Syrian hamster (<em>Mesocricetus auratus</em>) erythrocytes Kimberly McCormack Oklahoma State University</td>
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<tr>
<td>15:30-16:15</td>
<td>78. Serum induces <em>Haemonchus contortus</em> larval aggregation via complement and antibody complexes that differs by larval stage Javier Garza West Virginia University</td>
<td>84. The geospatial range of <em>Fasciola hepatica</em> and <em>F. gigantica</em> in Asia based on climate effects John Malone Louisiana State University</td>
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<td>16:00-16:15</td>
<td>79. <em>Haemonchus contortus</em> induced neutrophil extracellular trap formation differs between resistant and susceptible sheep breeds Javier Garza West Virginia University</td>
<td>85. Parasite associated mortality in Shortnosed (<em>Chasimistes brevirostris</em>) and Lost River Suckers (<em>Dektistes luxatus</em>) Drew Janik Oregon State University</td>
<td></td>
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<tr>
<td>16:15-16:30</td>
<td>80. RNA-Seq analysis of immune cells cultured with <em>Haemonchus contortus</em> larval antigen reveals differential gene expression in parasite resistant and susceptible sheep Jessica Jacobs West Virginia University</td>
<td>86. Parasites in laboratory zebrafish: problems and research opportunities Justin Sanders Oregon State University</td>
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<tr>
<td>16:45-17:00</td>
<td>81. <em>Haemonchus contortus</em> fourth stage larval secretory/excretory proteins inhibit serum mediated larval aggregation Javier Garza West Virginia University</td>
<td>87. Advertising of antiparasitic drugs through time Raffaele Roncalli Retired member</td>
<td></td>
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<tr>
<td>17:00-18:00</td>
<td><strong>Poster Viewing and Wine Social</strong> Sponsored by Ceva Room: Navarro Foyer</td>
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<tr>
<td>18:00-18:30</td>
<td><strong>Break</strong> (no refreshments)</td>
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<tr>
<td>17:30-18:30</td>
<td><strong>DACVM meeting (Camino Real)</strong></td>
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<td>18:30-19:30</td>
<td><strong>Elanco Symposium</strong> Moderator: Jason Drake 88. The misplaced risk of macrocyclic lactones in heartworm infected dogs Dwight Bowman Cornell University 89. Correlating genotype with phenotypic response to a macrocyclic lactone in <em>Dirofilaria immitis</em> Timothy Geary McGill University Room: Navarro A</td>
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<td>19:30-21:30</td>
<td><strong>ELANCO Monday Night SOCIAL</strong> Room: Navarro Foyer</td>
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<tr>
<td>8.30-10.00</td>
<td><strong>PRESIDENT’S SYMPOSIUM: New Vistas in Veterinary Parasite Diagnostics</strong></td>
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<td><strong>PRESIDENTS SYMPOSIUM</strong></td>
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<td>Moderator: Timothy Geary</td>
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<td><strong>Announcement of Student Winners &amp; Introduction of Speakers</strong></td>
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<td>90.</td>
<td>Intestinal parasite diagnostics—Advances in coproantigen detection</td>
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<td>David Elsemore</td>
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<td>91.</td>
<td>Macrocyclic lactone resistance in <em>Dirofilaria immitis</em>: The next phase in understanding this complex and still contentious issue</td>
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<td>Cassan Pulaski</td>
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<td>Louisiana State University</td>
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<td><strong>Student Award Winners! Please stay afterwards for group photo.</strong></td>
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<td>10.00-10.30</td>
<td><strong>Coffee Break (Navarro Foyer)</strong></td>
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<td>10.30-12.30</td>
<td><strong>AAVP-NCVP Parasitology Clicker Cases</strong></td>
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<td>Moderator: Andrew Peregrine</td>
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<td>Boxed lunches for attendees (sponsored by NCVP)</td>
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<td>12.30-</td>
<td><strong>Meeting Adjourns – Happy Trails, to You!</strong></td>
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<td>13.45 -</td>
<td><strong>AAVP Students - USDA-ARS Knipling-Bushland</strong></td>
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<td><strong>U.S. Livestock Insects Research Laboratory Tour in Kerrville, TX</strong></td>
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<td>Tuesday, August 9, 2016, 1:45 PM</td>
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|         | Students attending the tour of the USDA-ARS Knipling-Bushland U.S. Livestock Insects Research Laboratory in Kerrville should meet in the lobby of the Westin Riverwalk hotel by 1:45 p.m. on Tuesday, August 9. Once in Kerrville, there will be an overview of the work conducted at the Tick and Biting Fly Research Unit and the Screwworm Research Unit and a tour of the facilities. The bus will return to the Comfort Inn at the San Antonio Airport by 9 p.m. on Tuesday, August 9, where rooms are provided.
2016 AAVP PROGRAM
POSTER PRESENTATIONS

Please put up all posters in the Navarro Foyer by Sunday morning and leave your poster up until the end of the Monday poster viewing at 6:00 PM. Plan to stand at your poster during the afternoon wine and cheese poster social per the following schedule.

Posters 92-103 - Navarro Foyer, Sunday, August 7, 2016, 5:00 PM – 6:00 PM

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<td>Insecticidal repellency of a topical administration of dinotefuran- pyriproxyfen-permethrin spot-on (Vectra® 3D) on mice against Aedes albopictus mosquitoes. Djamel Tahir, CNRS - INSERM</td>
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<td>Lateral resistance of macrocyclic lactones compounds in Brazilian field isolates of the cattle-tick (Rhipicephalus microplus). Guilherme Klafke, Instituto de Pesquisas Veterinarias &quot;Desiderio Finamor&quot; - FEPAGRO/RS</td>
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<td>99.</td>
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<td>The effect of ivermectin on Brugia malayi females in vitro: a transcriptomic approach. Cristina Ballesteros, McGill University</td>
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<td>Double stranded RNA and Brugia malayi as agents for studying anthelmintic receptor pharmacology of parasitic nematodes. Saurabh Verma, Iowa State University</td>
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2016 ABSTRACTS

The AAVP claims copyright privileges to the non-abstract portions of this proceedings booklet and acknowledges that the copyright assignment for each abstract remains with the submitting author.

If a company, an institution or an individual wishes to reproduce and distribute our proceedings (even as an internal document), they must obtain copyright permission for each and every abstract in the book, as well as permission from the AAVP for the non-abstract portions of the book. Alternatively, they may purchase a copy of the proceedings from the AAVP for each individual who may wish to utilize the content of the book.
1 Parasitic nematode functional genomics – fit for purpose?
Angela Mousley*, Louise Atkinson, Ciaran McCoy, Nikki Marks, Aaron Maule. Queen's University Belfast, Belfast, United Kingdom

The recent growth in genomic, transcriptomic and proteomic datasets for parasitic nematodes provides a welcome gateway to the identification of putative drug targets, vaccine candidates, and diagnostic biomarkers. Indeed, omics-directed approaches to drug target identification have become widely adopted drug-finding strategies for human therapeutics, and have begun in earnest for nematode parasites where a cohort of ‘druggable’ targets, believed to have chemotherapeutic appeal due to their predicted ‘essentiality’, have been identified and prioritized in key nematode pathogens including *Haemonchus contortus*, *Ascaris suum* and *Brugia malayi* through *in silico* analyses. Despite this, a key hurdle to the exploitation of putative targets is the absence of validation tools that allow the manipulation of target function in therapeutically-relevant pathogens. Reverse genetics tools have advanced to the stage where sophisticated methods of transgenesis, gene silencing (RNA interference), and genome editing (CRISPR/Cas9 technology) are established experimental tools that are being applied to probe the biology of many organisms. Their application to nematode parasites has been eagerly awaited; however translation of these technologies has either been difficult or is in early stages of development, such that their potential to novel drug discovery in the parasitology discipline is yet to be realised. This presentation provides an overview of the genetic manipulation tools that are currently available for use in parasitic nematodes, and evaluates the advantages and limitations of these tools to the discovery of novel control targets.

2 Parasite microRNAs: key regulators and potential control targets
Collette Britton*1, Alan Winter1, Neil Marks1, Henry Gu1, Roz Laing1, Kirsty Maitland1, Graham Hamilton1, Eve Hanks1, Tom McNeilly2, Victoria Gillan1, Eileen Devaney1. 1University of Glasgow, Glasgow, United Kingdom, 2Moredun Research Institute, Edinburgh, United Kingdom

MicroRNAs (miRNAs) are small (22 nucleotide), non-coding RNAs that regulate gene expression at the post-transcriptional level. They are expressed in a diverse range of organisms from viruses to humans. We are examining miRNAs in parasitic nematodes to investigate their regulatory roles in parasite development, immune modulation and drug resistance. We are focusing on the sheep blood-feeding gastrointestinal nematode *Haemonchus contortus*, although genome sequence data shows that many of these miRNAs are conserved in related nematodes of veterinary and human importance. We identified 192 miRNAs expressed by *H. contortus* and examined their developmental expression in larval and adult stages, and in adult gut tissue, using microarrays. Many miRNAs are differentially expressed in specific life-cycle stages and we are focusing on two miRNAs that are significantly enriched in the infective L3 stage. Potential functions of these miRNAs in regulating larval arrest and development are being investigated. miRNAs are also released in the excretory-secretory (ES) products of *H. contortus* and have been sequenced from both the ES supernatant and from ES microvesicles. Secreted parasite miRNAs can
be detected in gut tissue from *H. contortus* infected sheep and we speculate that these may modulate immune outcome. Finally we have detected significant upregulation of one miRNA, Hco-mir-9551, in two distinct strains of *H. contortus* resistant to ivermectin. This miRNA may be directly responsible for changes in gene expression leading to resistance or, alternatively, is genetically or functionally linked to an ivermectin resistance locus. Further study of the roles of miRNAs in parasitic infections is important in progressing understanding of parasite development, host-parasite interactions and drug resistance, and is relevant to the design of novel therapeutics for veterinary parasite control.

3

**Novel synthetic biology approaches to combat drug resistance in parasites of terrestrial and aquatic animals**

Richard Peterson*, Arun Dhar. Intrexon, Germantown, MD

Parasites are a major cause of economic losses in terrestrial and aquatic animals. Economic impact of parasites could be direct (e.g. due to reduced productivity, losses due to mortality) and indirect (e.g. parasites serving as vectors for diseases, and often results in much greater economic losses than direct losses). Over the years, integrated parasite management programs have been developed to attain optimal parasite control by minimizing the use of chemical control and incorporating management tools like parasite monitoring and non-chemical strategies such as nutrition, genetics and pasture management. Despite these strategies, development of drug resistant parasites has become a major problem globally. Synthetic biology has the potential to expand the toolbox of strategies for parasite control. These tools include development of genetically engineered parasites carrying a lethality trait, that when released in their natural habitat will seek out and mate with wild populations, passing this trait to progeny. Use of self-limiting genes in engineered male insects to control pest populations has been successfully applied to reduce populations of the *Aedes aegypti* mosquito, a vector of dengue and Zika virus, in efficacy trials. This self-limiting, environmentally friendly approach is also under development for limiting the spread of agriculturally important crop pests like pink bollworm, Mediterranean fruit fly, and diamondback moth, as well as animal health pests, and is showing promise in initial trials. Other biological control strategies being pursued include the use of the bacterium *Lactococcus lactis* for delivery of bioactive proteins. **Employing a broad arsenal of strategies to include genetically engineered self-limiting male insects and therapeutic probiotics opens up a new horizon in developing novel and environmentally safe anti-parasitic drugs in the years ahead.** Synthetic biological approaches can be used to address the emerging drug resistance issues and to develop ecologically sustainable and novel therapies for parasite control.

**AAVP-Merck Outstanding Graduate Student Award Presentation**

4

**Ecoepidemiology of Trypanosoma cruzi in the US**

Rachel Curtis-Robles*, L Auckland, E Wozniak, K Snowden, G Hamer, S Hamer. Texas A&M University, College Station, TX

Although the protozoan parasite *Trypanosoma cruzi* and its triatomine insect vectors (*Triatoma* spp) have been documented in the southern United States since the early 1900s, Chagas disease has recently garnered much public attention in the U.S. As a zoonotic disease, Chagas disease is an important One Health
research issue. Our research program has focused on examining the ecology, epidemiology, and circulating strain types of *T. cruzi* in vector, wildlife, and domestic dog populations.

To describe vector ecology at the human-vector interface, we initiated a citizen science program in 2012, through which we have collected over 3,000 triatomine bugs encountered by citizens largely in the peridomestic environment and in dog kennels. Seven species of the genus *Triatoma* were identified, and all bug species are competent vectors. Based on our data, adult triatomines are most active from May through October, and infection prevalence with *T. cruzi* in this insect collection exceeds 60%. Of the six strain types or discrete typing units (DTUs) of *T. cruzi*, we identified DTU TcI and TcIV in bugs.

In wildlife populations, we have documented 70% infection prevalence in raccoons (*Procyon lotor*) sampled from central Texas, as well as 14% infection prevalence in coyotes (*Canis latrans*), bobcats (*Lynx rufus*), and foxes (*Urocyon cinereoargenteus*). We found mainly DTU TcIV in raccoon cardiac tissues.

Samples from a population of working dogs revealed high seroprevalence (58%) and evidence of *T. cruzi* DNA (27%) in blood samples, as well as *T. cruzi* DNA in cardiac and reproductive tissues from seropositive dogs. Infections included DTUs TcI and TcIV.

Elucidating the relationships among the hosts, vectors, and parasite strains will provide an ecological basis for the observed epidemiological patterns of disease.

## Ectoparasites

### 5

**Assessment of the onset and residual speed of kill against fleas of a topical Dinotefuran-Fipronil ectoparasiticide on cats over 6 weeks**

Romain Delcombel*1, Marie Varloud1, Julian Liebenberg2, Elizabeth Hodgkins3. 1Ceva Santé Animale, Libourne, France, 2Clinvet, Bloemfontein, South Africa, 3Ceva Animal Health, Lenexa, KS

**Introduction**

Cats are frequently exposed to flea infestations. This study evaluates the onset and speed of kill of a dinotefuran-fipronil topical ectoparasiticide (DF) against adult *Ctenocephalides felis* fleas in cats over six weeks.

**Material and methods**

The protocol was approved by an ethics committee. Twenty-four cats (2.1-4.6 kg BW) were allocated to 3 groups: an untreated control group (C, n=8), and 2 DF-treated groups (DF1, n=8, and DF2, n=8). Cats in the treated groups were administered 0.5 mL of DF on day 0. Each cat was infested with 100 adult fleas on days -6, -1 in DF1 and on days -6, 7, 14, 21, 28, 35, 42 in DF2, respectively. The fleas were removed from all cats on day -5. The fleas falling off the cats were collected on day 0: 5, 15, 30 and 120min after treatment, before removal 12h after treatment in C and DF1 groups. After 6h and 48h of infestation, the fleas were counted on cats in groups C and DF. Fleas were categorized as live or dead. Insecticidal efficacy was calculated using both geometric (GM) and arithmetic means. Comparisons between groups were performed on the flea counts by ANOVA. Veterinary examinations and clinical assessments were performed throughout the study.
Results and conclusion

The product was well tolerated. Control cats retained in average >48.1 fleas, with less than 3 fleas falling in total. Two hours after treatment, a total of 144 fleas were dislodged from cats in DF1. Three hours after treatment the insecticidal efficacy was 97% (GM). The residual insecticidal speed of kill at 6h after infestation was maintained >94% over 1 month. The residual efficacy 48h after infestation was >95% for 6 weeks. This study underlines the performances of DF against fleas on cats over 6 weeks.

6 Evaluation of fluralaner and afoxolaner treatments to control flea populations, reduce pruritus and minimize dermatologic lesions in naturally infested dogs in private residences in West Central FL. USA

Michael Dryden*1, Michael Canfield2, Kimberly Kalosy1, Amber Smith1, Lisa Crevoiserat1, Jennifer McGrady1, Kaitlin Foley1, Vicki Smith1, Kathleen Heaney3, Lisa Math3, Christine Royal3, Fangshi Sun3.

1Kansas State University, Manhattan, KS, 2Animal Dermatology South, New Port Richey, FL, 3Merck Animal Health, Madison, NJ

A study was conducted to evaluate and compare the effectiveness of two different oral flea and tick products to control flea infestations, reduce pruritus and minimize dermatologic lesions over a 12 week period on naturally infested dogs in West Central FL USA. Thirty-four dogs with natural flea infestations living in 17 homes were treated once with a fluralaner chew on study day 0. Another 27 dogs living in 17 different homes were treated orally with an afoxolaner chewable on day 0, once between days 28-30 and once again between days 54 – 60. All products were administered according to label directions by study investigators. Flea populations on pets were assessed using visual area counts and premise flea infestations were assessed using intermittent-light flea traps on days 0, 7, 14, 21, and once between days 28–30, 40–45, 54–60 and 82-86. Dermatologic assessments were conducted on day 0 and once monthly. Pruritus assessments were conducted by owners throughout the study. Following the first administration of fluralaner or afoxolaner, flea populations on pets were reduced by 99.0% and 99.3%, respectively within 7 days. Flea populations on the fluralaner treated dogs were 0 (100% efficacy) on days 54-60 and 82-86 after the administration of a single dose on day 0. Administration of 3 monthly doses of afoxolaner reduced flea populations by 100% on days 82-86. Flea numbers in indoor-premises were markedly reduced in both treatment groups by days 82-86, with 100% and 98.9% reductions in flea trap counts in the fluralaner and afoxolaner treatment groups, respectively. Marked improvement was observed in FAD lesion scoring, Atopic Dermatitis lesions scoring (CADESI-4) and pruritus scores with both formulations.

7 Therapeutic and residual speed of kill against adult fleas over 1 month of a topical dinotefuran-permethrin-pyriproxyfen combination when used on dogs at the minimal recommended dose

Marie Varloud*, Audrey Deflandre. Ceva Santé Animale, Libourne, France

Introduction

The 2h residual speed of kill of a dinotefuran-permethrin-pyriproxyfen topical ectoparasiticide (DPP) against adult *Ctenocephalides felis* fleas in dogs was already demonstrated at the label dose (Varloud & Fourie, 2015). This study was designed to investigate the 2h residual speed of kill when DPP is applied at the minimal recommended dose.

Material and methods
The protocol was approved by an ethics committee. Sixteen dogs were allocated to an untreated control group (18.6±3.4 kg BW, n=8), and to a DPP-treated group (17.1±2.6 kg BW, n=8) based on gender and pre-treatment live flea retention. The dogs in the treated groups were administered the minimal recommended dose (0.12 mL/kg BW) of DPP on day 0. Each dog was infested with 100 adult fleas on days 0, 1, 7, 14, 21 and 28. The live fleas were counted and removed from dogs 2h after each infestation. Insecticidal efficacy was calculated using geometric means and the Abbott formula. Comparisons between groups were performed on the flea counts by ANOVA. Veterinary examinations and clinical assessments were performed throughout the study.

Results and conclusion

The product was well tolerated. Control dogs retained in average 64.2±11.7 fleas. Two hours after treatment, the insecticidal efficacy was 83%. The residual insecticidal speed of kill at 2h after re-infestation was maintained ≥95% starting from day 1 and over 1 month. The difference between control and DPP groups was significant at each time point (p<0.001). This study confirms the high residual speed of kill performances of DPP against fleas on dogs over 1 month.

8


Byron Blagburn, Jamie Butler, Tracey Land, Jane Mount, Joy Bowles, Joe Hostetler. Auburn University, Auburn, AL, Bayer Healthcare LLC, Shawnee Mission, KS

*Ctenocephalides f. felis* and *C. canis* (Siphonaptera: Pulicidae) are fleas that infest dogs, cats and other urban and rural mammals. Prior surveys indicate that their geographic and host distributions vary. Herein, we report the prevalence of *C. f. felis* and *C. canis* collected from dogs and cats in shelters from the northeastern, southeastern, midwestern and western United States (US). All fleas were placed in plastic bags and shipped to Auburn University by overnight courier. Identification was based on the following structural features: shape of the head, length of the first spine of the genal comb, number of bristles on the lateral metanotal area, and the number of short stout bristles of the dorsal margin of the hind tibia (Linardi and Santos, 2012). A total of 2,621 fleas were identified as either *C. f. felis* or *C. canis*: 96% (2,524) were *C. f. felis* and 4% (97) were *C. canis*. For *C. f. felis*, 44% (1,113) were recovered from dogs, 56% (1,411) were from cats. *C. canis* was recovered more commonly from dogs (71% [69]) than cats (29% [28]). *C. f. felis* and *C. canis* were recovered more often in the southeastern and midwestern US. Results of this survey indicate that *C. canis* and *C. f. felis* infest both dogs and cats and that both species are present in all four US geographic regions.

This research was sponsored by Bayer HealthCare Animal Health US.
Update on acaricide resistance in the Southern Cattle Tick (Rhipicephalus microplus) in South America and multiple resistance to acaricides in Southern Brazil: where do we go from here?
Guilherme Klafke*, Anelise Webster, Bruno Dall"Agnol, Marcelo Becker, Melanie Mansson, Mateus Osorio dos Santos, Rafael Barreto, Ugo Araújo Souza, Julsan Silveira dos Santos, Jose Reck, Joao Ricardo Martins. Instituto de Pesquisas Veterinarias "Desiderio Finamor" - FEPAGRO/RS, Eldorado do Sul, Brazil

Since the late 19th century chemical acaricide treatment of cattle remains the main method of controlling the southern cattle tick, *Rhipicephalus microplus*, worldwide. Populations of *R. microplus* have developed resistance to every acaricide chemical class since the first report of resistance to arsenicals in the 1940s. Synthetic pyrethroids (SP), organophosphates (OP), amitraz (AM), fipronil (FIP), macrocyclic lactones (ML) and fluazuron (FLZ) are generally marketed in South America. No literature information about resistance in the cattle tick against these molecules is available from Paraguay, Bolivia, Ecuador, Chile, Peru, Suriname or the Guyanas. Acaricide resistance in *R. microplus* is confirmed in Colombia (SP, OP, AM, ML), Venezuela (SP, OP, AM), Argentina (SP, OP, AM), Uruguay (SP, OP, FIP) and Brazil (SP, OP, AM, FIP, LM, FLZ). In Southern Brazil multiple acaricide resistance (MAR) is the major obstacle for sustainable *R. microplus* control. A laboratory bioassay-based survey conducted between 2013 and 2015 included 104 tick samples from the State of Rio Grande do Sul. Findings indicated resistance to SP, OP, AM, ML, and FIP is spread throughout the State. Resistance to fluazuron was found in 15 of 50 samples evaluated. MAR to three or more compounds was detected in 78.5% of the samples tested. The results obtained in this study are alarming and reveal a challenging scenario for the practice of chemical tick control. There is an urgent need for alternative methods for controlling ticks and for the development of molecular diagnostic tools to rapidly detect these populations to support effective surveillance program and avoid the spread of MAR among *R. microplus* populations. Otherwise, widespread MAR can impair animal welfare and economy of cattle industry in the state of Rio Grande do Sul, Brazil. Funding: CNPq, FAPERGS, FINEP, US Department of Energy.

Risk factors associated with multiple drug resistance development in cattle tick populations from Rio Grande do Sul, Brazil.
Endrigo Pradel1, Guilherme Klafke*2. 1Secretaria da Agricultura, Pecuaria e Irrigacao do Rio Grande do Sul (SEAPI), Porto Alegre, Brazil, 2Instituto de Pesquisas Veterinarias "Desiderio Finamor" - FEPAGRO/RS, Eldorado do Sul, Brazil

The cattle tick (*Rhipicephalus microplus*) is present in most of the cattle producing regions in the world. Rio Grande do Sul state (RS), Southern Brazil suffers with wide presence of this tick due to predominance of susceptible European cattle breeds, intensive grazing and favorable climate to the parasite in most of its territory. Recurring and indiscriminate use of chemical acaricides has led to resistance development to all drugs available. Its dissemination may impact negatively the profitability and viability of livestock production in the area. We developed an epidemiological study in the North Coast of RS to characterize resistance to acaricides, determining its prevalence and associated factors to development of multiple drug resistance (MDR) (resistance to three or more acaricides). A survey was conducted in 107 farms to characterize production system, parasite control practices and acaricide resistance status of local ticks populations. Larval bioassays were carried out with 101 tick samples against cypermethrin, chlorpyrifos, amitraz, fipronil and ivermectin. MDR was detected in 42.4% of the farms, especially associated to the
largest and most technified farms. Moreover, it was not uncommon to find populations with resistance to the five acaricides tested. Univariate statistical analysis showed 17 factors associated with MDR (p ≤ 0.20). Most important were: Presence of European cattle breeds; farm size; herd size and stocking rate; aspects of technification and management such as having cultivated pasture and use of crop-livestock integration system; acaricide administration to all cattle simultaneously; observation of cattle with clinical signs of worms or lice; and the use of fluazuron. Misinformation is the biggest problem on the control of the cattle tick in the region, highlighting the need for extension education on tick control and resistance management among producers and field technicians.

Molecular and Biochemical - 1

11 Identification of semiochemicals attractive to black flies of the Simulium vittatum complex, putative vectors of Onchocerca spp.
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Many black fly species (Diptera: Simuliiidae) are economically important insect pests, both as nuisance biters and vectors of pathogens of medical and veterinary relevance. Among the important black fly pest species in North America is the widespread Simulium vittatum Zetterstedt sensu lato. Recently, a species within the S. vittatum complex, Simulium tribulatum Lugger, was implicated as a potential vector of Onchocerca lupi (Nematoda: Onchocercidae), an emerging parasitic infection in companion animals and humans. The objective of this study was to identify compounds excreted by mammalian hosts (e.g., dogs, humans, cattle) that are attractive to host-seeking S. vittatum females. The attractiveness of putative compounds to colonized S. vittatum (IS-7) was tested through electrophysiological (electroantennography; n=58 compounds) and behavioral bioassays (Y-tube). Out of the 58 initial compounds, seven were further tested using the behavioral bioassay in three concentrations (1:1000, 1:100, 1:10). Five compounds were significantly attractive to host-seeking S. vittatum females: 1-octen-3-ol, 2-heptanone, acetophenone, 1-octanol, and naphthalene. These candidate compounds might be useful as attractants for traps that could be developed as an alternative or complementary management tactic in suppression programs of nuisance black fly populations, or for collection of samples to study the transmission ecology of O. lupi in endemic areas in North America.

12 Cystic echinococcosis in cattle slaughtered in Santiago, Chile: Prevalence, distribution, genotype and hydatid cyst fertility.
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INTRODUCTION
Cystic Echinococcosis (CE) is a worldwide-distributed zoonosis. Despite its economic and public health significance, there is lack of information on CE in Chile. We here provide the first evidence of the presence of E. ortleppi in Chile.
MATERIALS AND METHODS

From 2961 inspected cattle, information was recorded and hydatid cyst (HC) from each infected animal was collected. Genomic DNA was extracted from germinal layer and a fragment of the mitochondrial cox1 gene was amplified. PCR products were sequenced and compared with cox1 reference sequences of *E. granulosus* genotypes retrieved from GenBank.

RESULTS

The prevalence of CE was 19%. Of 558 cattle harbouring HC, 51% had cysts only in their lungs, 19% only in their liver, and 30% in liver and lungs, while 79% were infertile, 6% fertile and 15% smaller than 3cm (unable to process). Partial PCR amplification of cox1 gene resulted in 284 samples identified as *E. granulosus* sensu stricto (G1-G3) and 6 as other genotype (G4-G10). DNA sequencing revealed the existence of 58 G1 and 2 G5 samples in the studied area.

CONCLUSION

Cystic echinococosis is widespread in cattle in Santiago and we report the presence of *E. ortleppi* (G5) strain in Chile for the first time.

ACKNOWLEDGMENTS

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**Investigating the molecular epidemiology of benzimidazole resistance in trichostrongylid nematodes using deep amplicon sequencing of the isotope-1 b-tubulin locus**

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Understanding the patterns of emergence and spread of anthelmintic resistance is an important prerequisite to developing evidence-based approaches to the management and prevention of resistance. The molecular basis of benzimidazole resistance in several trichostrongylid nematodes is at least partially understood; three mutations in the isotype-1 b-tubulin gene (F200Y, E198A and F167Y) are associated with resistance to varying degrees depending on the parasite species and geographical location. We have previously used conventional Sanger DNA sequencing and phylogenetic network analysis of resistance and susceptible isotype-1 b-tubulin haplotypes to explore the molecular epidemiology of benzimidazole resistance in *Haemonchus contortus*. However, recent developments in next-generation sequencing technologies now allows such studies to be undertaken on an unprecedented scale and with much greater resolution. Consequently, we are developing deep-amplicon sequencing approaches to study the frequency of the F200Y, E198A and F167Y mutations and investigate the haplotype diversity of the isotype-1 b-tubulin locus for number of cattle and sheep trichostrongyliid parasite species. The development and application of these assays to investigate the molecular epidemiology of a number of trichostrongyliid nematodes will be presented.
The use of deep amplicon sequencing to investigate the impact of ivermectin treatment on gastrointestinal nematode communities in Canadian cattle
Russell Avramenko*1, Murilo Bichuette2, Elizabeth Redman1, Roy Lewis3, Thomas Yazwinski4, John Gilleard1. 1University of Calgary, Calgary, AB, Canada, 2São Paulo State University, Jaboticabal, Brazil, 3Merck Animal Health, Canada, Calgary, AB, Canada, 4University of Arkansas, Fayetteville, AR

Gastrointestinal parasitic nematodes of cattle often occur as mixed species infections, which vary in pathogenicity and drug sensitivity. We have used our newly developed and validated deep-amplicon “nemabiome” sequencing approach to quantify the species composition of parasitic nematode communities in cattle. We assessed parasitic nematode populations from across Canada, the mid-west/southern United States and Brazil, to determine which species are prevalent in each of the observed areas and compare overall species diversity. Canada had the least species diversity while Brazil had the highest. In Canada, the most prevalent species were Cooperia oncophora and Ostertagia ostertagi, with Cooperia punctata being present at significantly higher levels in Ontario compared to Western Canada. This contrasts with the United States and Brazil where Cooperia punctata and Haemonchus placei were the most prevalent species with a variety of other species also being present.

In addition, we assessed the efficacy of macrocyclic lactone treatments on parasitic nematode communities in Canadian cattle. We collected 20 individual fecal samples from 49 farms across Canada. Farms were treated with macrocyclic lactones and 20 additional fecal samples were collected. Fecal samples were cultured to obtain L3 larvae and species composition determined by “nemabiome” sequencing before and after treatment. We observed a significant decrease in species diversity following ivermectin treatment. Cooperia spp. significantly increased proportionally after treatment, while Ostertagia ostertagi deceased significantly. The results indicate that ivermectin treatments used in Canadian beef cattle often have sub-optimal efficacy against Cooperia spp. but good overall efficacy against Ostertagia ostertagi.

Deep amplicon sequencing assays to investigate gastro-intestinal nematode species distribution and anthelmintic resistance in Western Canadian sheep flocks
Camila de Queiroz*, Elizabeth Redman, Russell Avramenko, Michel Levy, John Gilleard. University of Calgary, Calgary, AB, Canada

Clinical Haemonchosis and parasitic gastro-enteritis is of increasing concern to Western Canadian sheep producers and our on-going fecal sampling survey has detected high infection intensities of trichostrongylid nematodes in many flocks in Alberta, Manitoba, Saskatchewan and British Columbia. Haemonchus contortus was historically considered to be relatively uncommon in Western Canada but has emerged as a major concern to sheep producers over the last decade. Farm visits to perform fecal egg count reduction tests from four farms in 2014 and seven farms in 2015 indicate that both benzimidazole and ivermectin resistance is very common in gastro-intestinal nematode species in the region. We are developing next-generation deep amplicon sequencing approaches to improve the diagnosis and surveillance of parasite infections and of anthelmintic resistance. In this presentation, we will present the development of a “nemabiome” sequencing assay, previously developed for cattle parasites, to quantify the proportions of the different parasite species in sheep fecal samples pre- and post- anthelmintic treatment. The approach is based on a “microbiome-style” next-generation deep sequencing of ITS-2 rDNA amplicons and allows large scale analysis of samples. The steps to optimise and validate the assay.
will be presented. Application of this assay suggests that *H. contortus* is the predominant parasite on many western Canadian sheep farms but that some farms have mixed infections of species associated with parasitic gastroenteritis. We will also present the results of a second deep amplicon sequencing assay we are developing to detect and quantify benzimidazole associated mutations in the isotype-1 β-tubulin gene and to investigate the haplotypic diversity and phylogenetic relationships of resistance alleles in the field.

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Identifying and quantifying common GI nematodes of cattle using PCR and high resolution, size fragment analysis
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A plethora of PCR techniques have surfaced for identifying parasites most of which fall short of easily quantifying mixed infections. Classic approaches for discerning GI nematodes from fecal eggs require cultivation to infective L3 and morphological examination; however, differences in optimal culture conditions and inconsistencies in morphological identification can generate capricious results. Herein, we developed a simple assay for differentiating and quantifying mixed infections of GI nematodes, using fluorescently-labeled PCR primers and a capillary-based sequencer. The ITS2 region of common cattle GI nematodes is sufficiently distinct in length to delineate among infecting genera. As such, conserved PCR primers that span the ITS2 were synthesized, one of which was fluorescently-labeled with FAM. DNA from egg samples or infective L3 was PCR amplified, diluted in HI-DYE sequencing buffer containing LIZ 500 standard, then analyzed in an ABI 3100 sequencer adapted for size fragment analysis. Tests were first performed on monospecific infections to validate the ability to differentiate *Haemonchus, Ostertagia, Cooperia, Trichostrongylus* and *Oesophagostomum*. Secondarily and as proof of principle, L3 from *Ostertagia ostertagi, Cooperia punctata* and *Haemonchus Contortus* were mixed in 10% increments, and PCR products analyzed using Gene Marker V1.85. The following size fragments were generated: *Haemonchus* - 365 bp; *Ostertagia* - 372 bp; *Cooperia* - 375 bp; *Trichostrongylus* - 370 bp, and; *Oesophagostomum* - 356 bp using primers 1247 and 1328. Data showed that primer design is critical for quantitative analysis. Quantified peak intensities using predefined mixes of *Cooperia* and/or, *Ostertagia* and/or *Haemonchus* gave a linear response in the range of 10%-90%. Comparisons between PCR data from eggs and coproculture followed by morphological examination were highly variable suggesting deficiencies in microscopic techniques. Preliminary information indicates that size fragment analysis is both diagnostic and quantitative on a relative scale, and adaptable to large sample numbers.

Heartworm

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Assessment of parasitological and clinical findings in heartworm-infected beagles treated with Advantage Multi® and doxycycline.
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Anecdotal reports from veterinarians state that the adulticidal heartworm treatment utilizing doxycycline and Advantage Multi® successfully converted antigen-positive dogs to antigen-negative. To date, no experimental studies have demonstrated the adulticidal efficacy of this treatment regimen. The aim of this
The study was to evaluate the parasitological and clinical effects of Advantage Multi® (10% imidacloprid, 2.5% moxidectin) and doxycycline on heartworm-infected beagles. This study utilized 16 dogs: 8 dogs each in the control and treated groups. A total of 16 adult *Dirofilaria immitis* (Missouri Strain) were surgically transplanted into the jugular vein of all study dogs. The treatment regimen of monthly Advantage Multi® topically for 10 months and 10 mg/kg doxycycline BID orally for 30 days was initiated 30 days post-surgical transplant.

Echocardiograms, radiographs, complete blood counts, clinical chemistry profiles, heartworm antigenemia, and microfilaremia were evaluated every 4 weeks. All dogs tested positive for the presence of heartworm antigen post-surgical transplant prior to treatment. Control dogs have remained antigen-positive and 7 of the 8 have detectable microfilariae to date. No microfilariae in treated dogs were detected after 21 days post-treatment. Heartworm antigen levels began declining in treated dogs 3 months post-treatment.

Radiographs of dogs depict right heart enlargement and main pulmonary artery enlargement. These lesions are resolving in treated dogs. Echocardiograms were unable to detect adults at 3 months post-treatment in 3 treated dogs. Normal heart functions were observed for all animals throughout. Necropsy adult worm recovery data will be available during presentation.

Preliminary data indicates that this treatment regimen successfully eliminates *D. immitis* microfilariae by 21 days post-treatment and reduces heartworm antigen concentration over time. Adult worm recovery will provide percent efficacy for the elimination of canine adult heartworms and determine if this is an appropriate treatment when the approved adulticidal therapy is not an option.


*Advantage Multi®* (10% imidacloprid + 2.5% moxidectin) is approved for use as a monthly topical solution for the prevention of heartworm disease caused by *D. immitis*. This laboratory study, which was conducted in compliance with VICH GL 9, examined the efficacy of *Advantage Multi®* for the prevention of heartworm disease and infection all month long and included two groups of 8 dogs each. Dogs in Group 1 received *Advantage Multi®* while those in Group 2 remained as non-treated controls. All dogs entering the study completed a physical examination including examination for heartworm antigen and *D. immitis* microfilariae. Dogs in Group 1 were treated on study day (SD) -30 as per the label recommendation while those in Group 2 remained as non-treated controls. On SD 0 dogs in Groups 1 and 2 were subcutaneously infected with approximately 50 infective third-stage *D. immitis* larvae (“Missouri” isolate). In addition to general health observations conducted daily throughout the study, blood was collected on SD 120 and 147 for examination for heartworm antigen and *D. immitis* microfilariae. On SD 148, all animals were euthanized and necropsied for recovery of adult heartworms. Results from this study showed that no heartworms in the treated dogs compared to 6 of 8 non-treated dogs with heartworm (range of 2-33 worms/dog). Even with only 5 of 8 Group 2 dogs having 5 or more heartworms (range of 19-33 worms/dog), the distribution of heartworm counts and the level of infection in these dogs were considered adequate to permit acceptable statistical methods and biological conclusion. The *Advantage Multi®*
treated dogs had significantly fewer heartworms (p<0.05) compared to the non-treated controls. The results demonstrated that *Advantage® Multi* is efficacious for the prevention of heartworm disease and infection all month long with no observation of treatment-related adverse events.

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**The safety of milbemycin oxime after administration to heartworm positive microfilaricidal dogs.**
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**Background.** Although heartworm prophylaxis should be avoided in infected dogs, prophylaxis may sometimes be initiated without the necessary pre-treatment testing. **Objective.** To evaluate the safety of a combination of milbemycin oxime (MBO) and spinosad administered to dogs with patent heartworm infections. **Design.** Dogs were ranked by sex and microfilarial counts (range 398–1980) and randomized among four groups of 8 dogs to receive three treatments at 28-day intervals: placebo (control), or combination product at the high end of the label range (MBO 1 mg/kg = 1X), three (3X), or five (5X) times that dose. On Days 7, 25, 53 and 63, blood samples were collected for antigen and Knott’s tests. **Results.** One control dog died from heartworm-associated complications. Other adverse events involved observations of mild, transient emesis in a single dog in each of the 1X and 5X groups and three 3X-group dogs. At necropsy (Day 65) a similar number of heartworms was observed across all groups (range 13 – 41). Antigen and Knott’s test results were positive throughout the study (except for one 3X and one 5X dog which became microfilariae negative on Days 53 and 63, respectively). Mean microfilarial counts increased in the control group. Reductions from baseline were 71.7%-82.5% in the 1X group and 61.5% to 96.4% in the 3X and 5X groups. Conclusions. Repeated monthly MBO treatments are incompletely microfilaricidal. Although microfilarial counts decreased following treatment, hypersensitivity reactions were not observed in any microfilaricidal domestic animals administered repeated treatments of up to 5 times the MBO label dose.

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**Examination of the “susceptibility gap” in the treatment of patent canine heartworm infections**
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“Susceptibility gap” has been referred to as a period existing between when a dog is diagnosed with heartworms and when treatment will be most successful in clearing all heartworm stages. This was previously defined as a period of about three months based upon “as per product labels.” It can be postulated that a susceptibility gap doesn’t exist with the combination of continued macrocyclic lactone (ML) therapy coupled with a three-dose melarsomine dihydrochloride (MD) protocol where the first MD treatment is given at the time of diagnosis. MD was originally developed as a “preventive” for heartworm infection designed to be given every 4 months to kill four-month-old worms with an 82.1% efficacy. When MD was given to dogs with older worms, 7 to 12 months or age, a single injection was only 55.6% and 51.7% effective, respectively. There is no published data on MD against younger worms, but the related arsenical, thiacetarsamide, was 99.7% effective against two-month-old worms, suggesting that MD also may have efficacy against these younger forms. Also, with the development and FDA approval of spinosad + milbemycin oxime (Trifexis®, Elanco) and milbemycin oxime + praziquantel (Interceptor® Plus, Elanco), it was shown that repeated treatments of dogs with MLs has additional efficacy against 3 month-old worms. Thus, no expected improvement in efficacy is created by waiting a period of time following
diagnosis to initiate therapy with both MD and ML, regardless of the possible presence of younger worms. Starting treatment at diagnosis appears to be acceptable for maximal worm clearance based on published data, while delaying treatment actually allows disease progression. Continued ML administration with two additional injections of MD a month later will protect dogs against incoming larvae and developing forms 4 months of age or younger when both are first administered at the time of initial diagnosis.

21 Blocking of the transmission of *Dirofilaria immitis* L3 (JYD-34 ML resistant strain) from infected mosquitoes to dogs and prevention of infection in dogs treated topically with dinofuran-permethrin-pyriproxyfen and orally with milbemycin oxime alone or in combination

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Thirty-two Beagle dogs were randomly allocated to 4 groups of 8: Group 1, untreated controls; Group 2, treated topically with Vectra® 3D on Day 0; Group 3, treated orally with Interceptor® on Day 51 (23-30 days after infection); and Group 4, treated with Vectra® 3D on Day 0 and Interceptor® on Day 51. Dogs were exposed for 1 h to infected mosquitoes on Days 21 and 28. Before exposure, mosquitoes were dissected to determine the number of L3/mosquito. Sufficient infected mosquitoes to transmit 30-50 L3/dog/exposure were released into each exposure container, allowing mosquitoes access to the sedated dog. After exposure, 3 blood-engorged mosquitoes were removed from each container and dissected, yielding the number of L3 remaining after feeding. After exposure, mosquitoes were counted and categorized as live/moribund/dead and engorged/non-engorged) during aspiration into labelled cartons. Live mosquitoes were incubated for daily survival assessment for 3 days. Number of L3 transmitted to each dog was estimated by subtracting average number of L3/mosquito remaining after feeding from average number of L3/mosquito before feeding multiplied by number of mosquitoes that fed on that dog. Dogs will be necropsied for recovery of heartworms 150-157 days PI. Anti-feeding (repellency) effect after exposure was analysed. A total of 413 mosquitoes fed on the 16 dogs in the 2 groups not treated with Vectra® 3D, while only 6 fed on the 16 dogs treated with this product [overall anti-feeding effect (repellency) of 98.5%]. Anti-feeding effect for groups treated with Vectra® 3D, Interceptor® and Vectra®3D plus Interceptor® was 98.1%, 5.2% and 99.1%, respectively. Insecticidal efficacy at 24 h after exposure will be presented. The average estimated number of L3 transmitted to untreated controls, Vectra® 3D, Interceptor®, and Vectra® 3D plus Interceptor® dogs were 76, 2, 78, and 1. Heartworm preventive efficacy using this multi-modal approach will be presented.

22 *Dirofilaria immitis*: P-glycoproteins, macrocyclic lactones and resistance to heartworm preventives

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Resistance to macrocyclic lactone (ML) heartworm preventives has been recently described. ML resistance is relatively common in a number of other parasitic nematodes and there are many studies which implicate P-glycoprotein (Pgp) transporters, members of the ATP binding cassette (ABC) transporter ABC-B sub-family, in ML resistance in several parasitic nematodes. Furthermore, we have found an association between genetic changes in a Pgp gene in *Dirofilaria immitis* with loss of efficacy to ML heartworm preventives. It was therefore of interest to investigate the Pgp genes in *D. immitis*. In some
nematodes there are many Pgp genes; for example, *Caenorhabditis elegans* has 14 full size Pgp genes, while *Haemonchus contortus* has 10 full size Pgp genes. A search of the *D. immitis* genome followed by amplification and sequencing of all cDNA and genomic ABC-B genes, from samples of *D. immitis* adult worms, has revealed that heartworms have only 3 full size Pgps (*Dim-pgp-3 Dim-pgp-10* and *Dim-pgp-11*). This is a relatively small number of full size Pgps, making it feasible to investigate their role in ML transport and possibly in resistance to MLs in *D. immitis*. So far we have investigated the functioning of the protein derived from *Dim-pgp-11* with ML heartworm preventives and have found some interesting differences between different MLs. Research on each of these *D. immitis* Pgps is continuing in order to investigate their possible role in ML resistance in heartworms.

**Treatment/Control**

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**Strong immune response and significant parasite burden reduction induced by *Cryptosporidium parvum* gp45 surface protein: a promising vaccine candidate against bovine cryptosporidiosis**

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At the moment, no vaccine or drug can efficiently prevent or cure bovine cryptosporidiosis. We developed a candidate vaccine made of the *Cryptosporidium parvum* gp45 surface protein and we determined its efficiency to reduce intestinal parasite burden in interferon gamma receptor knock-out (IFNγR-KO) mice. In previous studies, we showed a gender difference in susceptibility to infection with this mouse model; female mice being more susceptible to *C. parvum* infection. Male IFNγR-KO mice immunized with 40 μg of *C. parvum* gp45 recombinant protein had an intestinal parasite burden reduction of 70%. However, reduction of parasite burden was less significant with female mice. In order to increase the protective effect of the vaccine, we attempted to combine the gp45 protein with an adjuvant. Oligodeoxynucleotides containing CpG motifs (CpG ODN) have known adjuvant properties. Nonetheless, mice immunized with a combination of gp45 protein with CpG ODN had a higher parasite burden than mice immunized with the gp45 protein alone. Both formulations of the gp45 vaccine, with and without CpG ODN, induced high specific antibody titers and mice immunized with the gp45 protein alone developed a strong Th2 immune response. Nevertheless, the combination of gp45 protein with CpG ODN elicits a lower Th2 response; CpG ODN is known to be a strong Th1 inducer. Accordingly, a strong Th2 immune response seems to be a key factor to significantly reduce burden of *C. parvum* oocysts in mouse intestine. Therefore, we suggest combining gp45 to a Th2 inducer adjuvant to take full advantage of the Th2 immune response naturally elicited by the gp45 recombinant protein. Studies are ongoing to address this new objective. Our results show that *C. parvum* gp45 surface protein is a promising candidate for a vaccine against bovine cryptosporidiosis.
Larvicidal efficacy against mucosal equine strongyles
Martin Nielsen1, Kristen Krebs*1, Jennifer Bellaw1, Jessica Scare1, Craig Reinemeyer2. 1University of Kentucky Gluck Equine Research Center, Lexington, KY, 2East Tennessee Clinical Research, Rockwood, TN

Equine cyathostomin parasite larvae invade the mucosal walls of the cecum and colon and spend a variable period of time in an encysted stage. Early third stage larvae (EL3) can undergo arrested development for several years, and large encysted burdens can accumulate. Mass emergence of encysted larvae is a known cause of larval cyathostominosis, a disease complex characterized by a severe typhlocolitis. Two anthelmintic formulations are labelled for treatment of encysted larvae; moxidectin (0.4 mg/kg) given in a single oral dose and fenbendazole (10 mg/kg) administered for five consecutive days. In recent years, fenbendazole resistance has been widely documented in cyathostomin populations and some studies have reported shortened egg reappearance periods following moxidectin treatment. This has raised concerns whether larvicidal efficacies of these compounds could have declined. The aim of this study was to evaluate larvicidal efficacies in a cohort of naturally infected ponies. A second aim was to evaluate two different time intervals between treatment and euthanasia; 2 weeks and 5 weeks. Thirty-six ponies aged 2-4 years were enrolled in the study. Ponies were blocked by age and gender, ranked by magnitude of strongyle egg counts and randomly allocated to three groups; moxidectin, fenbendazole and an untreated control. The research team was blinded to group allocation information. At 2 weeks post treatment, moxidectin had a 74.59% reduction of late third and fourth stage (LL3/L4) larvae, compared to 70.76% for fenbendazole. The EL3 efficacies were 60.81% and 50.36% for moxidectin and fenbendazole, respectively. The 5-week data illustrated similar EL3 efficacies, while LL3/L4 counts were inexplicably low in all three groups. Moxidectin larvicidal efficacy fell within reported ranges (63-97%), while fenbendazole efficacy levels were markedly lower than previously reported (>97%). Moxidectin does not have a label claim for EL3s. Benzimidazole resistance is the most likely cause of this diminished larvicidal efficacy.

Scanning and transmission electron microscopy of Haemonchus contortus exposed to cranberry vine in vivo.
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Purpose: Condensed tannins, also called proanthocyanidins (PAC), suppress gastrointestinal nematode infections in small ruminants. The objective of this study was to investigate the anthelmintic efficacy of the daily feeding of PAC-containing cranberry vine (CV) in lambs artificially infected with Haemonchus contortus using scanning (SEM) and transmission electron microscopy (TEM). Methods: Lambs (14) were experimentally infected with 10,000 H. contortus third stage larvae, and stratified into two groups (n = 7) based on gender and fecal egg count (FEC) once the infection matured. Lambs were fed either CV0 (0 g CV, 200 g chopped alfalfa hay (AH)), or CV200 (200 g CV, 0 g AH) for five weeks. Fecal egg counts were measured weekly for the duration of the trial. At the conclusion of the study, total worm burden was determined and five adult H. contortus worms were collected from the abomasum of each lamb and preserved until viewed under SEM or TEM. Results: There was no difference in FEC between CV0 and CV200. Although there was a slight reduction in worm burden in CV200 (3335 ± 378) versus CV0 (3908
± 399), the difference was not significant. Evaluation of worms using SEM showed cracking in the cuticle of the adult worms from the CV200 group, compared to minimal or no cracking observed in CV0. Some accumulation of aggregate was observed on worms collected from CV200 lambs. Evaluation of internal structures of worms using TEM is pending. Conclusion: Preliminary results indicate that feeding 200 g of CV to lambs experimentally infected with *H. contortus* for five weeks resulted in cuticle damage on the adult worms and may have potential as an anti-parasitic against *H. contortus*. Further investigations using TEM and higher intake of CV are warranted.

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**In vitro Effects of a Novel Compound (Bedoukian Research) on Poultry Eimeria spp. Development and Excystation**

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Coccidiosis is one of the most common and devastating parasitic diseases in the poultry industry. Current methods of control or treatment of infections are costly, and in many cases are becoming less efficacious as resistance to traditional control and treatment methods increases. This has produced a need for alternative forms of treatment. Several different possibilities have been studied and used with varying degrees of success on both helminthes and protozoa. These alternative treatments include but are not limited to: Copper Oxide Wire Particles, *Lespedeza cuneata*, and *Pinus maritima*. The purpose of this study was to investigate the efficacy of compounds developed by Bedoukian Research on excystation of sporulated oocysts. Several of the compounds used for this study were derived from celery, all are in the form of several concentrated ketone liquids. Mixed samples of poultry *Eimeria spp* were exposed to 1:10, 1:100, and 1:1000 dilutions of seven Bedoukian compounds. A positive control and negative control was included for each compound. Once plated out, each compound was incubated for 30 minutes, 1 and 4 hours at 40° C with constant agitation. Samples were then removed, washed, and concentrated in eppendorf tubes. Each sample was stained with trypan blue and two 20µL aliquots were counted using a hemocytometer. Analysis was completed using GraphPad Prism 5.0, ANOVA repeated measures and Tukey’s multiple comparisons test, p<0.05 was considered significant. Each compound behaved differently on the *Eimeria* sporocysts. Two compounds reduced excystation at significant levels. All other compounds increased excystation. Future work will include work on ruminant *Eimeria spp*. as well as cell invasion assays after exposure to alternative treatments, including the Bedoukian compounds.

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**In vitro and molecular approaches for investigating the pharmacology of larval toxocariasis**

Jeba Jesudoss Chelladurai*, Christopher Bader, Matthew Brewer. Iowa State University, Ames, IA

*Toxocara canis*, the common round worm of dogs, has a complex lifecycle that includes a somatic migratory phase and an intestinal phase. The persistence of infection in adult dogs is due to the presence of somatic hypobiotic larval stages. In pregnant bitches, reactivation of these larvae results in prenatal/placental and lactogenic transmission to puppies, with subsequent maturation to patency. The somatic larval stages are commonly resistant to macrocyclic lactone anthelmintics at the doses and frequencies used for prevention, resulting in incomplete elimination of infection. We hypothesized that the ABCB family of efflux pumps plays an important role in ML resistance, as has been demonstrated in other nematodes of veterinary importance. In the present report, we describe techniques for isolation of larvae,
a novel computer-aided larval drug assay, and molecular investigation of ABCB genes from *Toxocara canis*.

**Sarolaner for Ectoparasite Control**

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**Sarolaner (Simparica™) Efficacy and Speed of Kill Against Adult Fleas on Dogs**

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Five studies were conducted to evaluate the efficacy of the minimum oral label dose of 2 mg/kg sarolaner for the treatment and control of flea infestations on dogs. Purpose-bred Beagles and/or mixed breed dogs were allocated randomly to treatment with either placebo or sarolaner (8 to 10 per group) based on pre-treatment parasite counts. In three studies, dogs were infested with *Ctenocephalides felis felis* recently isolated from the field in the US, EU or Australia; in the fourth, dogs were infested with a *C. felis* strain (KS1) with tolerance to a number of insecticides, and in the fifth, dogs were infested with *Ctenocephalides canis*. Dogs were infested with approximately 100 unfed, adult fleas prior to treatment and at weekly intervals post-treatment. Comb counts were conducted at 24 h after treatment on Day 0 and after each weekly infestation. In two speed of kill studies, dogs were infested and dosed in the same way but comb counts were conducted to determine the numbers of viable fleas at one to three, four, eight and 12 h after treatment on Day 0, and after each weekly re-infestation.

Efficacy against *C. felis, C. canis* and the resistant KS1 strain was 99.8–100% from treatment through Day 35. In all five studies, elimination of existing infestations was achieved within 24 h after dosing, with only a single live *C. felis* on one dog on Day 1. Control of flea challenges was achieved within 24 h after infestation throughout the 35 day study period. The speed of kill studies demonstrated that sarolaner started killing fleas within three to four hours after treatment or subsequent re-infestations for a full month, and achieved ≥98% control of fleas by eight hours after treatment or re-infestation for 28 days. There were no sarolaner-related adverse reactions during any of the studies.

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**Evaluation of the effects of sarolaner (Simparica™) on flea reproduction and effectiveness in a simulated infested-home environment.**

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Two studies were conducted to evaluate the effect on egg production and efficacy in a simulated infested-home environment. Purpose-bred Beagles were used in each study and were allocated randomly to groups based on pre-treatment parasite counts. In the flea egg production study, groups of dogs infested with approximately 100 fleas prior to treatment were treated orally with placebo or sarolaner tablets providing the minimum label dose of 2 mg/kg and then were each re-infested with approximately 100 fleas once weekly for five weeks post-treatment. At 48 hours after each infestation the dogs were housed for 20 hours in cages allowing the collection and counting of all flea eggs produced during this period. The flea eggs
collected were incubated to evaluate hatch and development to adults. For the second study dogs were housed in a flea-infested simulated-home environment. Dogs were allocated to treatment with either placebo or sarolaner tablets providing a dose of 2 mg/kg once a month for three treatments. Flea infestations were assessed by comb counts (fleas were replaced on the dogs) on Days 14, 30, 44, 60, 74 and 90.

In the study to assess effects on flea reproduction, a single oral treatment of sarolaner resulted in the rapid kill of fleas with no egg-laying for 35 days. The effects of the inhibition of reproduction were confirmed in a simulated infested-home environment where the existing flea infestations were reduced by >95% within two weeks of the first treatment and eliminated from the dogs after two monthly doses. There were no sarolaner-related adverse reactions during any of the studies. These studies demonstrated that sarolaner completely suppressed flea egg-laying for one month following a single treatment and provided excellent control of existing environmental infestations of fleas.

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Field efficacy and safety of sarolaner (Simparica™) against fleas on dogs in the United States
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The efficacy and safety of sarolaner in controlling flea infestations and the clinical signs of flea allergy dermatitis (FAD) in dogs was evaluated in a field study conducted at 19 veterinary practices throughout the USA. Eligible households were allocated randomly to treatment with either sarolaner or spinosad. Treatments were administered orally per label directions on Days 0, 30 and 60 to provide a minimum of 2 mg/kg sarolaner or a minimum of 30 mg/kg spinosad. Of the 479 dogs enrolled, 293 (195 sarolaner and 98 spinosad) were primary dogs included in efficacy evaluations. Dogs ranged in age from 8 weeks to 18.2 years; purebred dogs comprised 58.5% of the enrolled population with Labrador Retrievers (7.7%), Chihuahuas (6.3%) and Shih Tzus (4.2%) enrolled most frequently. Flea burdens were assessed by comb counts on Days -1 or 0 (prior to treatment), 14, 30, 60 and 90.

In sarolaner-treated dogs geometric mean live flea counts were reduced by >99% on Day 14 and continued to reduce throughout the study. Treatment success (proportion of dogs with ≥90% reduction in fleas) for the sarolaner-treated dogs was superior to that for spinosad-treated dogs at Days 14 and 30, and non-superior on Days 60 and 90. Fifty-three (53) sarolaner-treated dogs were diagnosed as likely having FAD. Prior to the first treatment, these dogs had clinical signs of pruritus (88.7%), papules (49.9%), erythema (96.2%), scaling (67.9%), alopecia from self-trauma (69.8%), and dermatitis/pyodermatitis (69.8%). Reductions in these signs were seen by the first re-examination at 14 days after the first treatment, and by Day 90 had improved markedly with incidences of ≤15.1%. There were no treatment-related adverse events in sarolaner-treated dogs.

Sarolaner was safe and highly effective in veterinary patients against fleas on dogs and resulted in a rapid and substantial improvement in the clinical signs associated with FAD.
Efficacy of Sarolaner (Simparica™) Against Adult *Amblyomma americanum*, *A. maculatum*, *Dermacentor variabilis*, *Ixodes scapularis* and *Rhipicephalus sanguineus*

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Ten laboratory studies were conducted against five tick species (two per species) to evaluate the efficacy of the minimum single oral label dose of 2 mg/kg sarolaner against the most important tick species known to infest dogs in the United States. Purpose-bred mongrels or Beagle dogs were randomly allocated to treatment with either placebo or sarolaner (8 per group) based on pre-treatment host-suitability tick counts. Dogs were infested with approximately 50 unfed adult *Amblyomma americanum*, *Amblyomma maculatum*, *Dermacentor variabilis*, *Ixodes scapularis* or *Rhipicephalus sanguineus* ticks on Days -2, 5, 12, 19, 26 and 33. Tick counts were conducted 48 h after treatment on Day 0 and after each subsequent weekly re-infestation.

Geometric mean live tick counts were significantly lower in the sarolaner-treated group compared to the tick counts in the placebo group at all time points. Treatment with sarolaner resulted in ≥99.6% efficacy against existing infestations of all five tick species within 48 h. The efficacy against weekly post-treatment re-infestations of all tick species was ≥96.9% for at least 35 days after treatment. There were no sarolaner-related adverse reactions during any of the studies.

These studies demonstrated that a single dose of sarolaner resulted in excellent efficacy within 48 h against existing tick infestations, which persisted against weekly re-infestations for at least a full month after treatment.

Sarolaner (Simparica™) speed of kill against induced infestations of *Amblyomma maculatum*, *Ixodes ricinus* and *Ixodes scapularis* on dogs.

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Three laboratory studies were conducted to evaluate the speed of kill of the minimum single oral label dose of 2 mg/kg sarolaner against three tick species known to infest dogs in the United States or Europe. Purpose-bred Beagle and mixed-breed dogs were allocated randomly to treatment with either placebo or sarolaner (7 or 8 per group) based on pre-treatment host-suitability tick counts. Dogs were infested with approximately 50 unfed adult *Ixodes scapularis*, *Ixodes ricinus* or *Amblyomma maculatum* ticks on Days -2, 7, 14, 21, 28 and 35. Tick counts were conducted at 4 (*I. scapularis* only), 8, 12 and 24 hours after treatment on Day 0 and after each subsequent re-infestation.

Following treatment, live tick counts were significantly reduced relative to placebo at the 8 hour post-treatment counts indicating that sarolaner started killing existing infestations of ticks rapidly after treatment. Efficacy was 90.1% against *I. ricinus*, 98.8% against *I. scapularis*, and 99.2% against *A. maculatum* within 12 hours, and 100% efficacy was achieved at 24 hours after treatment against all three tick species. This speed of kill was maintained throughout the month with ≥95.7%, ≥98.7% and ≥89.6%
efficacy against *I. scapularis*, *I. ricinus*, and *A. maculatum*, respectively, at 24 hours after re-infestation at least through Day 28. There were no sarolaner-related adverse reactions during any of the studies.

These studies demonstrate that sarolaner has a rapid onset of action against *A. maculatum*, *I. scapularis* and *I. ricinus*, which results in the rapid and consistent kill of existing and subsequent re-infestations of ticks for a full month after a single oral dose.

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**Comparative efficacy of sarolaner (Simparica™) and afoxolaner (NexGard®) against *Ixodes scapularis* infestations on dogs.**
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The speed of kill of sarolaner against *I. scapularis* on dogs was evaluated and compared with afoxolaner for five weeks after a single dose in a controlled laboratory study. Twenty-four Beagle dogs were randomly allocated to treatment groups based on pre-treatment tick counts. On Day 0, dogs received either a placebo tablet, Simparica™ Chewable tablet per label directions (sarolaner at 2 to 4 mg/kg), or NexGard® tablet per label directions (afoxolaner at 2.5 to 6.8 mg/kg). Live (attached and free) ticks were counted *in situ* at 8 and 12 hours, and counted and removed at 24 hours after treatment and after subsequent re-infestations on Days 7, 14, 21, 28 and 35.

Sarolaner significantly reduced tick counts versus placebo from Day 0 to Day 21 at 8 and 12 hours, and on all count days through Day 35 at 24 hours. Efficacy of afoxolaner was only significantly lower than placebo at 8 hours on Days 0 and 14, and at 12 hours only on Day 0. Significantly more live ticks were recovered from afoxolaner-treated dogs than from sarolaner-treated dogs at 24 hours after infestation from Day 14 to Day 35. At 24 hours, efficacy based on geometric mean counts of afoxolaner declined to less than 80% from Day 21 through the end of the study, while efficacy for sarolaner was >95% for 35 days. There were no sarolaner-related adverse reactions during the study.

This study demonstrated that sarolaner had a faster speed of kill against *I. scapularis* than afoxolaner and this was more pronounced towards the end of the treatment period. The rapid and consistent speed of kill provided by sarolaner ensures highly effective and reliable tick control over the treatment interval and should help reduce the risk of tick-borne diseases, including Lyme disease organisms, which are vectored by *I. scapularis*.

### Large Animal: Diagnosis/Epidemiology

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**Dynamics of *Cooperia oncophora* establishment in calves**
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The dynamics of the establishment rate of *Cooperia oncophora* in young cattle in relation to host age and previous exposure have been investigated in an experiment. Young 4 to 6 month old Friesian cross calves were blocked by age and randomized to one of three treatment groups and kept on a feed pad during the 325 days of the experiment. The treatment groups were subject to different levels of trickle infection with an ivermectin-susceptible isolate of *C. oncophora*, i.e. a non-trickle infected group (n=16) received 0, a low trickle infection group (n=16) received 2000 and a high trickle infection group (n=22) received 10000
L3/week. In intervals of four to six weeks two calves from each group were challenged with a single dose of 15000 ivermectin-resistant *C. oncophora* L3, did not receive further trickle infection and were separated from the remaining calves. After 25 days the challenged calves were orally treated with the recommended dose of ivermectin (0.2mg/kg, Ivomec®) and 5 days later slaughtered to determine *Cooperia* worm burdens. On three occasions two calves from the high trickle infection group were treated with the recommended dose of ivermectin 7 days before challenge and separated but followed the same procedure as for other challenged calves otherwise. Analysis of the worm burden data has shown a significant difference between the non-trickle infected group and the two groups receiving trickle infection. The low and high trickle infection groups showed a similar progression and the establishment rate rapidly declined in both groups compared to the non-trickle infected group. The animals that were treated with ivermectin before challenge showed no significant difference compared to the non-trickle infected group. The results indicate that an existing *C. oncophora* worm burden had a strong negative effect on establishment rate of incoming larvae.

36 Accuracy and Precision of a Smartphone-based Parasite Egg Count System
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In the field of parasitology, fecal egg counts make up a strong basis of field diagnostics as well as scientific research. However, the operator dependency, method variability, equipment requirements, and time commitment create challenges. We have developed a new technologically advanced diagnostic system involving a smartphone for generating counts automatically. The purpose of this two-part study was to generate data on accuracy and precision for an iPhone-based prototype and compare these to the manual McMaster and Mini-FLOTAC methods. Part one utilized naturally infected samples, and part two comprised spiked samples. For part one, fecal egg counts were performed in triplicate according to each method’s protocol on 50 horse samples to determine precision. Counts were analyzed with a dependent group t-test using the t-test procedure with the Cochran option for evaluation of unequal variance in SAS 9.3. For part two, feces confirmed to be egg count negative were spiked with strongyle eggs at the 0, 5, 50, 500, and 1000 eggs per gram (EPG) level and accuracy was determined for all three techniques. Precision was evaluated across the 50 samples using the coefficient of variation (CV) and were 0.28, 0.54, and 0.37 for smartphone, McMaster and Mini-FLOTAC techniques, respectively. Smartphone variance was significantly less than McMaster and Mini-FLOTAC (p<0.0001), and Mini-FLOTAC variance was significantly smaller than McMaster (p=0.0228). Mean accuracies defined as ([observed-expected]/expected) X100% for each technique were 27%, 16% and 64% for smartphone, McMaster and Mini-FLOTAC, respectively. In conclusion, the smartphone system was significantly more precise than the other two methods and as accurate as the McMaster. However, the mini-FLOTAC was substantially more accurate than the two other methods. The iPhone-based prototype shows promise as an onsite automated egg counting technique, but further improvements in camera optics, phone application algorithm and sample preparation should be investigated to improve accuracy further.
37 Parasite dynamics in naturally infected and untreated horse foals
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Parasite control in foals is of utmost importance due to the high susceptibility to parasitic infection and disease in this age group. Foals are commonly co-infected with strongyle and ascarid parasites, which complicate parasite control strategies. The present study retrospectively investigated necropsy records of foals born into a university herd kept without anthelmintic treatment since 1979. The aims were to analyze statistically the relationship between fecal egg counts, worm burdens, foal age, gender, and season with specific focus on *Parascaris* spp. and *Strongylus* spp. A total of 83 foals born between 1999 and 2015 were included. Foals were born between January and September within the given year and age at necropsy ranged between 27 and 563 days of age with a mean and median of 202 and 204 days, respectively. One set of multivariate mixed linear models were constructed analyzing strongyle and ascarid fecal egg counts as outcome variables, and another set of analyses investigated the following worm counts as outcome variables: Intestinal *Parascaris* spp. counts (immatures and adults), *Strongylus vulgaris* (migrating and intestinal stages), *S. edentatus* (migrating and intestinal stages). Both ascarid and strongyle egg counts were influenced significantly by differences between study years (P<0.05). In addition, total ascarid egg counts were statistically influenced by age (P=0.0195) exhibiting a peak around four months of age. Fillies had significantly higher ascarid worm burdens (P=0.0148), and these counts were also significantly affected by birth month (P=0.0022) and month of euthanasia (P=0.0327). Foal age had significant influences on intestinal *S. vulgaris* (0.0260) and *S. edentatus* counts (P=0.0277), as well as counts of migrating *S. edentatus* larvae (P=0.0148). Counts of migrating *S. vulgaris* larvae were not statistically associated with any of the investigated covariates. This study provides novel information on the dynamics of important parasites in naturally infected foals.

38 Comparison of fecal egg counting methods in four livestock species
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Accurate quantification of strongyloid eggs is necessary for evaluating anthelmintic efficacy and making anthelmintic treatment decisions. Numerous fecal egg counting (FEC) techniques exist, however, they vary in detection sensitivity and efficiency of egg recovery. In this study we evaluated the Modified-Wisconsin, 3-chamber (high-sensitivity) McMaster, and the relatively new Mini-FLOTAC methods; having 5, 8 and 5 eggs per gram (EPG) detection sensitivity, respectively.. The objective of this study was to compare these methods on fecal samples from horses, sheep, cattle and llamas to determine which method has the highest level of egg recovery, and if differences existed among these four common host species. Multiple replicate FEC using each method were performed on fecal samples from five individual animals of each host.

For ruminants, Mini-FLOTAC consistently yielded the highest EPG, revealing a significantly higher level of egg recovery (p<0.0001). Mini-FLOTAC recovered 55.7% and 59.4% more eggs than Wisconsin and 44.6% and 29.6% more eggs than McMaster in sheep and cattle, respectively. McMaster recovered 20.2% and 43.2% more eggs than Wisconsin. In contrast for horses and llamas, both McMaster and Mini-FLOTAC yielded similar but significantly higher EPG than Wisconsin; Mini-FLOTAC recovered 50.0% and 30.5% and McMaster recovered 40.9% and 50.1% more eggs than Wisconsin for horses and llamas,
respectively (p<0.0001 and p<0.05). The superior egg recovery of Mini-FLOTAC may be due to having fewer steps where eggs could be lost, and having a sieve with larger diameter pores than the cheesecloth used in the other methods for straining samples. Based on these data, Mini-FLOTAC is the preferred method for ruminant species, and for equine and camelid species, both the McMaster and Mini-FLOTAC are preferred over the Wisconsin. However, given the increased efficiency of the Mini-FLOTAC, this method can be recommended for all host species, especially when high detection sensitivity is desired.

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Serological detection of antibodies against Babesia caballi and Theileria equi in Brazilian equids
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Babesia caballi and Theileria equi are tick-borne diseases endemic in most tropical and subtropical areas of the world. They commonly affects horses, mules, donkeys, and zebras and their presentation can be acute or chronic. Currently there have been few epidemiological studies of equine blood parasites in Brazil. Therefore, the goal of this study was to determine the serum prevalence of B. caballi and T. equi infection in Brazilian equids from the Northeastern Region of Brazil. For this research we obtained serum samples from 400 equids (horses, mules, and donkeys) raised in 12 different cities within Pernambuco State (8° 4’ 14” S, 37° 15’ 57” O), both male and female, and older than one year. The samples were analyzed by enzyme-linked immunosorbent assay (ELISA). The results showed the prevalence of T. equi to be 10.8% (43/400; C.I. 8.0 – 14.3%) ranged from 0 to 17.6% in all cities; and 4.3% (17/400; C.I. 2.6 – 6.9%) ranged from 0 to 18.2% for B. caballi. No statistical difference in the prevalence these tick-borne diseases was observed between horses, mules, or donkeys. However, a slightly higher prevalence of these diseases were observed in native horse breeds, such as Mangalarga Marchador and Mangalarga, but the difference was not statistically significant.

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Dirofilaria immitis exhibits sex- and stage-specific differences in excretory/secretory miRNA and protein profiles
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The canine heartworm Dirofilaria immitis releases excretory/secretory molecules into its host and in culture. We report analyses of the types, amounts and stage-dependence of microRNAs and proteins found in D. immitis culture media recovered after incubating 800,000 microfilariae for 6 days, 500 L₃ and 500 L₄ for 7 days, as well as 40 adult females and 40 adult males for 48 hours, all separately. In addition, the presence of exosome-like particles was established by nanoparticle tracking analysis. Our results are in concordance with the D. immitis molecules previously detected in dog blood and in culture medium, but add additional insight into the sex- and stage-specificity of these processes. Of 131 miRNA candidates analysed, none of the most abundant sequences was exclusively associated with one stage. Several
isoforms of the nematode miR-100 family, miR-279, miR-71, were highly represented and overlapped substantially with the profile of heartworm miRNAs described from infected dog blood. lin-4 secretion was primarily associated with males. We also report 4, 27 and 72 proteins in media from microfilariae, females and males, respectively. The only protein in common to all samples was actin, and only 8/85 proteins with a gene ontology description had not been reported in other studies of filarial secretomes. Exosomal proteins were well represented, dominated by cytoskeletal proteins, metabolic enzymes, zeta polypeptide, and chaperones. These data offer new insights into the continuity of miRNA secretion in vivo and in vitro and show that the menu of secreted parasite molecules is stage-dependent.

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Transcriptomic Study on Ovine Immune Responses to Fasciola hepatica Infection
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Fasciola hepatica is not only responsible for major economic losses in livestock farming, but is also a major food-borne zoonotic agent, with 180 million people being at risk of infection worldwide. This parasite is sophisticated in manipulating the hosts’ immune system to benefit its own survival. A better understanding of the mechanisms underpinning this immunomodulation is crucial for the development of control strategies such as vaccines. This in vivo study for the first time has investigated the global gene expression changes of ovine peripheral blood mononuclear cells (PBMC) response to both acute & chronic infection of F. hepatica, and revealed 6490 and 2364 differential expressed genes (DEGS), respectively. Several transcriptional regulators were predicted to be significantly inhibited (e.g. IL12 and IL18) or activated (e.g. miR155-5p) in PBMC during infection. Ingenuity Pathway Analysis highlighted a series of immune-associated pathways involved in the response to infection, including ‘Transforming Growth Factor Beta (TGFβ) signaling’, ‘Production of Nitric Oxide in Macrophages’, ‘Toll-like Receptor (TLRs) Signaling’, ‘Death Receptor Signaling’ and ‘IL17 Signaling’. We hypothesize that activation of pathways relevant to fibrosis in ovine chronic infection, may differ from those seen in cattle. Potential mechanisms behind immunomodulation in F. hepatica infection are a discussed. In conclusion, the present study for the first time performed global transcriptomic analysis of ovine PBMC, the primary innate/adaptive immune cells, in response to infection with F. hepatica, using deep-sequencing (RNAseq). This dataset provides information pertinent to understanding of the pathological processes in fasciolosis, as well as a base from which to further refine development of vaccines.

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Infection with Haemonchus contortus shifts genera diversity of fecal microbiome
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Consequences of helminth infection have the potential to significantly affect digestive Microbe populations. Thus, the objective of this study was to describe effects of H. contortus infection on diversity of host fecal microbiome. Fecal samples were obtained from Suffolk sheep that were either uninfected (n=4), infected (n=4), or previously infected with H. contortus (n=3). 16S ribosomal metagenomic analysis was performed on microbes extracted from samples using Illumina MiSeq. Overall Shannon Diversity indices, operational taxonomic unit (OTU) richness, and community evenness were calculated at the genus level. A one-way ANOVA was performed on mean diversity and individual genera. Tukey’s test was used on genera exhibiting a significant difference of abundance across treatments. Overall
Shannon Diversity from infected individuals (3.66614) was found to be significantly lower ($P < 0.05$) compared to primed individuals (3.79663), while naïve individuals (3.75602) did not differ significantly from either primed or infected individuals. A decrease in community evenness trending toward significance ($P = 0.0534$) was observed with no significant difference in OTU richness. Thirty-four genera exhibited significant differences across trials ($P < 0.05$). Iron-metabolizing Geobacter showed significant increase as a result of infection compared to primed individuals ($P = 0.0222$) while pathogenic Flavobacterium ($P = 0.0125$), Paludibacter ($P = 0.0447$), and Coprococcus ($P = 0.0357$) showed significant increases in abundance during infection compared to naïve sheep. Significant reduction in Clostridium species ($P = 0.0065$) during infection compared to naïve sheep was observed as well as reduction of Caloramator ($P = 0.0282$) and Symbiobacterium ($P = 0.0312$) in infected sheep compared to primed individuals. These data indicate that infection significantly lowers diversity of the GI microbiome by shifting populations toward particular genera, affecting evenness rather than reducing total number of unique genera.

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**Development of microsatellite markers for Dicrocoelium dendriticum and their application to investigate parasite epidemiology and transmission**

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Analyses of genetic markers have allowed parasitologists to assess aspects of parasite biology that are difficult or impossible to observe directly. Investigations of life cycles, invasion history, or resistance to drugs can be done using genetic data. However, careful scrutiny of new markers is required because technical errors and biological factors can bias genetic data and lead to incorrect conclusions. For trematodes, factors such as complex life cycles which include stages of asexual reproduction have been shown to affect population genetic structure. We have assessed the impact of these factors on a panel of newly developed microsatellite markers for the trematode Dicrocoelium dendriticum. Nine microsatellite loci, identified using next generation sequencing methods, were used to genotype 66 individual worms sampled from grazing mammals in the Cypress Hills, Alberta. Initial results showed that four of the loci deviated significantly from Hardy-Weinberg Equilibrium (HWE). This could be due to biological factors such as clonal transmission, or by technical factors such as null alleles. To answer this we created two datasets, one including all individuals and another with all identical genotypes reduced to a single copy, allowing us to determine the impact of clonal transmission on these data. The differences in results of the two datasets followed theoretical predictions regarding the impact of non-random transmission of clones. We were able to rule out the effect of clones on the data and conclude that deviations from HWE were due to the presence of null alleles. We also determined that the remaining five loci are in HWE and could be used to assess the population genetic structure of D. dendriticum including the impacts of clonal transmission. We are now using these markers to explore the life cycle, transmission and invasion history of D. dendriticum.
Investigating changes in trichostrongylid nematode community composition during cattle fecal coproculture using deep-amplicon “Nemabiome” sequencing

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Morphological identification of L3 larvae derived from coprocultures is commonly used to assess trichostrongylid nematode species composition in fecal samples from grazing ruminants. However, there are significant concerns about how accurately L3 larval communities reflect the species proportions of the eggs present in fresh fecal samples. Consequently, we have undertaken a study to evaluate how the proportions of the different cattle nematode species change over the course of coproculture. Larvae were collected at different times of incubation of fecal coprocultures derived from two experimental trials. In the first experiment, six 8–12 month old calves were treated with levamisole (7.5%) and fecal egg counts (FEC) were performed every two days after the treatment, for 16 days. After it was confirmed they were nematode free, the animals were infected with a mixed L3 culture composed of 21,000 Haemonchus spp, Cooperia spp, Trichostrongylus spp and Oesophagostomum spp (trickle infections of 3,000 larvae/day for 7 days). After 42 days, individual stool samples were harvested for analysis. In the second trial, individual fecal samples were collected from seven naturally infected 6–12 month old calves. From both trials, 10 sets of coprocultures were prepared for each animal, from the same individual fresh fecal sample. The larvae were extracted from each coproculture after 2, 4, 6, 8, 10, 12, 14, 16, 18 and 20 days. Approximately 1000 larvae were isolated from each extraction and the species proportions determined using deep-amplicon sequencing to assess the changes in species proportions throughout coproculture. Additionally, we compared the observed proportions to the adult worm burden in the animal, to assess the fecundity of different nematodes species and how these influence observed proportions in the feces.

RNA-seq reveals differential gene expression in abomasal lymph node during Haemonchus contortus infection

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*Haemonchus contortus* is a blood-feeding, gastrointestinal nematode of sheep responsible for vast economical losses. St Croix hair sheep possess remarkable resistance to this parasite and can eliminate the parasite within the first seven days of infection. Resistance observed in St. Croix sheep is largely thought to be immune-mediated but underlying immunological mechanisms regulating immune responses to this parasite are not well-defined. Abomasal lymph nodes are sites of immunological importance during infection, thus the purpose of this study was to employ RNA-sequencing technology to explore differences in lymph node gene expression. Abomasal lymph nodes were collected 7 days after *H. contortus* infection in 3 St. Croix (STC-resistant) and 3 Dorset crossbred (Dx-susceptible) lambs. RNA-seq analysis identified 51 genes differentially expressed between breeds (P < 0.1). Specifically, 14 genes were involved in immunological processes, of which 12 were upregulated in Dx lambs. Genes upregulated in STC lambs included ontogenies such as biological regulation, cellular process, developmental process, and metabolic process. Since *H. contortus* infection is nearly resolved in STC lambs by day 7, downregulation of immune genes would support the conclusion that immune responses are being suppressed at this point. Greater expression of immune-related genes suggests that Dx lambs are just beginning to generate immune
responses in the local lymph nodes by day 7. These data further demonstrate that susceptible sheep generate a delayed immune response to *H. contortus* infection, permitting their establishment.

**Novel Cases**

46 Immunologic detection of *Giardia duodenalis* in a specific pathogen free captive olive baboon (*Papio cynocephalus anubis*) colony
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Several commercially available immunoassays were evaluated to reliably detect *Giardia* in baboons that would be sensitive and specific as well as easy to use for testing a large colony. An additional objective was to identify the assemblage(s) of *G. duodenalis* present in this baboon colony. For diagnostic comparison, the MERIFLUOR® Cryptosporidium/Giardia direct immunofluorescence antibody test (IFA) was used as the reference test. Tests evaluated were a patient-side rapid test for dogs and cats (SNAP® Giardia Test, IDEXX), a human rapid test (GIARDIA/CRYPTOSPORIDIUM QUIK CHEK™, TECHLAB® Inc.), and a well-plate ELISA designed for use with humans (GIARDIA II™ ELISA, TECHLAB® Inc.). Test sensitivities and specificities were compared using McNemar’s paired t-test and were further evaluated for agreement using an unweighted Cohen’s kappa statistic. When compared to the IFA reference test, the GIARDIA II™ELISA was the most sensitive of the immunoassays. The assemblage of *G. duodenalis* was determined using PCR and sequencing of the small-subunit rRNA and glutamate dehydrogenase loci. The assemblage present in this baboon colony was assemblage AI. This study found 10 of the 110 (9.1%) baboons in the SPF colony were infected with a zoonotic strain of *G. duodenalis*, and that the human GIARDIA II™ ELISA was the most sensitive for detecting *G. duodenalis* in this baboon colony.

47 Detection of circulating *Sarcocystis* sp. in a cat with FIV
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An 8-year-old, 6-kg, male neutered domestic shorthair cat presented to The Ohio State University Veterinary Medical Center for difficulty breathing. He was approximately 5% dehydrated, normothermic at 101.4°F, with a pulse of 120 beats/minute that increased to 180 beats/minute by the end of the physical exam. Peripheral blood smear showed rare extracellular and intracellular elongated organisms (zoites) with a clinical suspicion of systemic toxoplasmosis potentially associated with a positive FIV status. Further clinical testing, including serology, immunocytochemistry, and parasite characterization, including PCR and DNA sequencing ruled out *T. gondii* and *Sarcocystis felis*, and identified the organisms as a *Sarcocystis neurona*-like agent. This case demonstrates using multiple parameters for differentiating parasites and confirmation of an unusual diagnosis.
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Efficacy of a monthly oral tablet containing spinosad and milbemycin oxime for the prevention of *Spirocerca lupi* infection in dogs

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This study investigated the efficacy and safety of a combination tablet containing spinosad and milbemycin oxime (MO) (Trifexis®; Elanco Animal Health) when administered for five consecutive months to prevent the establishment of *Spirocerca lupi* in dogs experimentally infected with L3 larvae. Dogs were randomly allocated to 2 treatment groups of 8 dogs/group. Group 1 were treated with a placebo containing no active drug and group 2 were treated on Days 0, 28, 56, 84 and 112 with a combination tablet containing spinosad and MO administered at a minimum MO dose of 0.5 mg/kg. Dogs were orally inoculated with approximately 10 L3 *S. lupi* on Days 26, 40, 54 and 70. Faecal *S. lupi* egg counts, euthanasia and necropsy were performed on Day 207. Lesions caused by *S. lupi* in the thoracic aorta and oesophagus were described and quantified during necropsy and any worms present recovered and quantified. *S. lupi* worms were recovered from all control dogs. Counts ranged from 6 to 24 (average 16.8 worms using geometric means; GM). *S. lupi* eggs were recovered from five control dogs. Counts ranged from 0 to 14 eggs (average 2.3 eggs; GM). No eggs or worms were recovered from the Trifexis treated dogs. Nodules were present in the oesophagus of all control dogs. The nodules were mostly large and contained adult *S. lupi*. No nodules were found in the oesophagus of any Trifexis treated dogs. In the control group, the nodules/lesions on the inside of the thoracic aorta ranged from 11 to 16. No lesions were found in the thoracic aorta of the Trifexis® treated dogs. The preventive efficacy of Trifexis® tablets was 100% against *S. lupi* infections in experimentally infected dogs given 5 consecutive monthly treatments. All dogs tolerated the consecutive monthly treatments well and no treatment-related adverse events occurred.

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New 18S rRNA partial gene sequence for a haemogregarine of the alligator snapping turtle, *Macrochelys temminckii* (Testudines: Chelydridae), in Tyler, Texas

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A severely underweight alligator snapping turtle *Macrochelys temminckii* was found in early January, 2015 by the side of a road near Tyler, Texas and was taken to the Caldwell Zoo. Examination of a Giemsa-stained blood film revealed the presence of haemogregarine-like inclusions in the red blood cells. A blood sample was submitted to TAMU for identification.

Morphological features by microscopic examination of the blood revealed intraerythrocytic narrow elongated parasites approximately 14 µm in length that appeared to be premeronts. The nucleus was generally centrally located. DNA was extracted from the blood sample and the DNA concentration determined. Segments of the 18S rRNA gene were amplified by PCR using specifically designed primers for haemogregarines. The resulting amplicons were cloned and sequenced.

The haemogregarine-like parasite morphology showed similarities to an intraerythrocytic organism, *Hemogregarina macrochelysi*, previously reported in alligator snapping turtles in Florida. Sequence analysis of the 18S rRNA gene in the present study revealed 96% identity to *Haemogregarina balli* (found in the common snapping turtle *Chelydra serpentina serpentina*) and to *Hemolivia stellata* (found in the
cane toad *Rhinella marina*). There are no available sequence data for *H. macrochelysi* as its taxonomic description did not include molecular characterization.

Adeleorinid coccidia have a complex life cycle and both *Haemogregarina* and *Hemolivia* are in the (suborder Adeleorina). Both *Haemogregarina* and *Hemolivia* spp. have indirect life cycles involving an ectothermic vertebrate as an intermediate host and an ixodid tick as a definitive host. Further characterization is underway to determine if the haemogregarine-like parasite found in the Texas alligator snapping turtle is conspecific with *Haemogregarina macrochelysi*.

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**Efficacy of praziquantel in the treatment of natural *Platynosomum fastosum* infections in cats**
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Heavy and chronic infections of *Platynosomum fastosum* can lead to liver failure in cats. Studies on the efficacy of treatment have relied on fecal egg counts, which are shed intermittently and do not necessarily reflect trematode burden. In this study, a high dose treatment (HT; 20 mg praziquantel/kg body weight (BW) for three days) was compared to a low dose treatment (LT; 5 mg praziquantel/kg BW once, repeated two weeks later). Naturally infected cats were randomly allocated to treatment group (RT: 6 cats; LT: 8 cats) and euthanized 10 d after the last treatment. Postmortem fluke counts were used to assess treatment efficacy with treatment success defined as no flukes post treatment. In cases where flukes were present post treatment, fluke reduction was estimated using the mean number of flukes seen in untreated cats on St. Kitts. The study was conducted under Ross University School of Veterinary Medicine IACUC approved protocols. Three of six cats in the HT group were cured, while none of the cats in the LT group were cured of the infection. The estimated fluke burden reduction was 99% in the HT group and 87% in the LT group. However, the LT group reduction was heavily influenced by one cat with an apparently heavier burden than the other cats. Despite differences in efficacy, both doses are potential options for treating *Platynosomum fastosum* infections in cats. The LT might be preferable in heavily infected cats to decrease the chances of bile duct obstruction during treatment. In endemic areas, the use of monthly preventatives with the LT also might be beneficial in maintaining lower parasitic burdens. The HT might be more appropriate for cats in non-endemic areas due to unlikely chance of reinfection and to help prevent the spread of the fluke.

**Dogs and Cats: Diagnosis**

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**Analysis of heat-treated serum from macrocyclic lactone-treated heartworm-positive dogs, a controlled study.**
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Recent studies have shown that heat-treatment of serum samples may convert canine serum samples to positive in which no heartworm antigen was previously detected, potentially by breaking antigen-antibody complexes. This phenomenon has been observed in canines undergoing various adulticidal treatments with macrocyclic lactones. The aim of this study was to evaluate the diagnostic efficacy of heat-treated serum during adulticidal heartworm treatment of experimental dogs undergoing treatment with Advantage
Multi® and doxycycline. This study utilized 16 dogs: 8 dogs each in the control and treated groups. A total of 16 adult *Dirofilaria immitis* (Missouri strain) were surgically transplanted into the jugular vein of all study dogs. The treatment regimen of monthly Advantage Multi® (10% imidacloprid, 2.5% moxidectin) topically for 10 months and 10 mg/kg doxycycline BID orally for 30 days was initiated 30 days post-surgical transplant. Serum samples were obtained every 4 weeks, and were tested for heartworm antigen using the DiroCHEK® heartworm antigen test kit pre- and post-heat-treatment. Serum samples were placed on a dry heat-block for 10 minutes at 103°C and then centrifuged. The DiroCHEK® was performed according to manufacturer’s recommendations and read using a spectrophotometer at 490 nm. Heat-treated samples contained a higher concentration of detectable antigen as compared to non-heated serum samples. Throughout this study, 4 dogs initially tested negative for heartworm antigen using the non-heated serum sample and then converted positive for heartworm antigen after heat-treatment. This conversion may be due to the presence of antigen-antibody complexes, but this has not been confirmed. Adult heartworm recovery will indicate whether these antigen-negative treated dogs are truly heartworm-negative. Necropsy adult worm recovery data is to be completed shortly, with results available prior to publication and presentation. Preliminary data collected demonstrates this treatment regimen experimentally reduces heartworm antigen concentration over time as compared to non-treated heartworm-positive dogs.

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**Do as the humans do: Detecting circulating antigens in dogs infected with *Heterobilhazia americana***

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*Heterobilharzia americana* is a trematode parasite (Family: Schistosomatidae) of dogs, horses, and wildlife in the southeastern United States. This parasite is related to the human schistosomes, *Schistosoma mansoni* and *S. japonicum*. Adult worms live in the mesenteric veins, and eggs migrate into the intestinal lumen to be excreted in feces. Circulating cathodic antigen (CCA) and circulating anodic antigen (CAA) are regurgitated from the adult worm and are detected in the serum and urine of humans infected with *S. mansoni*. These antigens are highly conserved across schistosome species and have been used as targets for immunodiagnostic test development. In this comparative diagnostic test study, we evaluated the ability to detect these antigens in dogs naturally infected with *H. americana*. We used point-of-care immunodiagnostic assays that detect *S. mansoni* infection in humans (POC-CCA and POC-CAA; Rapid Medical Diagnostics, Pretoria, RSA). Results were compared with fecal PCR and fecal saline sedimentation tests. Veterinarians submitted fecal, serum, and urine samples from suspected canine cases. Out of 57 dogs tested, 20 (35%) were positive by at least one of the diagnostic methods. Out of the 20 positive samples, 18 were detected by PCR of the fecal sediment, 10 by PCR of the fresh feces, 6 by fecal saline sedimentation, 5 by POC-CAA using serum, and 5 by POC-CCA using urine. All dogs that were diagnosed by antigen detection were also diagnosed by fecal exam and PCR. Although these tests perform well in humans, they may not be adequate for use in dogs for *H. americana* diagnosis. Nevertheless, the ability to detect *H. americana* CCA and CAA in some of these infected dogs is promising for future work. Because these point-of-care tests may not detect dogs with lower intensity infections, concentrating samples and using other immunodiagnostic test modalities could improve the sensitivity of antigen detection.
In vivo quantification of *Dipylidium caninum* and *Toxascaris leonina* in experimentally infected dogs

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The majority of *Dipylidium caninum* infections in dogs and cats are not detected by fecal centrifugal flotation or by external examination of feces for proglottids. This makes it difficult for pharmaceutical companies to identify naturally infected dogs for field efficacy studies. Capsule endoscopy (i.e. small bowel imaging using an ingestible camera) has demonstrated utility in quantifying certain canine nematodes in vivo, allowing for calculation of anthelmintic efficacy. This study evaluated the ability of capsule endoscopy (CE) to ascertain *D. caninum* infection status and infection intensity in dogs relative to gold-standard necropsy. The same analysis was also applied to *Toxascaris leonina* infection. Eight beagle dogs were infested weekly for 10 weeks with approximately 250-350 *D. caninum*-infected fleas. During the 4th week, dogs were orally inoculated with approximately 450 *T. leonina* eggs. Two weeks after the last flea infestation, capsule endoscopy was performed followed by necropsy within 3 days. CE and postmortem counts were completed by separate, blinded individuals. CE detected *D. caninum* in 3/4 dogs found to have scolices at necropsy and in 3/4 dogs from which no scolices were recovered. The one dog missed by CE had only a single scolex. Median counts were 3 (range: 0-28) for CE and 2 (0-3) for necropsy. CE detected *T. leonina* in 7/8 infected dogs. The one missed infection consisted of two worms 17mm and 18mm in length. Many immature and young adult *T. leonina* < 24mm long were not observed by CE. Median counts were 9 (range: 0-25) for CE and 25 (2-56) for necropsy. Based on these results, CE is useful in identifying *D. caninum*-infected dogs in vivo, but is not suitable for quantifying young *T. leonina*. For the latter, it is recommended to wait until the worms reach reproductive maturity before performing CE.

Baermann fecal examination survey of lungworm infection in clinically affected dogs in Ontario and Quebec, Canada.

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Canine respiratory disease due to helminth infection is considered infrequent. Diagnosis is challenging due to poor detection sensitivity of fecal flotation for most lungworm species. Along with an over-reliance in clinical practice on fecal flotation for detection of parasitism, this leads to the potential for under-diagnosis of lungworms. A further complication is the sporadic larval shedding patterns typical of metastrongyloid infections. Fecal samples (3 consecutive day collections) from dogs showing signs of respiratory disease were evaluated from October 2014 to May 2016 for first-stage larvae (L1) or eggs using the Baermann examination (BE) and zincsulfate centrifugal flotation (CF). BE was done on a 12-gram composite sample (4 grams from each day) and a 12-gram sample (day 3) for each dog. Larval counts (L1/gram feces = LPG) were done on each of the 3-day samples if L1 were detected on either the composite or day 3 sample. Helminths known to cause respiratory disease were detected in 6.9% (22/317) of the samples examined. Duration of clinical signs prior to diagnosis ranged from 14 – 210 days. L1 of *Crenosoma vulpis* (4.7%; 15/317), *Strongyloides stercoralis* (0.6%; 2/317), *Filaroides hirthi/Oslerus osleri* (0.3%; 1/317) and *Aelurostrongylus abstrusus* (0.3%; 1/317) were detected on BE. Eggs of
*Paragonimus kellicotti* (0.6%; 2/317) and *Eucoleus boehmi* (0.3%; 1/317) were detected on CFBE of the 3-day composite sample detected 86.7% (13/15) of the *C. vulpis* infections compared to 73.3% (11/15) detection by BE of the single (day 3) sample. Larval shedding levels ranged from 0 – 455 LPG (Mn = 22.2 LPG). Lungworm infection should be considered as a possible cause in any case of respiratory disease in dogs in eastern Canada (and likely elsewhere). Three daily BEs had greater *C. vulpis* detection sensitivity than a 3-day collection composite. Least effective was BE of a single day sample.

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A multicenter study demonstrating the added benefit of coproantigen testing to fecal flotation methods in the diagnosis of canine ascarid, hookworm and whipworm infections  
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A study to assess the added benefit of coproantigen testing for ascarids, hookworms and whipworms in canine fecal diagnostics was conducted at three veterinary colleges (Cornell University, Oklahoma State University and Texas A&M University). At each site, approximately 200 owned and 200 shelter dog fecal samples were examined for intestinal parasites. A total of 1202 samples from dogs of varied age were each independently evaluated by a novice examiner performing the most common fecal flotation methodology, passive flotation (Fecalyzer®), and an expert parasitologist performing the gold standard methodology, Sheather’s sugar centrifugal flotation. Blinded samples were then frozen and mailed to IDEXX for coproantigen testing. Centrifugal flotation by an expert detected 58 *Toxocara canis*, 223 *Ancylostoma caninum*, and 95 *Trichuris vulpis* positive samples, while respective results for passive flotation by a novice were 52, 217, and 67 positive samples. The percent positive agreement for these examinations was 69%, 83%, and 68%, respectively. Coproantigen detection identified more positive samples for ascarid (59) and hookworm (285) than either flotation method, and more positive whipworm samples (78) than passive flotation by a novice examiner. When results from passive flotation examination by a novice and coproantigen detection were combined, high positive agreement with the gold standard centrifugal flotation examination by an expert was obtained (91.4%, 93.7%, and 78.9% for ascarids, hookworms and whipworms, respectively). Results of this study support that by combining coproantigen detection with centrifugal examination by an expert, more ascarid, hookworm and whipworm infections may be detected, while still allowing more precise diagnosis of parasitic infections that may better inform treatment choice and zoonotic risk. Compared to passive flotation examination by a novice, coproantigen testing identifies more positives, may decrease misidentifications, and may help sort-out egg presence as a result of coprophagy.

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Teaching Diagnostic Parasitology: Results on *Giardia* and the Telephone Game  
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Applied Veterinary Parasitology at the Ohio State University, College of Veterinary Medicine, is taught in small laboratory sections containing 18-22 students, working at laboratory tables of 3 to 5 students (a group) per table. Each table is equipped with two dual headed microscopes. There are two instructors for the course. The third year veterinary class is divided into eight sections to accommodate all 164 students. *Giardia* cyst identification using double centrifugation flotation, zinc sulfate or Sheather’s sugar solution
is taught in the small animal protozoa laboratory. To evaluate instructional methods, we utilized 4 different laboratory sections which were further divided into the “the Telephone Game” (n= 42 students) or “one-on-one with instructor” (n=38 students) training to distinguish *Giardia* cysts from artifact. Instructors spent anywhere from 3 to 10 minutes per student, working with the student to ensure proper identification. In the “Telephone Game” training, the instructor only worked with one student initially from the group and then ensured the last student in the group appropriately “could teach” the other instructor cyst from artifact. In contrast, for the “one-on-one” sections the instructors worked with all the students individually in the section. To determine if the different training methods impacted later ability to identify *Giardia*, during the final examination, students could volunteer to read a slide, containing artifacts and *Giardia* cysts, and were required to appropriately identify either the artifact or a *Giardia* cyst at the end of a pointer to the instructor. All students volunteered for the exercise. Results of the two different training methods will be discussed, including the impact to student performance relative to accurately diagnosing *Giardia* (sensitivity, specificity, positive predictive value, and negative predictive value) and the time component for the instructors.

**Molecular and Biochemical - 3**

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*Cryptosporidium parvum* Hexokinase a Potential Drug Target for Developing Novel Therapeutics

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The apicomplexan, *Cryptosporidium parvum*, is recognized as one of the top 4 diarrheal pathogens in children under the age of five in developing countries. Cryptosporidiosis can be life threatening and fatal in immunocompromised individuals, particularly HIV-positive and patients with malignancy. Nitazoxanide is the only FDA approved drug for use in immunocompetent individuals, however, safe and effective treatments for cryptosporidiosis are not available for immunocompromised patients. Unlike other apicomplexans, *C. parvum* lacks the TCA (Krebs) cycle and cytochrome-based respiration while depending mainly on glycolysis for ATP production. Hence, the glycolytic pathway is essential in this opportunistic pathogen and can be explored for developing anti-cryptosporidial drugs. The recent biochemical and molecular studies of the *C. parvum* hexokinase (CpHK) suggested this key glycolytic enzyme could be explored as a potential therapeutic target in the opportunistic pathogen. In the present study, we performed a high-throughput screening assay using spectrophotometry-based assays to select possible CpHK inhibitors. Among the 1200 drug compounds screened, 14 possible CpHK inhibitors are identified. A qRT-PCR is currently performed to study the effect of those drugs and their analogues on the parasite growth in vitro. For further validation, the human hexokinase will be challenged with selected candidates for CpHK inhibition. It will be worth to study drugs effect on human (HCT-8) cells or detect toxicity, if any. By taking advantage of the knowledge, new avenues for the development of promising anti-cryptosporidial drugs can be opened.
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*Cryptosporidium* lactate dehydrogenase is associated with the parasitophorous vacuole membrane and is a potential target for developing therapeutics  
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The apicomplexan, *Cryptosporidium parvum*, possesses a bacterial-type lactate dehydrogenase (CpLDH). This is considered to be an essential enzyme, as this parasite lacks the Krebs cycle and cytochrome-based respiration, and mainly—if not solely, relies on glycolysis to produce ATP. Here, we provide evidence that in extracellular parasites (e.g., sporozoites and merozoites), CpLDH is localized in the cytosol. However, it becomes associated with the parasitophorous vacuole membrane (PVM) during the intracellular developmental stages, suggesting involvement of the PVM in parasite energy metabolism. We characterized the biochemical features of CpLDH and observed that, at lower micromolar levels, the LDH inhibitors gossypol and FX11 could inhibit both CpLDH activity (Ki = 14.8 μM and 55.6 μM, respectively), as well as parasite growth in vitro (IC50 = 11.8 μM and 39.5 μM, respectively). These observations not only reveal a new function for the poorly understood PVM structure in hosting the intracellular development of *C. parvum*, but also suggest LDH as a potential target for developing therapeutics against this opportunistic pathogen, for which fully effective treatments are not yet available.

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Characterization of a novel pharyngeal nicotinic acetylcholine receptor formed by EAT-2 and EAT-18 as a potential drug target  
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The long-term use of nicotinic agonists has led to the emergence of resistance among this class of anthelmintic agents, as with many others. Therefore, there is an urgent need to develop novel antinematodal targets and agents. The aim of our study is to identify the potential of EAT-2, a pharyngeal nAChR subunit and EAT-18, a small protein, as a chemotherapeutic target. We are also investigating the surface expression and nature of interaction between the two proteins. EAT-2 and EAT-18 have been reported to be involved in pharyngeal pumping and control of feeding behaviour in *Caenorhabditis elegans*. There are also orthologs in several parasite species. We expressed EAT-2 and EAT-18 from *C. elegans* in *Xenopus laevis* oocytes and used two electrode voltage-clamp to characterize the pharmacology of the receptor. Although, EAT-2 is a non-alpha subunit it was still able to express functionally but only when co-injected with EAT-18. The pharmacological profile of the receptor was found to be distinct from the previously characterized receptors making it a potential drug target. Importantly, our study is the first example of a cationic-selective non-alpha subunit successfully expressed heterogeneously in oocytes without the need of an alpha subunit. To further investigate the interaction between EAT-2 and EAT-18, we expressed GFP and His-tag labelled constructs of each protein. In the EAT-2 fusion protein, GFP was inserted in the intracellular loop between 3rd and 4th transmembrane domain. EAT-18 was tagged with GFP or His at the C-terminal end. Oocytes injected with either EAT-2::GFP & EAT-18::His or EAT-2 & EAT-18::GFP mix, exhibiting a robust current response were selected for fluorescence imaging to provide evidence for surface expression. We are currently performing proteomics experiments including western-blot and co-immunoprecipitation assays to test the physical interaction of EAT-2 and EAT-18.
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Isolation of third stage *Haemonchus contortus* cuticle and cuticle protein
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*Haemonchus contortus* infective stage (L3) is encased in a cuticle that protects the larvae from the environment. Previous studies have shown that immune cells directly bind to the cuticle of third stage *H. contortus* larvae, suggesting the presence of a pathogen-associated molecular marker on the surface of the cuticle that is facilitating this interaction. The objective of this study was to develop a high throughput procedure for isolation of cuticles and cuticle protein. L3 larvae were placed in a flask with EBSS, blasted with CO2 for 30 seconds and placed in an incubator overnight at 37°C. Using a Baermann apparatus, cuticles were isolated from the exsheathed larvae. Cuticles were collected, washed in sterile PBS and homogenized using a bead homogenizer. Supernatant from the homogenate was collected and quantified using a BCA Assay. As antibody is known to attach to the cuticle of L3, cuticle protein isolation was confirmed using an IgA checkerboard ELISA to optimize experimental methods. This method will be used as to obtain cuticle components for future immunological assays.

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Evidence of heartworm infection in dogs testing false negative for *Dirofilaria immitis* antigen
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Canine heartworm infection is commonly diagnosed by detection of antigen although false negative tests occasionally occur. To determine the identity of microfilaria in canine samples that were initially false negative for *Dirofilaria immitis* antigen, we evaluated samples from dogs in the southern US suspected to be infected with heartworm. Blood samples were collected from 96 dogs and examined for microfilaria by microscopy (n=51) and PCR (n=96) using 12S rRNA, COX1, and ITS2 mitochondrial gene assays. Amplicons were sequenced and analyzed to identify species. Antigen tests were performed as previously described before and after heat pre-treatment; a subset of samples were analyzed before and after addition of serum from an *Acanthocheilonema reconditum*-infected dog. Microfilaria were identified by microscopy in 17/51 (33.3%) blood samples. Characteristic fragments of 12S rRNA, COX1, or ITS2 genes were amplified and sequenced from 31/96 (32.3%) blood samples. Sequencing confirmed the identity of microfilaria as *D. immitis* in 29/31 and *Acanthocheilonema reconditum* in 3/31; one sample was co-infected. Antigen of *D. immitis* was detected in 24/96 (25.0%) samples before pretreatment; 16 of these 24 were also PCR positive. After pretreatment, 51/96 (53.1%) samples were antigen positive; 28 of these 51 were also PCR positive. Adding serum from an *A. reconditum*-infected dog converted *D. immitis*-antigen positive samples (n=7) to negative. Sequencing results confirm *D. immitis* infection is likely present in many patients with false negative heartworm antigen tests that convert to positive with heat treatment. In addition, *A. reconditum* was occasionally detected and preliminary results suggest infection with *A. reconditum* may block detection of *D. immitis* antigen in some patients.
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**Ixodes scapularis** tick saliva proteins sequentially secreted every 24 h during blood feeding

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**Ixodes scapularis** is the most medically important tick species and transmits five of the 14 reportable human tick borne disease (TBD) agents in the USA. To develop new tick control methods, a deeper understanding of how the tick feeds is needed. This study describes LC-MS/MS identification of 582 tick-and 83 rabbit proteins in saliva of rabbit fed **I. scapularis** ticks every 24 h through five days of feeding and towards the end of feeding. The 582 tick proteins include proteases (5.7%), protease inhibitors (7.4%), unknown function proteins (22%), immunity/antimicrobial (2.6%), lipocalin (3.1%), heme/iron binding (2.6%), extracellular matrix/ cell adhesion (2.2%), oxidant metabolism/ detoxification (6%), transporter/ receptor related (3.2%), cytoskeletal (5.5%), and housekeeping-like (39.7%). The main finding is that ticks apparently selectively inject functionally similar but unique proteins every 24 h, which we speculate is the tick's way to avoid the host's defense to protect important tick feeding functions from host immune system. The host immune responses to proteins present in 24 h **I. scapularis** saliva will not be effective at later feeding stages. This will influence how to design effective anti-tick vaccine antigens to stop disease agent transmission. This is the first comprehensive study of proteins in blacklegged tick saliva that provides insight into the molecular mechanisms that are at play at the tick feeding site every 24 h. These data sets the foundation for in depth **I. scapularis** tick feeding physiology and TBD transmission studies.

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**Anthelmintic Resistance: Horses**

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**Combination deworming - a possible solution or source of exacerbation for the disappearing drug classes?**

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Equine cyathostomin populations have been documented resistant to the benzimidazole and tetrahydropyrimidine drug classes world-wide, and several reports are suggesting emerging resistance to the macrocyclic lactone class. One possible solution for the disappearing drug classes is combination deworming. Evidence for this approach is based on New Zealand simulation studies involving sheep parasites harboring genetic resistance with an associated fitness loss. It showed that parasites surviving combination treatment ensued a fitness loss detrimental to the population. The goal of the present study was to provide information regarding the efficacy of repeated combination treatments against equine cyathostomin parasites with known resistance to both the benzimidazole and tetrahydropyrimidine drugs. The herd harboring these parasites consisted of 21 miniature ponies, ages ranging from 3 to 20 years. Prior to each anthelmintic treatment, the ponies were weighed on an electronic scale and a fecal sample was collected. Post-treatment samples were collected every two weeks for eight weeks. All samples have been processed using the mini-FLOTAC technique. The beginning of the study was dedicated to providing a baseline efficacy of oxibendazole (oxi) and pyrantel pamoate (pyr) when administered individually.
Hereafter, all the ponies were treated every eight weeks with both drugs to determine their combined efficacy. The group mean percent efficacies and 95% confidence intervals are as follows: Treatment 1 Oxi: 63.10% ± 16.27%, Pyr: 62% ± 14.96%; Treatment 2 Oxi: 70.70% ± 17.65%, Pyr 52% ± 20.86%. The efficacy of the first combination treatment was 76.60% ± 11.82%, but three subsequent treatments were averaging: 41.61% ± 9.06%. It is apparent, that after one treatment with combination therapy, a sustainable population of multi-drug resistant cyathostomins has emerged. This substantial decrease suggests that combination deworming with oxibendazole and pyrantel pamoate is not an effective treatment option for cyathostomin infections, when resistance is already present to both classes.

Drug to target - how you administer an anthelmintic is more important than you might think
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Anthelmintic resistance in gastrointestinal nematodes is now a global phenomenon affecting most species of grazing animals (e.g. goats, sheep, cattle, deer and horses), and considerable scientific effort has been put into understanding how resistance develops and how it can be delayed or managed. However, the development and marketing of anthelmintic products has evolved more or less independently of any considerations for the development of resistance. All anthelmintic products are registered as effective against a range of parasite species based on measured efficacy against populations which are susceptible to the active ingredient at the administered dose rate. However, the rate at which resistance develops is strongly influenced by efficacy against resistant genotypes, in particular the heterozygotes during the early phase of selection when resistance genes are still rare.

The way in which drugs are formulated and delivered can affect the dose, variability in dose and duration of exposure of the target worms to the drug, and all these factors can potentially influence the rate at which resistance develops in the treated population. Different routes of administration (e.g. pour-on, injection, oral) result in very large differences in drug concentrations in plasma and in the target worms. Formulations and routes of administration which result in persistent activity influence the reproductive advantage afforded to resistant genotypes, especially when drug concentrations decline to suboptimal levels over time. Combining different actives with similar spectra of activity into a single product has been shown to have benefits in reducing the survival of resistant genotypes. However, use of combinations raises the potential of drug-drug interactions and formulation effects which may also be important.

Anthelmintic resistance in parasites of horses – the need to do better
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Anthelmintic resistance in equine parasites is now common in many parts of the world. Resistance amongst the cyathostomins to pyrantel and the benzimidazole (BZ) class is common. Furthermore, shortened egg reappearance periods following treatment with a macrocyclic lactone has been reported from Europe, South America, and the US and is regarded as evidence of emerging resistance to this drug class. In Parascaris spp. resistance to the macrocyclic lactones is widespread throughout the world although the BZ and pyrantel groups are still largely effective. With a limited number of anthelmintic classes available for use in horses there is an urgent need to change how anthelmintics are used to reduce further selection of resistance. In general, horse owners around the world are fixated on the frequent
deworming of horses with treatment intervals as short as 6-8 weeks being common. This intensive and often unnecessary use of anthelmintics is unsustainable in the long term. A range of alternative options for treatment of horses have been proposed by veterinarians and parasitologists in an attempt to reduce selection for resistance. Until now there has been no way to evaluate these and other worm control options for selection for resistance in a quantitative framework, especially in different environments. The following presentations are the result of an international project initiated by Zoetis with leading parasitologists. The goal was to put more rigor around the options and decision making processes relating to the use of anthelmintics in horses. By developing models for the biology of these important parasites, including genetics for drug resistance, we aim to focus attention on treatment strategies with the greatest potential to maintain effective worm control while delaying the development of resistance.

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Equine cyathostomins – modelling biology and drug resistance
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A model has been constructed which describes the biology and development of anthelmintic resistance in equine cyathostomins. Because of the complexity of the cyathostomin species mix and the general paucity of knowledge on their biology, the model deals with the complex as a single unit rather than individual species. Biological assumptions were based on a literature search on parasite dynamics of external and internal stages of cyathostomin parasites. Using temperature and rainfall data to estimate development of eggs to infective larvae and subsequent survival and migration on pasture, the model can be tailored to any site for which weather data are available. The model was calibrated using historic data and fine-tuned using weather data from different climatic regions from which parasitology data were also available. This is important because anthelmintic treatment regimes which are suitable for one environment may be inappropriate for another. The parasitic phase of the cyathostomin life cycle was modelled using data from recent and historic necropsy studies with full worm counts of intestinal and mucosal stages. Within the host, the model follows the development of ingested larvae from encysted L3, with a variable period of arrested development, through moultng to L4 and migration into the gut lumen before moulting to adult. Adults removed by anthelmintic treatment are rapidly replaced by maturation of L3 / L4 stages in the lumen or mucosa, depending on the differential efficacy of anthelmintics against each stage. This presentation outlines the structure of the model, before discussing the benefits of using drugs in combination and the advantages of leaving a proportion of horses untreated based on model output. This will be evaluated for both tropical and temperate environments. Acknowledgements: The principle sponsor for this work was Zoetis. We thank Craig Reinemeyer, Ray Kaplan and Georg von Samson Himmelstjerna for their input.
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Equine *Parascaris* spp. – modelling biology and drug resistance

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A model has been developed for the biology of *Parascaris* spp. in the young horse. The model incorporates four main variables; the rate at which larvae migrate through host tissues to return to the small intestine, the proportion of migrating larvae which succeed in returning to the small intestine, the rate of growth in size of maturing and adult worms and the survival rate of maturing and adult worms. The most influential variable in determining model output is the survival rate of worms in the small intestine, which in the model, declines in response to the increasing age of the horse and the increasing cumulative length of worms in the intestine as a proxy for crowding. Given the importance of this variable to model behaviour and the paucity of experimental data on this topic this is identified as a priority for future study. The model was calibrated using necropsy data generated from several published studies. Incorporating genetics for anthelmintic resistance allows for a comparison of the long-term effect of different treatment strategies on the development of resistance. This presentation will compare the effect of varying the timing of first treatment on the contamination of pastures with eggs as a source of ‘refugia’, and the development of resistance. Acknowledgements. The principle sponsor for this work was Zoetis. We thank Craig Reinemeyer, Ray Kaplan and Georg von Samson Himmelstjerna for their input.

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How equine parasitology computer models become handy for both testing and generating hypotheses

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It is often emphasized how it is important to have a good general understanding of parasite biology and life cycles when advising veterinarians and horse owners on parasite control. This understanding stems from knowledge gleaned from a large number of parasitologic studies generated over the years and as scientific researchers we consider ourselves relatively well versed within our fields of expertise. Yet, our understanding is challenged when tasked with constructing a meaningful computer model describing infection biology and development of anthelmintic resistance. Perhaps most importantly, the models help outline and identify knowledge gaps to be addressed in future studies. While both models can be refined over coming years, their current formats do allow hypothesis testing. Using output from Cyathostomin and *Parascaris* spp. models, this presentation will examine the most promising strategies for managing these important parasites in equines. Both parasitism and the development of anthelmintic resistance in these parasites have been simulated in the models for a variety of different environments, treatment regimens and anthelmintic combinations. The model outputs can be regarded as hypotheses to be tested in subsequent field studies. The most interesting findings from these simulations will be highlighted and contrasted with current normal practice by horse owners and their veterinarians. In addition, key assumptions in relation to these strategies will be identified as priorities for future research so that confidence in these new approaches to anthelmintic use can be developed. Acknowledgements. The principle sponsor for this work was Zoetis. We thank Craig Reinemeyer, Ray Kaplan and Georg von Samson Himmelstjerna for their input.
Dogs and Cats: Epidemiology

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Timing of *Cytauxzoon felis* transmission by *Amblyomma americanum* to domestic cats in relation to duration of infestation and investigation of oral ingestion of infected ticks as a potential route of transmission

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The purpose of the present study was to determine the duration of infestation by *A. americanum* necessary for transmission of *C. felis* to domestic cats and to determine if oral ingestion of *C. felis*-infected *A. americanum* by cats is a route of transmission. Forty-nine cats were assigned to 1 of 7 groups with 7 cats per group. Treatment group cats were infested with *A. americanum* adults, acquisition fed as nymphs on a cytauxzoonosis survivor cat, for 12 hours (group 1), 18 hours (group 2), 24 hours (group 3), 36 hours (group 4), 48 hours (group 5), to repletion (group 6; control), and oral ingestion (group 7). Thumb counts were performed at the end of the duration of infestation for each treatment group and at 48 hours for the control group. In group 7, 50 live *C. felis*-infected adult *A. americanum* were mixed with food and fed to each of the cats. Transmission of *C. felis* was determined by examining blood of cats by DNA extraction followed by PCR. Of 50 ticks placed on each cat (groups 1–6), the percent mean attachment ± se ranged from 94.8% ± 2.5% in group 4 to 98.9% ±0.4% in group 1. In group 7, the average number ± se of ticks ingested was 46.5 ± 2.3. One cat in group 5 that had been infested for 48 hours became infected with *C. felis*. Six of 7 (85.7%) cats in group 6, the control group, became infected with *C. felis*. None of the cats in group 7 became infected with *C. felis*. Our results indicated that transmission of *C. felis* to domestic cat can happen as quickly as 48 hours of exposure to *A. americanum* infected with *C. felis* and that ingestion of *C. felis*-infected *A. americanum* is not a likely route of transmission.

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High *Trypanosoma cruzi* infection prevalence associated with minimal cardiac pathology among wild carnivores in central Texas

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Infection with the zoonotic vector-borne protozoal parasite *Trypanosoma cruzi* causes Chagas disease in humans and dogs throughout the Americas. Despite the recognized importance of various wildlife species for perpetuating *T. cruzi* in nature, relatively little is known about the development of cardiac disease in infected wildlife. Using a cross-sectional study design, we collected cardiac tissue and blood from hunter-donated wildlife carcasses from central Texas-a region with established populations of infected triatomine vectors and increasing diagnoses of Chagas disease in domestic dogs - including raccoon (*Procyon lotor*), coyote (*Canis latrans*), gray fox (*Urocyon cinereoargenteus*), and bobcat (*Lynx rufus*). Based on PCR analysis, we found that 2 bobcats (14.3%), 12 coyotes (14.3%), 8 foxes (13.8%), and 49 raccoons (70.0%) were positive for *T. cruzi* in at least one sample (right ventricle, apex, and/or blood clot). Although a histologic survey of right ventricles showed that 21.1% of 19 PCR-positive hearts were characterized by mild lymphoplasmocytic infiltration, no other lesions and no amastigotes were observed in any histologic section. DNA sequencing of the TcSC5D gene revealed that raccoons were disproportionately infected with *T. cruzi* strain Tc IV. Relative to other wildlife species tested here, our data suggest that raccoons may be important reservoirs of Tc IV in Texas and a source of infection for indigenous triatomine bugs.
The overall high level of infection in this wildlife community likely reflects high levels of vector contact, including ingestion of bugs. Although the relationship between the sylvatic cycle of *T. cruzi* transmission and human disease risk in the United States has yet to be defined, our data suggest that hunters and wildlife professionals should take precautions to avoid direct contact with potentially infected wildlife tissues.

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**Gastropods as paratenic hosts for *Crenosoma vulpis*, the fox lungworm.**
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Dogs and foxes acquire infection of *Crenosoma vulpis* by ingestion of third-stage larvae (L3) in tissues of gastropod intermediate hosts. Gastropods are infected by exposure to first-stage larvae (L1) acquired while feeding on canid feces. Recent studies have indicated the life cycle of *C. vulpis* and other metastrongyloids are more complicated than previously thought. Field and laboratory observations have indicated that some gastropod species will feed (cannibalize/scavenge) on the corpse of the same or other species of gastropods. The possibility of paratenic infection was investigated through experimental exposure followed by co-habitation of 2 different gastropod species. In 2 separate experiments, *Arion fasciatus* (20 slugs) and *Dercoeras laeve* (16) collected from a suburban site previously found to have a low prevalence of natural metastrongyloid infection were exposed to *C. vulpis* L1 (665 L1/slug and 937 L1/slug, respectively). At 3 weeks PI, an equal number of laboratory raised unexposed *Limax maximus* (20) were co-housed in the same container with the infected *A. fasciatus*. Also at 3 weeks PI, 14 unexposed *L. maximus* were co-housed with the *D. laeve*. Surviving slugs were tested for infection by artificial digestion (pepsin-HCl) to recover L3 at 16 weeks PI (*A. fasciatus*) and 11 weeks PI (*D. laeve*). None of the *L. maximus* died from either of the co-habitation containers, while 17 of the *A. fasciatus* and 15 of the *D. laeve* died during the study. L3 were recovered from all 3 surviving *A. fasciatus* (Mn= 18.0 L3/slug; 5-35L3) and from 80.0% (16/20) of the co-housed *L. maximus* (Mn=8.0 L3/slug; 0-19 L3). The single surviving *D. laeve* had 92 L3 and 64.3% of the co-housed *L. maximus* were infected (Mn=65.7 L3/slug; 0-352 L3). L3 survived the paratenic transfer from one gastropod host to another thereby increasing the possibility of transmission to a susceptible canid definitive host.

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**Detection of *Hammondia heydorni* oocysts in wild and domestic canid feces**
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*Hammondia heydorni* is a close relative of *Neospora caninum*, an important cause of abortion in cattle and neuromuscular disease in young dogs. *Hammondia heydorni* is generally considered to be non-pathogenic but has been reported to cause diarrhea in immunosuppressed dogs. Both parasites use domestic and wild canids as definitive hosts and various herbivores as intermediate hosts. Oocysts of these parasites are indistinguishable, therefore light microscopy cannot be reliably used to distinguish *N. caninum* and *H. heydorni* oocysts. The study goals were to collect free-ranging canid feces in and around an Ohio Wildlife Conservation Center, evaluate the feces for the presence of parasites, and use molecular methods to detect *Neospora* or *Hammondia* DNA. Using both universal and parasite specific PCR, 285 samples were evaluated. Results demonstrated no detectable *Neospora caninum* DNA, and only 1.1% of the 285 samples collected were positive for *Hammondia heydorni* DNA. The *H. heydorni* DNA detection prevalence is consistent with other published studies involving Canadian arctic fox (1.1%) and New York coyote (2%) feces.
Survey using ELISA of feline sera from rural New England for *Cuterebra*-specific IgG

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*Cuterebra* is a genus of obligate dipteran parasites of rodents and lagomorphs that can cause infection and clinical disease in cats and dogs. Eggs are laid along host trails and burrow entrances, and sensing a passing host, the larvae hatch from the egg, and make their way into the host via an orifice. The first larval instar migrates about in the viscera, and ultimately makes its way to a subdermal location where it creates a benign warble. In the warble, the larva matures prior to dropping to the ground to pupate. In the rodent and lagomorph hosts, there do not appear to be untoward consequences caused by the larvae during migration. However, in cats and dogs, larvae may invade the eyes, respiratory tract, and cerebral tissues, and thereby cause signs of depression, upper respiratory and neurologic disease, behavioral changes, and the infection sometimes proves fatal. Using an enzyme-linked immunosorbent assay (ELISA) with crude third larval instar antigens shown to detect *Cuterebra*-specific IgG in feline sera, the goal of this work was to examine the prevalence of this antibody in cats from rural New England. The positive or negative status of a cat is determined for each sample based on comparison to positive and negative control sera. The negative serum is a commercially supplied pool of normal cat sera, and the positive serum is from a cat with a high ELISA titer from which a bot was removed. In this study, the ELISA was used to screen sera from rural New England cats for *Cuterebra*-specific IgG. Out of 247 samples screened at a 1:20 dilution, 16 samples were found to have >75% probability of infection, and 32 samples had a >50% probability of infection.

Survey using IFA of feline sera from rural New England for *Aelurostrongylus*-specific IgG.

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*Aelurostrongylus abstrusus* is a heteroxenous nematode parasitizing the respiratory tract of felines. Most cats are asymptomatic or present with respiratory conditions, such as chronic cough and sneezing; however, infections can sometimes cause severe signs or be fatal. Diagnosis is typically by the demonstration of larvae in feces using fecal flotation or the Baermann technique. Infected cats do develop circulating antibodies to the infection that have been shown to be detectable using an immunofluorescent antibody assay (IFA). In this study, a previously developed and optimized IFA was used to determine the prevalence of *A. abstrusus*-specific IgG in cats from rural regions of New England. Sera collected from cats across rural and urban parts of New England were supplied by IDEXX laboratories and examined by IFA. Samples from presumed non-endemic regions were also provided. First-stage larvae harvested from feces of experimentally infected cats were used to test these samples for *A. abstrusus* antibody presence with epifluorescence microscopy using fluorescein-conjugated goat IgG fraction to cat IgG (Cappel, MP Biomedicals, LLC) and UV 450-490 nm excitation; the negative control sera was a commercial pooled sera from normal cats (Bethyl Laboratories). A fluorescent index of 0 (negative) to 3 (highly positive) was used to score the larvae. Under these conditions, comparing the mean fluorescent index score of individual test samples to those of the 99.9% CI of the negative control, 57.9% of the samples from rural New England were positive for *A. abstrusus* IgG. Analysis comparing the positivity index of each sample to
the maximum of 3 standard deviations above the mean of the negative control sera found 76.6% of the samples positive for *A. abstrusus* IgG.

### Immunology: *Haemonchus contortus*

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**Quantification of *Haemonchus contortus* larval death after culture with host immune cells by measuring larval ATP.**
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The objective of this study was to determine the impact of peripheral blood mononuclear cells (PBMC) on *H. contortus* larvae in the presence or absence of autologous serum by measuring larval ATP. Suffolk (SUF) and St. Croix (STC) lambs (n = 10 / breed) were randomly assigned to naïve (n = 5) or primed (n = 5) groups. Primed lambs were administered 10,000 *H. contortus* L3 and infection persisted for 5 weeks, after which lambs were dewormed. PBMC were isolated from whole blood samples collected and pooled by treatment group. Cells from each group were incubated in triplicate on a 24 well plate at a density of 5 x 10⁵ cells / mL with 100 *H. contortus* L3 in a total volume of 1 mL diluted in complete media. Cell and larval combinations were incubated for 18 hours at 37°C and 5% CO2 with or without serum. Adherent cells were enzymatically removed from larvae and separated using 40µm cell strainers. Larval ATP concentration was assessed using CellTiter-Glo Assay. Larvae exposed to STC-derived or SUF-derived PBMC had significantly lower ATP than live larvae (0.12, 0.16, and 0.27 µM ATP respectively) (P < 0.001), but no difference was observed between breeds. Larvae exposed to PBMC from both breeds were significantly greater than dead larval ATP (0.03 µM ATP) (P < 0.001). Larval ATP was significantly lower when exposed to STC-derived PBMC with serum (0.11 µM ATP) than SUF-derived PBMC with serum (0.23 µM ATP) or live control (0.22 µM ATP) (P < 0.001). There was no significant difference between live larvae and larvae treated with SUF-derived PBMC with serum (P = 0.59). Taken together, these data indicate a cellular response alone is capable of significantly impacting larval ATP and addition of serum to SUF-PBMC failed to reduce larval ATP.

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**Interleukin-4 and its downstream targets are rapidly upregulated in immune cells of St. Croix sheep exposed to *Haemonchus contortus* larval antigen in vitro**
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Early elicitation of immune response to *Haemonchus contortus* infection in sheep is critical for parasite clearance and development of protective immunity. The objective of these experiments was to compare interleukin-4 (IL-4) protein production and downstream gene expression of peripheral blood mononuclear cells (PBMC) after 6 hours of culture with *H. contortus* antigen. PBMC were collected from parasite resistant St. Croix (STC) and parasite susceptible Suffolk (SUF) sheep (n = 3 / breed) and cultured with crude larval antigen (CLA, 20µg/ml) or complete media control (CM) for 6 hours. Culture supernatant was collected for protein ELISA and cells were collected for gene expression analysis by qPCR. St. Croix PBMC produced increased IL-4 protein compared to SUF (823.57 pg/ml vs. 454.23 pg/ml, P < 0.05). Despite significantly different IL-4 protein production, STC and SX PBMC generate similar *IL4* gene expression (fold change of 8.42 vs. 9.70, P > 0.05). However, STC PBMC have up-regulated Th2 genes including the IL-4 receptor *IL4Ra* (P < 0.01), *IL13* (P = 0.05), *Arg1* (P < 0.05) and *IL5* (P < 0.05).
Supplementation of exogenous IL-4 had no effect on SX PBM ability to significantly increase Th2 profile genes. These data indicate a deficit of early Th2 immune activation in parasite susceptible Suffolk sheep, which may permit larval establishment resulting in pathology observed in *H. contortus* infection in susceptible sheep.

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**Serum induces *Haemonchus contortus* larval aggregation via complement and antibody complexes that differs by larval stage**

Javier Garza*, Scott Bowdridge. West Virginia University, Morgantown, WV

Complement and antibody attachment to the cuticle of parasitic nematodes is important for parasite expulsion by facilitating cellular attachment and promotion of larval killing. However, in the absence of immune cells, little is known about the effect of complement and antibody on larvae. The objectives of this study were to measure *Haemonchus contortus* larval aggregation by complement/antibody complexes, determine effect of breed resistance, infection status and larval maturation on larval aggregation, and to determine the role of antibody and complement in larval aggregation *in vitro*. Larval binding assays were performed on *H. contortus* third stage larvae L3, exsheathed L3 (xL3) and fourth stage larvae (L4) incubated with serum from either parasite naïve or *H. contortus* primed St. Croix (resistant) and Suffolk (susceptible) lambs. Data were analyzed using one-way and two-way ANOVA with a Tukey’s procedure for means comparison. No difference of breed or immune status were observed in serum-induced L3 aggregation (80%, P > 0.05), as such, when serum from primed Suffolk sheep was used, xL3 (62%) and L4 (40%) aggregation was significantly reduced compared to L3 (80%, P < 0.001). Removal of either complement or antibody effectively eliminated L3 aggregation compared to primed Suffolk serum (P < 0.001) and aggregation was restored by addition of purified antibody to antibody depleted serum. Use of fluorescence-labeled anti-sheep IgG antibody allowed documentation of IgG bound specifically to serum complexes within L3 masses and was present only in larvae incubated with normal serum and complement/antibody add-back serum. These data indicate that complement/antibody complexes inhibit larval motility through enhanced larval aggregation which may be critical in early larval clearance of *H. contortus* in sheep.

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***Haemonchus contortus* induced neutrophil extracellular trap formation differs between resistant and susceptible sheep breeds**

Javier Garza*, Scott Bowdridge. West Virginia University, Morgantown, WV

Infection with *H. contortus* results in an influx of neutrophils to the abomasum within seven days after infection in St. Croix (resistant) but not Suffolk (susceptible) lambs. The objective of this study was to evaluate the ability of neutrophils from resistant and susceptible sheep to bind *H. contortus* larvae via extracellular trap formation *in vitro*. *H. contortus* L3, xL3, and L4 were incubated with neutrophils isolated from naïve or *H. contortus* primed St. Croix or Suffolk lambs for 12 hours. The ability of neutrophils to trap larvae were evaluated via a larval binding assay and data were analyzed using one and two-way ANOVA with Tukey’s procedure for means comparison. Larval binding was higher in primed and naïve St. Croix derived neutrophils (93% and 68%) compared to Suffolk (78% and 45%, P < 0.001). Binding of L3 by neutrophils was dependent on immune status in both breeds and was reduced when cells were incubated with xL3 and L4. These data suggest that larval expulsion via neutrophil extracellular trap formation may be important in the early immunological responses to *H. contortus* prior to L4 stage.
RNA-Seq analysis of immune cells cultured with *Haemonchus contortus* larval antigen reveals differential gene expression in parasite resistant and susceptible sheep

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The objective of this experiment was to identify differentially expressed genes in immune cells of parasite resistant St. Croix sheep (STC) and susceptible Suffolk sheep (SUF) when cultured with *Haemonchus contortus* larval antigen. Peripheral blood mononuclear cells (PBMC) were collected from *H. contortus* primed sheep (n = 3 / breed) and cultured with crude larval antigen (CLA) or media control for 6 hours. RNA-Seq analysis revealed 499 significantly upregulated genes in STC PBMC cultured with CLA and 130 significantly upregulated genes in SX PBMC. Recent studies show NLRP3 acts as a transcription factor for Th2 differentiation and NLR inflammasome products support Th2 development. NLRP3, NLRP12 and inflammasome products (IL1B, IL18R1) are highly upregulated in STC PMBC (*P* < 0.0001). In addition, a transactivator of the hallmark Th2 cytokine (MAF) IL-4 was upregulated in STC (*P* < 0.0001). Antigens and receptors for *H. contortus* recognition are not known, however receptors known to bind conserved antigens were upregulated in STC (TLR4, TLR2, NOD1, *P* < 0.0001). C-lectin receptors have been shown to be involved in recognition of large pathogens such as fungi. Five C-lectin receptors were upregulated in STC PBMC (CLEC1A, CLEC4D, CLEC4E, CLEC5A, CLEC12A, *P* < 0.0001), while none were upregulated in SUF PBMC. St. Croix PBMC upregulated multiple genes associated with inflammation (IL1RAP, IL1A, IL6, IFNGR1, IL23A, CCR2, *P* < 0.0001) and cell adhesion (FGF1, ICAM5, MCAM, *P* < 0.0001). Suffolk PBMC upregulated three genes associated with inflammation (CXCR3, IL6ST, CD300E, *P* < 0.0001) and T cell activation (CD28, LCK, *P* < 0.0001). However, SUF PBMC also upregulated genes associated with T cell inhibition and senescence (IL27RA, BTLA, *P* < 0.0001). These data indicate a possible lack of pathogen recognition and immune cell activation by SUF PBMC, potentially contributing to increased parasite establishment in the host.

*Haemonchus contortus* fourth stage larval secretory/excretory proteins inhibit serum mediated larval aggregation

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*Haemonchus contortus* fourth stage larvae (L4) are known to secrete molecules which are believed to have immunomodulatory functions including complement inhibition. However, current studies regarding complement inhibition by excretory/secretory (E/S) molecules have been limited to protein structure characterization. The objective of this study was to evaluate the immunomodulatory properties of *H. contortus* E/S proteins as measured by inhibition of serum mediated third stage larval aggregation *in vitro*. Larval binding assays were performed on *H. contortus* third stage larvae (L3) incubated with serum from *H. contortus* primed suffolk lambs and L4 or adult excretory/secretory products. Data were analyzed using one-way ANOVA with a Holm-Sidak analysis for means comparison procedure. Larval aggregation was significantly reduced by the addition of L4 E/S products (18%) to the culture system when compared to serum alone (63%, *P* < 0.001), but not adult E/S (62%, *P* = 0.52). The ability of larvae to evade immune response is critical for establishment of infection. At the L4 stage, *H. contortus* remains in a stationary position within the abomasum and represents a period in the life cycle that should be most susceptible to attack by host immunological responses that mediate larval expulsion. These data indicate that L4 secrete complement binding molecules that may permit evasion of host responses which is critical for the establishment and development to adult stage.
Advances toward large scale production of *Acanthocheilonema viteae*.

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This paper reports ongoing efforts to optimize the life cycle of *A. viteae* and its vector *Ornithodoros tarakovskyi* to meet increasing NIH/NIAID Filariasis Research Reagent Resource Center (FR3) user demand. We have increased our *A. viteae* L3 yields from 14 L3/tick (n=475) to 142 L3/tick (n=56) by feeding only adult female ticks on infected gerbils with standardized microfilaremias. The median recovery of adult *A. viteae* from hamsters has risen from 49 (IQR=7.5-96.5, n=16) to 100 (IQR=80-133, n=17) after increasing the number of subcutaneous injections used for infection. Meta-analysis of laboratory data followed by an experimental trial demonstrated that worms isolated in RPMI-1640 in preparation for transplant into a new host failed to reproduce *in vivo*, as opposed to those isolated in HBSS. An ongoing trial demonstrates the value of using the fecundity of cultured adult female worms to predict success of parasite transplant into recipient gerbils. Cultured adult females that individually shed less than 7 mf in a 4-day period in culture reproduce poorly when co-transplanted with males (resulting in 34 and 57 mf/20 uL blood at 30 dpi; n=2) as compared to females that shed more than 34 mf in 4 days (resulting in 176 and 180 mf/20 uL blood at 30 dpi, n=2). A related preliminary study suggests that culture-derived mf are immediately infective for ticks, based on observations using 4-day old mf reconstituted in rabbit blood and delivered via an artificial membrane feeding system. The mf were fed to ticks at 247 mf/20 uL rabbit blood, and at 30 dpi we discovered 82% prevalence of infection (n=11) with mean intensity of $84 \pm 65$ L3s/tick (n=9). These ongoing modifications have made significant improvements to the propagation of this filarial nematode, an organism with fascinating biology that is available for no cost to researchers worldwide through FR3.

In vitro Cultivation of zoonotic *Babesia duncani* in Syrian hamster (*Mesocricetus auratus*) erythrocytes

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*Babesia duncani* is a hemoprotozoan parasite that has caused human babesiosis in California and Washington State. This pathogen is thought to be more virulent than the more common cause of human babesiosis in the United States, *Babesia microti*. It is considered a high risk pathogen in transfusion medicine. Little is known of the biology of this parasite. To date neither the natural host nor the tick vector has been identified.

The objective of this study was to establish continuous cultures of *B. duncani*. Cryopreserved *B. duncani* ATCC PRA302 was inoculated intraperitoneally into a Syrian hamster. After 10 days when the parasitemia was approximately 13%, the hamster was anaesthetized and blood collected via cardiac puncture into EDTA. Duplicate culture wells were initiated in 24-well plates using 1 part infected erythrocytes to 4 parts normal hamster erythrocytes. The medium was HL-1 supplemented with 20% fetal bovine serum and other additives. The plate was incubated at 37°C in a low oxygen humidified atmosphere. The cultures were fed daily by removing the spent medium and replacing with fresh. The
number of parasites increased by 24 hours, then dropped and maintained at the lower level until day 3 when the culture was passaged at a 1:5 split ratio. Cultures are subcultured every 3-5 days and are currently in the 30th passage. As the parasite maintained culture, two media and RBCs from alternate species were evaluated for ability to maintain B. duncani.

HL-1 medium with supplements best maintained the cultures and only hamster RBCs supported B. duncani growth. Cultures have been cryopreserved and successfully recovered. Future plans include infecting a hamster with cultured parasites to confirm infectivity.

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The geospatial range of Fasciola hepatica and F. gigantica in Asia based on climate effects
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Using geographic information systems (GIS) methods, preliminary risk models based on known biological requirements of Fasciola hepatica and F. gigantica and a monthly long term normal climate grid suggested that thermal regime of a study site in Dongtu, Anhui, China can support overlapping presence of both species. Analysis of daily climate data from Wuhu, China and forecast parameters for F. hepatica previously used to develop risk models in the USA indicated that soil moisture and thermal conditions for life cycle progression of F. hepatica occurs in March-May. The optimum temperature for development of free-living stages of F. hepatica is 18°C; sustained temperatures >23°C have been reported to be unsuitable for F. hepatica. The optimum temperature for F. gigantica, a tropical species, is 25°C; its usual habitat in deeper water bodies are less subject to summer drought than F hepatica. Results suggest a spring transmission pattern, where the first sustained drought of summer (over 2 weeks) ends transmission with aestivation and high mortality of snail hosts. Snails emerge from soil in fall-winter with return of wet conditions and begin a spring reproductive effort1. Results are consistent with weak annual transmission of F. hepatica in Anhui. Lymnaeid snail hosts of both F.hepatica and F. gigantica were found on study farms in Dongtu. Surveys on three separate dates, however, revealed low prevalence of only F. hepatica based on egg size measurements in cattle and goats, and moderate Schistosoma japonicum egg counts.

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Parasite associated mortality in Shortnosed (Chasimistes brevirostris) and Lost River Suckers (Dektistes luxatus)
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Shortnosed (Chasimistes brevirostris) and Lost River Suckers (Dektistes luxatus) are endemic to the Upper Klamath Basin of Southern Oregon and Northern California. Populations of these fishes have been dwindling since the 1960's and both species where listed to as endangered in 1988. Poor recruitment of juvenile fish is thought to be a major cause for their demise and we are investigating the role of parasites play as a contributing factor. In the summers of 2013 and 2015 we conducted histopathological examinations of age 0 and age 1 suckers, as well as other species of fish in the lake. The most remarkable pathological changes were in the heart, where large Contracaecum L3 larvae caused dramatic atrophy of the ventricle and prominent hypertrophy of the atrium. rDNA ITS1 sequencing showed that the worm most closely matched Contracaecum multipapillatum. The definitive hosts for this worm are pelicans, and this same lake is now a bird refugee in which white pelcians (Pelecanus erythrorhynchos) are abundant. With such severe heart infections, it is likely that infected fish are predisposed to pelican predation. We
are using a historical collection of 20,000 suckers spanning 13 years of monthly summertime collections to determine the host, temporal and geographic distribution of this parasite in suckers in attempt to elucidate its role in fish mortality.

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*Nanophyetus salmincola*, vector of the salmon poisoning disease agent *Neorickettsia helminthoeca*, harbors a second species of pathogenic *Neorickettsia*

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The trematode *Nanophyetus salmincola* is known as the carrier of *Neorickettsia helminthoeca*, an obligate intracellular endosymbiotic bacterium that causes salmon poisoning disease (SPD), a fatal disease of dogs. The bacteria are maintained through the complex life cycle of the trematode *Nanophyetus salmincola* that involves snails *Juga plicifera* as the first intermediate host, freshwater and anadromous fishes as the second intermediate host, and fish-eating mammals as definitive hosts. SPD is endemic to the Pacific Northwest, with the distribution dictated by the occurrence of the snail host. In Oregon, we are studying various aspects of the life cycle of the fluke, distribution of the snail host, and relationships of the metacercariae causing disease in salmonid fishes and the associated bacteria causing disease in dogs. We examined metacercariae of *N. salminicola* from adult Chinook salmon and we identified *N. salmincola* as the vector of yet additional species of *Neorickettsia* known as SF agent using DNA sequencing. This agent has caused mild disease in dogs in Japan, but our observation is the first report of it from *N. salmincola* making it a vector for at least two neorickettsia diseases of dogs. Reoccurrence of SPD in dogs is not uncommon in Oregon, but most cases are milder than those associated with the first infection. It has been assumed that these dogs lack complete protection to *N. salminicola*, but the finding of the SF agent in Oregon presents an alternative possibility – i.e., some of these dogs may actually be infected with a different *Neorickettsia*. We have initiated a program in cooperation with local veterinarians in which we are obtaining blood from dogs associated with salmon poisoning in attempt to elucidate the identity of the bacteria associated with primary and secondary SPD.

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Advertising of antiparasitic drugs through time

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In the USA, advertising of antiparasitic veterinary and human products started in the middle of the 19th century when a number of entrepreneurs (W. H. Comstock, L. D. LeGear, D. Roberts *et alia*), effected the promotion of their antiparasitic products with the distribution of beautiful colored cards (*Victorian cards*), which were, nearly always, decorated with charming designs. Later, veterinary antiparasitic drug advertising took place mostly in veterinary and agricultural journals.

A new additional technique for advertising antiparasitic drugs took place in 1964 with the launch of thiabendazole--the first broad-spectrum anthelmintic--when the producer of this drug advertised it to veterinarians along with the distribution of photographic slides

When ivermectin, the first broad spectrum endo-ectoparasiticide, was launched in 1981, the producer assisted the launch also with the distribution of informative posters to veterinarians depicting the use of the product in many animal species against ecto- and endo-parasites.
Today, judging from the advertising used for the promotion of new antiparasitic agents, it appears that the advertising pendulum for these products is swinging back to the charming designs of the Victorian era.

Elanco Symposium

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The misplaced risk of macrocyclic lactones in heartworm infected dogs
Dwight Bowman*. Cornell University, Ithaca, NY

Before macrocyclic lactone (ML) heartworm preventives were introduced, microfilaricidal diethylcarbamazine treatment would regularly be followed by severe, sometimes fatal adverse events (AEs). In the 1980s, recognition of the activity of MLs, particularly ivermectin and milbemycin oxime, led to development of formulations that would kill heartworm larvae transmitted to a dog during the month preceding treatment. These were not intended for use in dogs with patent heartworm infections. Nonetheless, investigations undertaken to determine ML potential as microfilaricides demonstrated that following off-label treatment, a microfilaremia would typically be reduced but usually not eliminated. The AEs that did occur following these ML treatments were fewer in frequency and generally of much reduced severity than those that followed diethylcarbamazine treatment. Reported AEs following use of MLs in microfilaremic dogs included transient diarrhea, vomiting and lethargy, while post-adulticidal microfilaricidal treatment appears to carry greater risk due to the dog’s compromised pulmonary/cardiovascular systems (only one ML, moxidectin, is FDA approved for this indication). It is now widely recommended that prophylactic ML use in dogs in which infections are established, in lieu of melarsomine dihydrochloride (MD) administration, should be avoided, particularly with the recognized emergence of ML-resistant *Dirofilaria immitis*. In conclusion, there is no apparent difference in the safety of one monthly ML over another. However, such treatment risks selecting for resistance, and should be avoided without concurrent adulticidal *D. immitis* treatment, and only then with use of an approved microfilaricidal product.

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Correlating genotype with phenotypic response to a macrocyclic lactone in *Dirofilaria immitis*
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Infections of dogs by *Dirofilaria immitis* under normally effective prophylaxis with macrocyclic lactones threaten our ability to control this parasite. Previous work associated with a set of single nucleotide polymorphism (SNP) genomic markers with loss-of-efficacy cases and breakthrough experimental infections. Some strains of *D. immitis* bearing these SNP markers also show reduced sensitivity of microfilariae to a dose of macrocyclic lactone endectocides. We initiated a prospective study with several veterinary clinics to investigate the possible correlation between SNPs and microfilarial response in heartworm infections. Animal health companies helped us to identify veterinary clinics that might wish to participate in this study. We contacted these clinics to enroll dogs with newly diagnosed heartworm infections. In this study, dogs with patent microfilaraemia are recruited to provide a blood sample for a Knott’s test. Microfilariae purified from the sample after shipment to McGill are analyzed for SNP presence or absence by genomic sequencing. The dogs are treated after diagnosis with a dose of Advantage Multi and the owners are asked to return to the clinic 2-4 weeks later to provide a second sample of blood
for analysis of surviving parasites at McGill (number and genotype). We have experienced a good response to the study and are now enrolling partners and clinics. A status report of the project will be presented in this talk.

**President's Symposium**

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**Screening for candidates to block transmission of vector borne apicomplexan parasites**

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Vector borne apicomplexan parasites are a major cause of mortality and morbidity to humans and livestock, globally. The most important disease syndromes caused by these parasites are malaria (*Plasmodium*), babesiosis and theileriosis (tick borne diseases primarily in ruminants, horses and dogs caused by *Babesia* and *Theileria* parasites). The economic loss in terms of medical care and livestock productivity caused by vector borne apicomplexa is huge and can be conservatively estimated in 10s of billions of dollars per year. Strategies for control often target stages in mammalian hosts that cause disease. This can result in reservoir infections that promote disease transmission and generate economic loss. Optimal control strategies would protect against clinical disease, block transmission and be applicable across related genera. We have used the tick borne apicomplexan, *Theileria annulata* to investigate processes that are fundamental to life cycle progression of vector borne apicomplexa. Three project areas will be summarised: a) we have used transcriptomics to identify putative regulators of development towards stages that promote transmission of vector borne apicomplexa; b) we have identified genes encoding surface proteins with conserved domains that are predicted to be required for transmission through the vector, and are vaccine candidates; c) we have demonstrated the efficacy of a drug predicted to operate across apicomplexa to block progression towards stages that promote transmission in *T. annulata*. These studies highlight the potential for possible development of generic control strategies against vector borne apicomplexan parasites.

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**Macrocyclic lactone resistance in Dirofilaria immitis: The next phase in understanding this complex and still contentious issue**

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Since the introduction of ivermectin in 1987, the veterinary community has relied almost exclusively on the use of macrocyclic lactone (ML) drugs to prevent the development of heartworm disease (HWD) in companion animals. The general consensus was that these drugs were 100% effective in preventing HWD and the threat of resistance developing in *Dirofilaria immitis* (DI) parasites was relatively low. However in 2005, ‘lack of effectiveness’ (LOE) claims for ML preventive drugs began to circulate, wherein dogs were developing HWD despite proper administration of ML products. These LOE reports continued to increase over the next 5 years, with the majority of cases being reported from the Mississippi River Delta (MRD) region of the USA. Multiple, large-scale collaborative projects were initiated to further investigate the possible emergence of resistance, and these efforts resulted in conclusive evidence of the existence of genuine ML resistant strains of DI. Now that ML resistance has been confirmed, the next steps should be
focused on gaining a better understanding of resistant strains, both in regards to their molecular signature and the mechanisms of ML resistance. This knowledge will prove vital in identifying animals suspected of harboring resistant parasites, as well as future ML resistance control and prevention strategies.

The purpose of this presentation will be to outline new and exciting developments in the field of ML resistance in DI, with an emphasis on novel molecular techniques and strategies. Recently published studies will be described, as well as research currently underway from multiple institutions. This includes projects focused on the identification of molecular markers of ML resistance, those aimed at describing its origins by utilizing population genetic approaches, and those combining molecular techniques with mathematical and spatial modeling. Recent molecular advances in the study of lymphatic filariasis and onchocerciasis will also be reviewed.
2016 POSTERS

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Poster Sessions

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Intolerance of albendazole therapy and failure to control hepatic alveolar echinococcosis in a dog in southern Ontario.
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In June 2015, a 4-year old castrated male Boxer dog presented to the Ontario Veterinary College Health Sciences Centre for acute lethargy, vomiting, abdominal pain and abdominal distention. Cytologic examination of abdominal effusion fluid revealed a highly cellular exudate with neutrophils, eosinophils and macrophages. Abdominal ultrasound revealed multiple large fluid-filled abdominal masses. Exploratory laparotomy confirmed the presence of three encapsulated hepatic masses, the largest of which had ruptured and was likely responsible for significant abdominal effusion. The two smaller masses were surgically resected; however, the large ruptured mass was unresectable and thus omentalized. Histopathology of resected hepatic tissue indicated the presence of multi-cystic structures containing eosinophilic, periodic acid-Schiff-positive membranes and calcareous corpuscles, consistent with Echinococcus multilocularis. Sequence data for a PCR-generated fragment of the mitochondrial 12S rRNA gene confirmed the etiology as E. multilocularis and a diagnosis of hepatic alveolar echinococcosis (HAE). For control of HAE, lifetime daily treatment with albendazole (10 mg/kg body weight) was recommended. However, the dog only tolerated an intermittent therapeutic protocol (4 weeks on, 4 weeks off, repeated). Seven months later, the dog re-presented for discomfort and abdominal distension. An exploratory laparotomy was performed and 1 liter of fluid was drained from a large cyst-like dilation of the omentum. Cytologic examination of the fluid revealed many folded parasitic membranes and calcareous corpuscles. Given the extensive hepatic involvement with numerous abdominal adhesions, the lesions were not amenable to surgical correction. Following laparotomy, the dog’s condition deteriorated rapidly and the animal was euthanized.

Since 2012, four cases of alveolar echinococcosis have been diagnosed in dogs in southern Ontario. Experience in Switzerland indicates that control of HAE in dogs is best achieved with long-term, daily treatment with albendazole; however, this was not possible in the present case due to albendazole toxicity concerns.

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Insecticidal repellency of a topical administration of dinotefuran-pyriproxyfen-permethrin spot-on (Vectra® 3D) on mice against Aedes albopictus mosquitoes
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Aedes albopictus is an important vector for the transmission of numerous viral pathogens and filarial nematodes in human and animals. In the absence of licensed vaccines against numerous vector-borne diseases, the best means of protection is to avoid mosquito bites by using, for instance, an insecticidal repellent. An ectoparasiticide combining three active ingredients: 4.95% dinotefuran, 0.44% pyriproxyfen
and 36.08% permethrin (Vectra® 3D, DPP) has been used in mice to evaluate its anti-feeding and insecticidal efficacy against *A. albopictus*.

Twenty-two adult female Swiss CD1 mice were randomly grouped into two groups of eleven animals: an untreated control group and a DPP treated group. DPP was administered topically as a line-on treatment. The dose administered (14 µL) was estimated by converting the dose for dogs to an equivalent surface area dose in mice. Anesthetized mice from both groups were exposed individually for one hour to 27±2 starved female mosquitoes on days 1, 7, 14, 21 and 28 post-treatment. At the end of the exposure, mosquitoes were assessed for immediate survival and engorgement status. Additionally, live mosquitoes in both groups were incubated separately under controlled environmental conditions and observed for mortality counts 24 hours after the end of the exposure.

The anti-feeding efficacy of DPP after the one-hour exposure period was 99.23%, 100%, 98.03%, 89.34% and 87.35% at 1, 7, 14, 21 and 28 days, respectively. Insecticidal efficacy evaluated at one hour and 24 hours after exposure at days 1, 7, 14, 21 and 28 was 36.65%, 28.85%, 30.84%, 23.07% and 11.85% and 68.41%, 44.96%, 43.30%, 37.89% and 19.9% respectively. At each time point, there was a significant difference between the treated and control groups for both anti-feeding and insecticidal efficacy.

The study demonstrates that the DPP combination has a significant anti-feeding and insecticidal efficacy against *Aedes albopictus* for at least one month.

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**Risk factors for subclinical Baylisascaris procyonis infection among wildlife rehabilitators from the United States and Canada.**

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Neural larva migrans caused by the raccoon roundworm, *Baylisascaris procyonis*, can cause severe or fatal neurologic disease in many intermediate host species. In humans, although rare, the majority of baylisascariasis cases have been fatal or resulted in permanent neurologic or ocular complications. However, the infectious dose and full clinical spectrum of disease are not understood and thus the true incidence may be under-recognized. Also, reported cases are mostly restricted to children who likely ingested a very large inoculum of eggs directly from raccoon feces. We hypothesized that healthy adults may develop subclinical infections resulting from accidental ingestion of low numbers of eggs. Zoonotic diseases are an occupational hazard for wildlife rehabilitators, and they may represent a special at-risk cohort for exposure to *B. procyonis* due to frequent contact with raccoons and/or their feces. We collected serum samples from 347 wildlife rehabilitators from the United States and Canada, and administered a questionnaire to assess potential risk factors. Twenty-four participants (7%) were positive for antibodies to *B. procyonis* via Western Blot, 16 (67%) of which were active raccoon rehabilitators, and 22 (92%) of which reported a history of general raccoon contact. Significant risk factors for seropositivity included practicing rehabilitation in the Western region and/or areas of very high (>50%) *B. procyonis* prevalence in raccoons, and failure to wash hands consistently after contact with live raccoons or feces. In summary, antibodies to *B. procyonis* were detected in healthy adult wildlife rehabilitators, indicating the occurrence of subclinical or covert baylisascariasis. Wildlife rehabilitators and other individuals with raccoon contact should be aware of this occupational hazard and be advised to use PPE consistently to reduce the risk of exposure. More work is needed to understand the epidemiology of baylisascariasis in the general population.
Neutralization of *Sarcocystis neurona* Merozoites with SnSAG 1, 5, 6 and *Sarcocystis fayeri* Seropositive Serum

Summer Towne, Chris Petrie. Titusville, FL

Equine protozoal myeloencephalitis is the most commonly diagnosed neurological disease affecting horses in North America. EPM commonly results from infection with *Sarcocystis neurona* parasites. The most successful infection model indicates that merozoites penetrate leukocytes in the intestines, travel within the leukocytes through the blood stream and across that blood-brain barrier, and egress in the central nervous tissue, where they induce disease-causing inflammation. Antibodies to *S. neurona* surface antigens SnSAG1-6 can be detected quantitatively in blood serum and cerebrospinal fluid of horses, and SnSAG antibody titers are used as a diagnostic tool along with clinical signs. A previous study tested the neutralizing ability of equine serum antibodies against *S. neurona* in vitro. The purpose of this study was to determine whether equine seropositive SnSAG 1, 5, or 6 sera neutralize *S. neurona* merozoites in vitro and whether *Sarcocystis fayeri* toxin reactive sera neutralize to inhibit infection of host cells. Clinical disease was determined by gait abnormality. Diseased horses were selected based on antibody titer (seropositive serum titer, reciprocal of > 1: 4 serum dilution; or seronegative serum titer, reciprocal of < 1:8 serum dilution). The ability of serum to inhibit invasion of host cells by SN2 merozoites was assayed. Serum from seronegative horses, SnSAG1 seropositive horses, and SnSAG6 seropositive horses exhibited similar (71%, 71%, and 73%, respectively) reduction of infection. *Sarcocystis neurona* SAG5 seropositive horses exhibited the highest level of neutralization (87% reduction of infection). Surprisingly, sera containing SAG 1, 5 and 6 antibodies only reduced host cell invasion by 68%. In contrast with previous studies, sera seropositive for SnSAG1, 5, and 6 do not neutralize the ability of *S. neurona* merozoites to invade host cells in vitro. Further research is needed to investigate the effects of disease on parasite neutralizing factor.

Soft tick studies in Ukraine: towards threat reduction through surveillance and enhanced epidemiological risk assessment for African swine fever

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African swine fever (ASF) is one of the most economically important viral diseases of domestic pigs worldwide. Outbreaks affect several Eastern European countries and the recent westward progression and endemicity of ASF are of grave concern for Western Europe. However, the drivers for the emergence of ASF in Europe remain to be fully understood. A facet of ASF epidemiology that requires attention is the assessment of soft tick involvement as vectors maintaining ASF virus (ASFV) in wild boar, or transmitting ASFV to domestic pigs during outbreaks. Each of these aspects has its relevance to disease eradication, but often difficult to access due to the cryptic nature of *Ornithodoros* spp., and insufficient data on their distribution and ecology in Eastern Europe. Addressing this knowledge gaps for Ukraine, which has been affected by ASF since 2014, is the main objective of the collaborative research project between the USD-
ARS and the National Scientific Center Institute of Experimental and Clinical Veterinary Medicine (IECVM) funded by the Defense Threat Reduction Agency titled “African Swine Fever Threat Reduction through Surveillance in the Ukraine” (CBEP Agreement IAA# U.S.C. 3318(b) – 15217). This project allowed us to systematically re-evaluate decades-old data to adapt surveillance campaigns with the goal to understand the current distribution of local soft tick species, and to optimize procedural methods required for colonizing soft ticks at the IECVM. Research progress has enabled the study of soft tick ecology, and the possibility to study vector-host-pathogen interactions through collaborations with other science partners in the region, which offer the opportunity to better understand the pathogenic landscape of soft tick-transmitted diseases in Eastern Europe.

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Variable tolerance towards raccoon roundworm (Baylisascaris procyonis) infection among four species of deer mice (Peromyscus ssp.)
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Raccoon roundworm, Baylisascaris procyonis, is a zoonotic ascarid that causes neural larva migrans in many wildlife and domestic species. Rodents such as Peromyscus spp. are common intermediate hosts for B. procyonis, and P. leucopus may serve an important role in parasite ecology. Although natural infections have been observed in a few Peromyscus species, no data are available on species-level susceptibility among this highly variable rodent genus. In this experimental infection trial, we compared survival and infection dynamics of B. procyonis in four species (P. leucopus, P. maniculatus, P. californicus, P. polionotus) which vary in size, habitat, and natural occurrence in areas of varying B. procyonis prevalence. Larvated B. procyonis eggs (500, 50 or 10) were administered per os to six captive-bred mice per group. Animals were monitored for neurologic signs and euthanized at the onset of CNS symptoms or at 45 DPI if no disease developed. Larvae were recovered from muscle and visceral organs by artificial digestion and enumerated, and in the brain by microscopic examination. Inoculation with 500 eggs nearly uniformly caused neurologic disease, while the medium dose did in 50-83% of individuals. In the low dose group, only one P. maniculatus was euthanized. Survival analysis revealed that dose and species (P. leucopus vs. others) were significant predictors of survival. The total number of larvae recovered did not differ across species; however, larvae were deferentially distributed in tissues. Finally, humoral response to infection was assessed via Western Blotting and ELISA based on recombinant B. procyonis antigens; preliminary data suggest differences in seroconversion and antibody concentrations across species. In summary, we found differences in B. procyonis tolerance across closely related Peromyscus species, with P. leucopus being the most tolerant. Future field investigations involving Peromyscus species are necessary to understand the impact of differences in tolerance on B. procyonis ecology.

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Lateral resistance of macrocyclic lactones compounds in Brazilian field isolates of the cattle-tick (Rhipicephalus microplus)
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Rhipicephalus microplus is the major economic impacting parasite of cattle in tropical and subtropical areas of the world. In Brazil the estimate is US$3.14 billion of annual losses caused by this tick. The main
method to control it is the use of chemical acaricides, including macrocyclic lactones (MLs). MLs have been extensively used to control parasites of cattle since 1980’s, however, only a few reports of resistance in the cattle tick were documented in Brazil and little is known about the existence of lateral resistance amongst MLs compounds (i.e. avermectins: ivermectin, abamectin, doramectin and milbemecins: moxidectin). The present study had the objective to document this phenomenon for the first time, using laboratory bioassays. We used tick larvae from susceptible reference strain (POA) and from eight different field isolates collected in ranches from Rio Grande do Sul, Brazil. Larval immersion tests were carried out with the MLs followed by non-linear regression statistical analysis in order to calculate lethal concentrations (LC50) and resistance ratios (RR) to each compound. Moxidectin was the most toxic compound among the MLs tested. Its LC50 was significantly lower than the other MLs for all tick isolates. Remarkably, there was a consistent susceptibility status to the different MLs compounds among the isolates evaluated. Five isolates were susceptible to all MLs tested. One sample was slightly resistant to moxidectin (RR=1.751). The other two isolates were simultaneously resistant to avermectins and milbemecins with higher RRs against avermectins (up to 24.33-fold) than for moxidectin (up to 5.42-fold). As far as we know, this is the first report of lateral resistance among MLs in the cattle tick. This information can be useful for the establishment of tick control strategies using ML. Financial support: CNPq, Capes, US Department of Energy.

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First report of acaricide resistance in Rhipicephalus sanguineus (Latreille, 1806) from southern Brazil.
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Rhipicephalus sanguineus (Brown Dog Tick) is the most common tick found in dogs from urban areas of Southern Brazil. This parasite can vector pathogens that causes severe diseases, many of them zoonotic. Chemical treatments against ticks can lead to the selection for resistance and consequential failures on their control. Unfortunately, little is known about acaricide resistance on this canine tick species in Brazil and this information is remarkably important to small animal clinical practice. The objective of this study was to analyse acaricide susceptibility of R. sanguineus from the metro area of Porto Alegre, Southern Brazil. Between November 2014 and January 2016, engorged female R. sanguineus were collected in eleven different locations, from naturally infested dogs or the environment (homes, shelters and kennels). As susceptible control, a R. sanguineus reference strain from the Federal University of Rio de Janeiro (Rs-RJ) was used. The isolates were reared in incubators to allow egg laying and obtain 14 days-old larvae that were used in the bioassays with deltamethrin (larval packet test) and ivermectin (larval immersion test). Mortality data was submitted to probit non-linear regression analyses in order to obtain median lethal concentrations (LC50). The calculated LC50 (in ppm of active ingredient) for Rs-RJ strain were 16.054 for deltamethrin and 2.903 for ivermectin. Calculated LC50 for deltamethrin in the field isolates ranged from 0.774 to 22.817 and one isolate was considered resistant. LC50 for ivermectin ranged between 8.821 and 21.179, and all the isolates were considered resistant. The results reveal a notable variation of susceptibility to deltamethrin and ivermectin in R. sanguineus isolates studied. This study documents for the first time the existence of acaricide resistant populations of R. sanguineus in the metro area of Porto Alegre, Brazil. Funding: CNPq and Capes (Brazil); US Department of Energy.
The effect of ivermectin on *Brugia malayi* females *in vitro*: a transcriptomic approach

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Macrocyclic lactones (MLs), including the avermectins and milbemycins (e.g., ivermectin (IVM) and moxidectin, respectively), are extensively used in veterinary medicine for the treatment of filarial and gastro-intestinal nematode infections and ectoparasite infestations. In human medicine, IVM has been used for Mass Drug Administration campaigns against lymphatic filariasis and onchocerciasis. The prevention of heartworm disease in dogs and cats caused by *Dirofilaria immitis* has relied heavily on the use of MLs. Recently, however, ML-resistant strains have been identified in parts of the USA. The risk of emerging resistance to IVM in human populations also remains a threat.

IVM pseudo-irreversibly activates nematode and arthropod glutamate-gated chloride channels, resulting in hyperpolarization of neurons and pharyngeal muscle cells, leading to paralysis of movement and pharyngeal pumping. In filarial nematodes of veterinary and human medical importance, treatment causes dramatic reductions in microfilaria production in the host, but the mechanisms involved are not fully understood.

Paralysis of pharyngeal pumping by IVM in clade III nematodes (such as in clade V species) could result in deprivation of essential nutrients, leading to altered gene expression, changes in metabolic pathways, and altered developmental states in embryos.

We analyzed transcriptomic profiles from *Brugia malayi* adult females, a convenient laboratory model for veterinary and human filarial nematodes, using RNAseq after exposure in culture to IVM at various concentrations (100 nM, 300 nM and 1 µM) and time points (24, 48, 72 h, and 5 days). Our analysis revealed drug-related changes in expression of genes involved in meiosis and oxidative phosphorylation, which were significantly down-regulated. Enriched RNA interference phenotypes of the orthologs of these down-regulated genes in *C. elegans* include “maternal sterile”, “embryonic lethal”, “larval arrest”, “maternal sterile”, and “larval lethal”.

These changes provide insight into mechanisms involved in IVM-induced reduction in microfilaria output and impaired fertility, embryogenesis, and larval development.

Simultaneous identification of *Haemonchus*, *Teladorsagia* and *Trichostrongylus* eggs in goat and sheep fecal samples with three specific lectins

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Multiple species of trichostrongyle nematodes are important gastrointestinal parasites in sheep and goats, and their pathology and control strategies vary depending on the species present. In these hosts, *Haemonchus contortus* causes acute deaths, and *Teladorsagia circumcinta* causes a chronic loss of productivity. Species of *Trichostrongylus* are generally less problematic even though they are common. Studies have demonstrated the usefulness of some fluorophore-conjugated lectins for identifying trichostrongyle genera through their abilities to bind selectively to eggs isolated from fecal samples.
Several studies have shown that peanut agglutinin (PNA) can be used to identify *H. contortus*; a couple studies have shown that *Lens culinaris* agglutinin binds specifically to *T. circumcinta*. A single study found that *Aleuria aurantia* agglutinin (AAL) bound selectively to *Trichostrongylus* sp. eggs. There have been no attempts to simultaneously stain these eggs with all 3 lectins even though it’s important for validating their specificities in field samples. The feasibility of collectively staining with 3 lectins was evaluated using goat samples containing *H. contortus*, *T. circumcinta*, *Trichstrongylus colubriformis*, *T. vitrinus*, and *T. axei* eggs (based upon PCR analysis also including *Cooperia*, *Chabertia* and *Oesophagostomum* primers). Autofluorescence (AF) was observed in these eggs using wide-field epifluorescence with DAPI and FITC filter cubes, especially with formalin-fixed eggs. Lambda-scans with a Fluoview 1200 confocal microscope also showed AF most intensely with the 405nm laser extending from 420 to 520nm. In spite of the AF, it was possible to use Alexa-405 conjugated PNA to stain *Haemonchus* eggs, coupled with rhodamine conjugated LCA for *Teladorsagia* eggs and finally FITC conjugated AAL that presumably bound to at least some of the *Trichostrongylus* eggs. With this approach, some eggs were observed that did not bind with any of the 3 lectins, and PCR analysis of these isolated eggs will enable their identity to be determined.

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**Giardia** fatty acyl-CoA synthetases as potential drug targets
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Giardiasis caused by *Giardia intestinalis* (syn. *G. lamblia*, *G. duodenalis*) is one of the leading causes of diarrheal parasitic diseases worldwide. Although limited drugs to treat giardiasis are available, there are concerns regarding toxicity in some patients and the emerging drug resistance. By data-mining genome sequences, we observed that *G. intestinalis* is incapable of synthesizing fatty acids (FA) *de novo*. However, this parasite has five long-chain fatty acyl-CoA synthetases (GiACS1 to GiACS5) to activate FA scavenged from the host. ACS is an essential enzyme because FA need to be activated to form acyl-CoA thioesters before they can enter subsequent metabolism. In the present study, we performed experiments to explore whether some GiACS enzymes could serve as drug targets in *Giardia*. Based on the high-throughput datasets and protein modeling analyses, we initially studied the GiACS1 and GiACS2, because genes encoding these two enzymes were found to be more consistently expressed in varied parasite life cycle stages and when interacting with host cells based on previously reported transcriptome data. These two proteins were cloned and expressed as recombinant proteins. Biochemical analysis revealed that both had apparent substrate preference toward palmitic acid (C16:0) and myristic acid (C14:0), and allosteric or Michaelis–Menten kinetics on palmitic acid or ATP. The ACS inhibitor triacsin C inhibited the activity of both enzymes (IC50 = 1.56 μM, Ki = 0.18 μM for GiACS1, and IC50= 2.28 μM, Ki = 0.23 μM for GiACS2, respectively) and the growth of *G. intestinalis in vitro* (IC50 = 0.8 μM). As expected from giardial evolutionary characteristics, both GiACSs displayed differences in overall folding structure as compared with their human counterparts. These observations support the notion that some of the GiACS enzymes may be explored as drug targets in this parasite.
Double stranded RNA and *Brugia malayi* as agents for studying anthelmintic receptor pharmacology of parasitic nematodes

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Our studies on nicotinic acetylcholine receptors (nAChRs) have focused on identifying the molecular and pharmacological properties of the different targets of cholinergic anthelmintics. We have used single muscle cell PCR assays to identify the different nAChR subunits (*unc-63, unc-29, unc-38, acr-8* and *acr-16*) that are present in the adult muscle cells of *Brugia malayi*. We have also used whole cell patch-clamp to characterize *Brugia* muscle nAChR current responses to different cholinergic anthelmintics. The most potent compound was pyrantel, which generated the largest current responses (EC$_{50}$ 63.5nM) but acetylcholine (EC$_{50}$, 2.36 µM), levamisole (EC$_{50}$, 3.35 µM), nicotine (EC$_{50}$, 30.5 µM) and bephenium (EC$_{50}$, 4.24 µM), also produced currents. In addition we have used RNA interference (dsRNA) as a reverse genetic tool for pharmacological and phenotypic characterization of the nAChRs. We were able to disrupt nAChR formation using dsRNA directed against *unc-29* & *unc-38*. The resulting *Brugia* phenotype showed more than a 50% reduction in motility. qPCR confirmed that there was a mean reduction of 91% of *unc-29* and 88% reduction of *unc-38* transcript levels. Our patch-clamp recordings from the dsRNA treated worms revealed that levamisole and pyrantel responses were reduced to a greater extent than nicotine and acetylcholine responses suggesting that there are different receptor sub-types present on the *Brugia* muscle, some being more sensitive to levamisole (L-sub-type), some being more sensitive to nicotine (N-sub-type). There was also evidence of other still to be characterized sub-types. Characterizing the pharmacological properties of the nAChRs of these parasites will help us to identify novel drug targets, which could be utilized alone or combination with other anthelmintics.

Characterization and target validation of blood meal induced *Ixodes scapularis*

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Ixodid ticks are blood-sucking ectoparasites that are essentially dependent on blood-meals from hosts for survival. *Ixodes scapularis* are vectors of multiple pathogens, including *Borrelia burgdorferi*, the Lyme disease agent; *Anaplasma phagocytophila*, the causative agent of human granulocytic ehrlichiosis; *Babesia microti*; and Powassan virus. The feeding style of ticks, disrupting host tissue and then sucking host blood is expected to provoke host tissue repair response to limit blood loss. Ticks accomplish feeding by injecting multiple proteins into the host, including trapping serine protease inhibitors (serpins). Host defense to tick feeding is mediated by serine protease mediated pathways that are controlled by serpins. From this perspective, there has considerable interest to understand roles of tick-encoded serpins in tick feeding success. *I. scapularis* encodes more than 45 serpin transcripts, some of which are highly identical.

The goal of this study was to relate expression patterns and validate the importance of 11 blood meal induced *I. scapularis* serpins in nymph and adult tick feeding. Quantitative RT-PCR analysis suggest that majority of the 11 serpins are expressed in abundance at the 24-48h feeding time points, which precedes time period when ticks transmit most of the disease agents. We designed two dsRNA targeting the 11 serpins in two clusters of seven and four serpins each. Although injection of both dsRNA affected nymph and adult tick fitness, the effect of the second dsRNA targeting four serpins was more dramatic with more than 95% mortality in both nymph and adult. The long-term goal is to identity tick serpins that can be used in designing tick protein based anti-tick vaccines. Targets in the second cluster represent potential targets for anti-tick vaccine development.
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The potential use of levamisole in a macrocyclic lactone resistance management strategy in *Dirofilaria immitis* infections
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The existence of strains of *Dirofilaria immitis* (DI) resistant to currently available macrocyclic lactone (ML) preventive drugs has been demonstrated on multiple occasions, in multiple regions of the USA. Anecdotal reports in Louisiana now indicate the number of heartworm preventive drug ‘lack of effectiveness’ (LOE) claims are decreasing, nevertheless veterinary practitioners in some regions around the state continue to see suspect LOE cases. Traditionally, a dog was suspected as a LOE case and thought to be infected with ML resistant strains of DI when the animal developed heartworm disease, despite proper administration of ML preventive drugs. Another approach to identify a suspect LOE case requires the monitoring of microfilariae (Mf) counts following the administration of MLs at a dosage known to be microfilaricidal. This approach, better known as the ‘microfilariae reduction assay’ has been shown to be useful on multiple occasions. The author was contacted regarding multiple suspect LOE cases, wherein dogs were no longer harboring adults HWs (based on negative antigen testing) but microfilariae populations continued to survive. The practitioner attempted on multiple occasions to kill the Mf, including repeat administration of multiple ML drugs, known to traditionally be effective against Mf stages, with little success. Based on previous studies, the decision was made to attempt to clear Mf from circulation using levamisole at 5mg/kg PO SID for 10 days. This approach was successful in 9 of the 10 cases. Detailed descriptions of each case will be reported, as well as the results from an *in vitro* Mf motility assaying comparing the efficacy of levamisole against another ML in previously confirmed ML-resistant strains of DI.

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De-gluing the tick: Disrupting putative tick cement glycine-rich proteins weakens the *Amblyomma americanum* tick cement cone.
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Hard ticks of the family Ixodidae are of public and veterinary health importance because they are vectors of human and animal pathogens. The hard tick species *Amblyomma americanum* vectors many zoonotic pathogens including *Francisella tularensis*, *Cytaxzoon felis*, and *Borrelia lonestari* which is the causative agent of southern tick-associated rash illness (STARI). Adult hard ticks feed for up to two weeks and they secrete a cement-like adhesive into the skin of the host to stay attached during feeding. Therefore, the question arises if disrupting cement formation will affect successful attachment by the tick. We conducted LC-MS/MS analysis of proteins in tick cement recovered from manually detached *A. americanum* ticks and identified thirteen putative cement transcripts based on glycine content. Expression analysis of the thirteen mRNA transcripts through five days of feeding was performed by semi-quantitative Reverse Transcription-Polymerase Chain Reaction (RT-PCR). The transcripts were grouped into three categories: pre-appetence present (PAP) (n=3), upregulated in response to blood-meal feeding (UP) (n=6), and feeding induced (FI) (n=4). Cluster double-stranded RNA (c-dsRNA) was designed and synthesized for each category, and injected into female adult *A. americanum* ticks. Green Fluorescent Protein (GFP) dsRNA was used as a control. The effect of RNAi silencing of putative tick cement genes on *A. americanum* tick attachment onto host skin and feeding completion was investigated. Our data shows that
disruption of PAP and FI genes caused weakening of the tick cement cone as revealed by intense bleeding around tick attachment sites.

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*Propagation of Tetratrichomonas sp. from bovine preputial scrapings in Diamond’s and InPouch® culture media*

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*Tritrichomonas foetus*-like trichomonads were recovered from preputial wash (PW) samples of two yearling bulls originating from different herds in Ontario Canada. These animals were undergoing routine isolation testing for entry into a semen production facility under the Canadian Food Inspection Agency’s National Artificial Insemination Program. Trichomonads were detected during examination of wet mounts prepared from inoculated Diamond’s culture medium, as early as two days post-inoculation; they were also detected, less frequently, on initial examination of the sample submitted in transport medium. A second consecutive sample from one of the animals collected one week later yielded similar trichomonads. Propagation of all isolates in both Diamond’s and InPouch® culture media appeared comparable to that of the *T. foetus* reference control. Examination of wet mounts and stained smears for evidence of more than three anterior flagella, indicative of an organism other than *T. foetus*, was inconclusive. However, trichomonad-specific PCR targeting the ITS1 region of the rRNA operon generated a product with closest homology to *Tetratrichomonas* spp., as revealed by direct sequencing of the amplicon. Although *Tetratrichomonas* has been reported as an occasional, presumably fecal-derived, contaminant of PW samples tested for *T. foetus*, such isolates typically do not propagate well in selective media and are considered unlikely to colonize the reproductive tract. However, for the current isolates, their detection in successive samples from the same animal and propagation in selective media comparable to *T. foetus* suggest otherwise. Further molecular characterization is underway to better elucidate the phylogenetic relationships between these isolates and *T. foetus*.

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*Investigating the eco-epidemiology and transmission potential of Trichomonas spp. from hunter-killed Columbiformes in California*

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Avian trichomonosis is a deadly disease in wild birds caused by flagellated protozoan parasites of the *Trichomonas* genus. To determine if mourning doves (*Zeneida macroura*), white-winged doves (*Z. asiatica*), and Eurasian collared-doves (*Streptopelia decaocto*) may be involved in transmission of *Trichomonas* spp. to Pacific Coast band-tailed pigeons (*Patagioenas fasciata monilis*) in California, 32 hunter-killed doves were sampled for *Trichomonas* spp. via the InPouch™ TF culture system (BioMed Diagnostics, White City, OR) during September, 2015. A documented *Trichomonas*-associated mortality event in band-tailed pigeons occurred to the west of our sampling locations between January and March 2015. Trichomonads were detected by culture in 43% (10/23) of mourning doves, 100% (6/6) of white-winged doves, and 33% (1/3) of Eurasian collared-doves. PCR was performed on each isolate obtained from culture-positive samples, targeting the ITS1-5.8S-ITS2 region. Genotypes from mourning doves and white winged doves sampled in 2015 most closely aligned with ITS-group genotypes I, J, and L which
were previously isolated from white-winged doves, mourning doves and a Cooper’s hawk from Arizona and Texas. Complete overlapping sequences were not obtained for the single Eurasian collared-dove isolate, although partial reverse and forward sequences most closely aligned with *Trichomonas gallinae* isolates found in Egypt and China. The prevalence of *Trichomonas* in mourning doves, white-winged doves, and Eurasian collared-doves sampled during the 2015 hunting season (53%; 17/32), was higher than the prevalence detected in hunter-killed band-tailed pigeons sampled in 2011 in northern California (11.1%; 6/54). Ongoing investigations of avian host species, trichomonad genotype, and geographic associations among California wild birds continue to improve our understanding of the ecology and epidemiology of avian trichomonosis.

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**Maintenance of adult *Haemonchus contortus* in vitro**

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Excretion/secretion (E/S) products of nematodes impact the host immune system and can be potential vaccine sources. E/S products also might play a role in parasite-parasite interactions within and across species. An *in vitro* method for maintaining adult nematodes in culture could provide a unique opportunity to study E/S products, specifically those related to parasite interactions within species. This study focused on the ability to maintain adult *Haemonchus contortus* in vitro with a target of 6 das. Two methods were used: a culture media with commercially available fetal bovine serum and a culture media with feeding on defibrinated blood through a membrane. Other variables included: culture media (RPMI; Eagle’s minimal essential medium); ratio of females to males (1:1 to 8:3); frequency of media/blood changes (8 h and 12 h intervals); CO2 level (5 or 10%); and pH (4 and 7). All *H. contortus* used were harvested from sheep and goats at the abattoir. The adult worms were placed in culture within 3 h of collection and kept at 37°C. For membrane feeding, blood was obtained from the same animal as the adult *H. contortus*. At each blood/media change, the number of live worms was assessed and all dead worms were removed. *H. contortus* adults remained alive for four days regardless of the methods used. Six days was achieved more consistently with RPMI and serum, although <1/2 of the worms survived to this time point. Membrane feeding is possible and, while 6 days has not yet been achieved, the females maintained a barberpole appearance for up to 5 days indicating that they did feed via the membrane. While the worms live longer with serum, it is unclear if they are actually healthier than those feeding on blood. Further studies are planned using different membranes and an acetylcholinesterase assay to assess worm health.

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**Further Characterization of Molecular Markers in canine *Dirofilaria immitis* Infections**

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*Dirofilaria immitis* is a common filarial parasite found in dogs and cats, however the pathophysiology differs between the two species. This current study expanded on previous work by our group to determine if microRNA nematode biomarkers (miR-34 and miR-71) can be used to discriminate between dogs with known low and high levels of *D. immitis* worm burden. Serum samples were collected from 13 random dogs humanely euthanized and total number of *D.immitis* were recorded. Three groups were created based on the *D. immitis* burden: Control group (0 worms; 5 animals), Low Burden (10-18 worms; 4 animals),
High Burden (41-72 worms; 4 animals). RNA purification, cDNA synthesis, and qPCR was performed for each sample in order to identify expression of miR-34 and miR-71.

Data analysis of all three groups revealed that there was no significant difference in expression levels of the chosen microRNAs. Therefore the low and high burden samples were re-categorized into an infected category and compared to non-infected controls. Presence of worms (infected group) had a significant increase in copy numbers for both miR-34 and miR-71 (p = 0.015 and p= 0.027, respectively) in comparison to non-infected animals. ROC-curve analysis evaluated microRNA expression levels at specific Ct cutoff points associated with the presence or absence of worms. Results revealed that miR-34 and miR-71 correctly discriminate between the infected and non-infected groups (p value < 0.0001).

These findings indicated that both miRNA 34 and miRNA 71 serve as biomarkers for *dirofilaria immitis* infection in dogs. Further investigations are needed to determine if these nematode biomarkers are present and have similar expression in cats. Even though the experiment was unable to discriminate between low and high burden samples, it has provided the next step in determining a diagnostic assay protocol for future investigations into the parasitological manifestations between dogs and cats.

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**Detection of macrocyclic lactone resistance in field isolates of *Haemonchus contortus*: does dyf-7 genotype correlate with the larval development assay?**

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Current bioassays for the detection of macrocyclic lactone (ML) resistance are slow and time-consuming. A recent report that polymorphisms in the sequence of the dyf-7 gene of *Haemonchus contortus* were correlated with resistance suggested that a quicker molecular test might be possible. In order to assess this, we analyzed partial sequences of the dyf-7 gene amplified from archived samples of eighteen *H. contortus* field isolates, all of which were from the United States, and which had been submitted to the University of Georgia for resistance testing using the DrenchRite™ larval development assay (LDA). The samples included representative isolates that spanned the range from completely susceptible to highly resistant. Genomic DNA was extracted from either eggs or L3 larvae that had been stored under ethanol. The amplified dyf-7 fragments were cloned into pCR-Blunt and multiple plasmids isolated from the resultant colonies for sequencing. The sequences were aligned and the proportion of putative ‘resistant’ and ‘susceptible’ alleles compared to the resistance status as determined in the DrenchRite™ LDA. All of the sequence polymorphisms reported previously were found in these isolates. Initial comparisons of the sequences from two laboratory isolates, UGA/2004 (which is moderately ML-resistant) and UGA/S (which is susceptible), demonstrated alleles fairly consistent with those reported previously for susceptible and resistant isolates. However, in the field isolates there was little correlation between the proportion of the putative ‘resistant’ and ‘susceptible’ sequences and the ML-resistance status. ‘Resistant’ sequences were present in very susceptible isolates and ‘susceptible’ sequences present in highly resistant ones. Possible reasons for this discrepancy will be discussed, but these results suggest that a molecular diagnostic based on dyf-7 sequences will not be a reliable indicator of the ML-resistance status of US field populations of *H. contortus*.
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Parasitic load and DTU determination of Trypanosoma cruzi in stray dogs from Southern Mexico
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Trypanosoma cruzi is the aetiological agent of Chaga’s disease, widely distributed from the south of the US to Argentina. T. cruzi is able to infect several mammal species (<150) including humans. In Mexico there is no formal program of vector control in areas where the main vector Triatoma dimidiata is well established. Seroprevalence rates in dogs from Yucatan Mexico have been reported from 17.5% in urban areas to 35% in rural areas. However, the parasitic load of T. cruzi in infected dogs is unknown. Fifty-two stray dogs from the dog pound were blood sampled and after humane euthanasia, cardiac tissue samples were collected. Serum and DNA were obtained from blood and DNA from the cardiac tissue was purified. Serological evaluation was performed with ELISA as screening test and positive cases were confirmed by Western blot. All DNA samples were evaluated by qPCR to detect and quantify satellite DNA from T. cruzi. A total number of positive cases was 31%. In 20% of sampled dogs (9/52), T. cruzi IgG antibodies were detected. Five dogs (9.6%) showed DNA of T. cruzi in blood samples and were seronegative. A mean of 16.7 ± 11.18 parasites/mL was estimated by qPCR, and DNA of T. cruzi was also detected in cardiac tissue from the 14 seropositive cases, for which a mean of 329.2 ± 177.1 parasites/mg was found. In the 28.5% of serological positive cases + qPCR positive cases (from cardiac tissue) the DTUs involved were I in 21.4 % (3/14) and DTU-group II/V/VI in the 7.14% (1/14). These results shows that dogs are important reservoirs of T. cruzi, maintaining a high circulation of different DTUs of T. cruzi in the urban area studied. The high number of cases in acute and indeterminate stage, is probably due to the lack of vector control.

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Seroprevalence and determination of Toxoplasma gondii parasite load in tissues of Mexican hairless pig (Sus scrofa)

In recent years, the consumption of meat from Mexican hairless pig (Sus scrofa) has been increasing both nationally and internationally, with the state of Yucatan the leading producer. Currently, no epidemiological studies provide information about the health status of this population of animals destined for consumption. This study aimed to estimate the seroprevalence and determine the parasitic load of Toxoplasma gondii in the heart and tongue tissues and from the semimembranosus/gracilis muscles in a population of Mexican hairless pigs. A cross-sectional study was conducted in 81 hairless pigs aged 9-12 weeks from 10 municipalities in the state of Yucatan, Mexico. The prevalence was estimated by indirect ELISA using specific IgG antibodies to T. gondii in sera. The parasite load from the tissues was determined by real-time PCR (qPCR) amplifying a fraction of the B1 gene of T. gondii. The seroprevalence was 53% with variation depending on the municipalities of origin. The presence of T. gondii in the three tissues examined (heart, tongue and semimembranosus/gracilis muscles) was 33.3%. The largest absolute quantification of parasite load was in muscle tissue (2.05 ± 2.03 parasites/gr) and was significantly higher (P <0.05) compared to heart tissue (0.17 ± 0.19 parasites/gr) and the lingual tissue (0.43 ± 0.68 parasites/gr). It is concluded that the Mexican hairless pigs from Yucatan are widely exposed to T. gondii from early ages showing a noticeable tropism towards muscle tissue.
114
Presence of *Toxoplasma gondii* in pork intended for human consumption in tropical Mexico

Toxoplasmosis is caused by the protozoon *Toxoplasma gondii*, one of the most widespread parasitic infections of animals and humans worldwide. One of the main routes of infection for humans is through the consumption of infected meat containing tissue-cysts of bradyzoites. Pork is one of the foremost meat types associated with outbreaks of acute toxoplasmosis in humans. The objective of this study was to determine the presence of specific IgG antibodies against *T. gondii* in the serum of finalized pigs ante-mortem and the presence of *T. gondii* DNA in tissue samples obtained post-mortem from the same pigs, in an abattoir from a tropical region of Mexico. Sixty blood samples were collected from finished pigs at slaughter time and their sera was evaluated by an indirect-IgG ELISA. Tissue samples were obtained from the tongue and loin. Blood and tissue samples were evaluated to search for *T. gondii* DNA using a nested-PCR (nPCR). Seroprevalence of *T. gondii* was 98.3% (59/60) of sampled pigs. Meanwhile, *T. gondii* DNA was present in 23.21% of tongue tissue samples (13/56), 7% of loin tissues (4/57) and 0% in blood samples (0/44) respectively. Results from the present study suggest a high exposure to *T. gondii* in pigs intended for human consumption from the tropical region of Mexico where the study was conducted. This is the first report of the presence of *T. gondii* DNA in tissue samples obtained from finalized pigs in Mexico. Thus, the consumption of raw or undercooked pork meat could represent a significant risk for acquiring infection for the human population.

115
Description of *Procamallanus* (*Spirocamallanus*) *spiralis* Baylis 1923 (*Nematoda: Camallanidae*) from the freshwater fish, *Parachanna obscura* GUNTHER, 1861 (*Osteichthyes: Channidae*)
Akinsanya Bamidele*. University of Lagos, Lagos, Nigeria

The detailed structure of parasites of freshwater fishes is lacking in Nigeria. There have been several studies on the morphological details of *Procamallanus* spp with the main aim of addressing the validity of the genus. There are several re-descriptions of the parasites in the genus since ultrastructure is one of the reliable way of classifying organisms. SEM descriptions of male and female species of *Procamallanus* with attendant histopathological consequences were undertaken. The two species were obtained from the intestine of *Parachanna obscura*. They were fixed in 2.5% glutaraldehyde and post-fixed in osmium tetroxide, sputter coated and examined with the electron microscope.

The male specimens (213) recorded a prevalence of 12.7% (n = 27) while the female specimens (68) recorded a prevalence of 20.5% (n = 14). A total of ninety six (n = 96) parasites were recorded from the fish species. An overall prevalence of 14.6% was obtained in the fish species. The two *Procamallanus* species differ from the already described species of the genus *Procamallanus* (*Spiracamallanus*) with the posterior end not ventrally bent, tail not short but long and straight bending slightly with no spikes, inner depression at the posterior region, excretory pore very near the end of the posterior region, wider cephalic region with inner sieve-like compartment, longitudinal cephalic papillae, papillae of external circles distinctly larger and lateral cuticular extensions with spiral thickenings in front of the buccal capsule.

The two new species show new morphological data in the number of pre anal and post anal papillae and different body measurements. The histopathological changes seen in the host include hyperplasia of intestinal villi, mucosal hypercellularity of lamina propria and calcification of intestinal mucosa which
116
Identification of an Undocumented Microsporidia in Captive Populations of Threatened Eurycea Salamanders.
R. Hoyle*, F. Guo, G. Zhu Department of Veterinary Pathobiology, College of Veterinary Medicine, Texas A&M University.

The Barton Springs salamander (Eurycea sosorum) was enlisted as an endangered species in 1997 and a captive breeding program was established to preserve E. sosorum and two other species in the genus, namely E. nana and E. rathbuni. These unique animals are endemic the Edwards Aquifer region of Texas and human activity in their natural habitats has resulted in adverse conditions for salamanders that are sensitive to environmental changes. In addition, a parasitic outbreak in the breeding center has significantly decreased the salamander population causing symptoms including: erythema, tail loss, asymmetric gills or brachial loss, rhabdomyolysis, kyphosis, and behavior changes. Our initial investigation suggested that the parasite was a microsporidian species so the objective of this study was to develop a sensitive PCR-based detection method and to obtain the 16S SSU rRNA sequence in order to determine its phylogenetic relationship. We carried out phylogenetic analysis using maximum likelihood and Bayesian Inference methods and identified this microsporidian as an undocumented species of the family Pleistophoridae, which typically infects fish or insects. Moreover, the microsporidian infection of cell lines, SF9 insect cells and AB9 zebrafish, is currently being investigated for further validation and study.
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August 6th – 9th 2016, San Antonio, Texas, USA

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### American Association of Veterinary Parasitologists – 61st Annual Meeting
### August 6th – 9th 2016, San Antonio, Texas, USA

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