2015 Ruminant and Equine Antiparasitic Drug Use and Resistance Survey

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I. INTRODUCTION

Antiparasitic drugs with demonstrated effectiveness against a broad spectrum of parasite species are vital to animal health in the United States and around the world. The development of resistance to antiparasitic drugs poses a significant threat to the health and productivity of food-producing animals and horses worldwide and has become a major concern among veterinarians, parasitologists, and animal owners globally.

Antiparasitic resistance is the decreased effectiveness of an antiparasitic drug for parasite species and life stages for which it was previously effective. This may include a moderate decline from how well the drug worked initially, a shorter duration of effectiveness requiring more frequent treatments, or a complete failure of the drug. In the US, resistance to antiparasitic drugs has been documented in helminths of all primary domestic grazing species: cattle, small ruminants, and horses (Ballweber and Baeten, 2012; Edmonds et al., 2010; Gasbarre, 2014; Wolstenholme and Kaplan, 2012). Although the actual prevalence of antiparasitic resistance throughout the US is unknown, cases of resistance (including multi-drug resistance) in helminths are most commonly reported in small ruminants, with an increasing number of cases reported in cattle and horses (FDA, 2012b).

FDA distributed a survey between September 28, 2015, and November 4, 2015, for the purpose of gathering information from US veterinarians and veterinary parasitologists to learn their a) current level of awareness of and concern about antiparasitic resistance; b) commonly used strategies for detecting, monitoring, and/or managing parasites and antiparasitic resistance; and c) opinions about the best ways to ensure the safe and effective use of antiparasitic drugs.

To our knowledge, this is the first survey describing the perceptions and practices of the US veterinary community related to antiparasitic drug use and resistance. Although US livestock producers and horse owners have been surveyed about their parasite detection and control practices (Nielsen et al., 2018; Robert et al., 2015; The University of Rhode Island, 2014; USDA, 2010, 2011, 2013, 2014, 2017), information was previously lacking about the level of awareness of and concern about antiparasitic resistance among US veterinarians and strategies they use to detect, manage, and treat parasitism and/or resistance.

This survey was not designed to provide data on the prevalence of antiparasitic drug resistance or frequency or amount of antiparasitic drugs used. The collection of such data would require a multi-year, multi-site study of parasite resistance and antiparasitic drug use in multiple species in diverse geographic regions throughout the country. However, the survey results provide descriptive and qualitative insight into awareness of the issues related to antiparasitic drug resistance in cattle, horses, and small ruminants in the US.

II. ACKNOWLEDGMENTS AND CONTACTS

The authors thank the following external subject matter experts who pre-tested the survey and provided input on the content and format of the survey: Thomas Craig, DVM, MS, PhD, Louis Gasbarre, PhD, Timothy Geary, PhD, Ray Kaplan, DVM, PhD, Dave Leathwick, PhD, Roger Prichard, PhD, and Martin K. Nielsen, DVM, PhD.

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III. GLOSSARY

Antiparasitic resistance: The decreased effectiveness of an antiparasitic drug for parasite species and stages for which it was previously effective. This may include a moderate decline from how well the drug worked initially, a shorter duration of effectiveness requiring more frequent treatments, or a complete failure of the drug.

Egg hatch test assay: An *in-vitro* resistance detection method for benzimidazoles based on the percentage of eggs that hatch or die at different concentrations of the antiparasitic drug.

FAMACHA© (FAffa MAlan CHArt): A method of scoring the degree of anemia in sheep and goats secondary to infection with *Haemonchus contortus* by comparing the color of mucous membranes in the lower eyelid with a standardized color chart. The results are used to determine which animals should be treated with an antiparasitic drug.

Fecal egg count (FEC): A procedure to detect parasite eggs in feces. Quantitative fecal egg counts provide results as the number of parasite eggs in 1 gram of feces. Qualitative fecal egg counts provide results as either “positive” or “negative” for parasite eggs. If positive, results are given as +, ++, or +++ as a rough gauge of infection.

Fecal egg count reduction test: A calculation of the reduction in parasite eggs after treatment with an antiparasitic drug based on a comparison of fecal egg counts before and after treatment.

Larval culture (coproculture): A method to identify parasite species by culturing feces, allowing parasite eggs to hatch and develop into larvae which are speciated.

Larval migration test: An *in-vitro* resistance detection method based on an evaluation of third stage parasite larvae (L3) motility in different concentrations of an antiparasitic drug.

Larval development assay: An *in-vitro* resistance detection method for antiparasitics through a measurement of the development of parasite eggs to third stage larvae (L3).

Pasture management: Methods of reducing the number of parasites ingested by grazing animals on the pasture, including multispecies grazing; controlling forage height; rotational grazing; regular removal of manure; composting of manure; and routine mowing and harrowing of pasture.

Refugia: The proportion of the total parasite population that is not exposed to antiparasitic drug treatment; essentially, those parasites that are in "refuge" from the drug. This includes egg and larval stages in the environment (pasture refugia), parasites in other animals in the herd not treated at the same time (host-based refugia), and life stages of the parasite that are unaffected by drug treatment due to physiologic or pharmacokinetic factors (McArthur and Reinemeyer, 2014; Nielsen et al., 2014b).

Rotational deworming: Treating animals with a different dewormer based on a predetermined schedule (for example, every X number of months or season), usually without using diagnostics to determine if parasites are present or the level of infection. Often, in a rotational deworming program, several dewormers are used within one year.

Selective treatment: A method of determining which animals to treat based on fecal egg counts.

Strategic deworming: Deworming animals at a time when most parasites are in the animal and not in the environment.

IV. SURVEY METHODS AND STATISTICAL ANALYSIS

A. Survey preparation

The proposed survey was announced in a Federal Register notice, which requested public comment on the proposal (FDA, 2012a, 2014). FDA CVM considered all comments in the design of the final survey, which was approved by the Office of Management and Budget (OMB Control number 0910-0779[1]). The FDA CVM designed the survey using the Dillman Tailored Design Method customized for internet surveys (Dillman et al., 2009) and used comments from the pre-testers to improve the clarity and validity of the questions.

B. Survey distribution

The survey was administered using a third-party internet survey hosting service (SurveyMonkey Inc.). Organization-specific URL links were disseminated by the American Association of Bovine Practitioners (AABP), American Association of Small Ruminant Practitioners (AASRP), American Association of Veterinary Parasitologists (AAVP), American Association of Equine Practitioners (AAEP), and American Veterinary Medical Association (AVMA) in the following ways. A direct email, giving details of the survey and the URL link, was distributed through the listservs of three veterinary professional organizations resulting in invitations to approximately 2,316 AABP members, 642 AASRP members, and 509 AAVP members. The URL link was distributed to AAEP members as part of an online newsletter with approximately 9,400 subscribers. Finally, stories about the survey with the URL link were featured in the AVMA blog "AVMA at Work" and AVMA

[1] Documents available at https://www.reginfo.gov/public/do/PRAViewICR?ref_nbr=201407-0910-002

newsletter “JAVMA News Bulletin.” Both the AVMA blog and newsletter were available to any AVMA member who subscribed to them. While the number of AVMA subscribers was not available, publicly available membership statistics show approximately 12,244 AVMA members identified as food animal, equine, or mixed animal practitioners in 2015 (AVMA, 2015). FDA CVM selected the three species-specific organizations (AABP, AASRP, and AAEP) and the one veterinary parasitology organization (AAVP) because their members were most likely to have experience with parasites of cattle, small ruminants, and horses. In addition, FDA CVM wanted to reach veterinarians or veterinary parasitologists who may not be AVMA members or who may identify more with a specific practice type than with a general veterinary organization. Links were active from September 28, 2015, through November 4, 2015. To enhance the response rate, FDA CVM asked each group to send out several reminders during the five weeks the survey was open.

C. Protecting confidential information

Information was kept confidential in accordance with 18 USC 1905 and 21 USC 331(j), as well as section 301(j) of the Federal Food, Drug, and Cosmetic Act. The survey was provided an exemption approval by the Research in Human Subject Committee (Exemption approval #11-020V, dated April 11, 2011). No identifying information was collected from respondents and all responses are reported in aggregate. Data in categories with a low number of responses are excluded in this report to avoid inadvertently disclosing the personal identity of any respondents (mosaic effect).

Although the online survey instrument stored network IP addresses used to access the survey, this information was used only to determine that duplicate surveys were not completed. SurveyMonkey has a security infrastructure in place for all survey data including procedures to address user, data center, network, storage, and organizational security, availability of data, and software usage. This includes but is not limited to use of Secure Sockets Layer (SSL) technology for authentication and data encryption, a staffed and surveilled SAS70 Type II certified facility, redundant IP connections, intrusion detection systems, and encrypted back up.

D. Statistical analysis methods

Responses from each of the URL links were consolidated in the survey platform software (SurveyMonkey Inc.) and exported to standard data management software (Microsoft Corporation, 2016). Data were analyzed using commercially available statistical software (SAS Institute Inc, 2012). Descriptive statistics, including frequencies, percentages, and the associated 95% confidence intervals, were used to summarize responses. Respondents were not required to answer every question and could complete Parts III and IV for any or all of the three species subsets: cattle, small ruminants, and horses; therefore, the number of responses could vary for each question.

E. Limitations

Although the survey provides valuable information about the awareness of the US veterinary community about antiparasitic resistance and current practices related to how veterinarians diagnose, treat, and manage parasites and/or antiparasitic resistance, there were several limitations. We could not calculate a precise response rate but found that the estimated response rate varied by the

organization sampled. The three organizations that directly emailed their members with details of the survey and the URL link had the highest response rate: AASRP (approximately 17%), followed by AABP and AAVP (approximately 9% each). Low response rates resulted when the information was included as part of an organization's newsletter or blog: AAEP and AVMA (<1%). The estimated response rates for AABP, AASRP, and AAVP were similar to those reported for other web-based surveys of bovine practitioners conducted through association listservs which ranged from 8% to 26% (Cattaneo et al., 2009; Coetzee et al., 2010; Fajt et al., 2011) and to web-based surveys of physicians (Swaminath et al., 2011). Low response rates do not always equate to high non-response bias or inaccurate survey results (Groves, 2006); however, non-respondents may have had less interest in or knowledge of the topic areas and chose not to participate. Individuals who did not subscribe to the various organizations' listserv, newsletter, or blog were not notified about the survey. Therefore, the results may be biased toward the opinions of respondents who have greater access to and/or interest in current information about the three species subsets or parasitology in general. Methods of contacting all veterinarians and veterinary parasitologists, such as through phone or direct mail, were not practical or possible. The length of the survey may also have decreased the response rate for some sections of the survey. The introduction to the survey stated that the survey would take about 30 minutes to complete; however, it may have taken longer than the estimated 30 minutes to complete if respondents answered questions in Part III and IV for more than one species or class of animals.

It is also important to recognize that this survey collected perceptions, recommendations, and practices regarding parasite control and antiparasitic resistance from members of the US veterinary community. It did not measure the actual prevalence of resistance or the actual use of specific parasite management practices. However, the veterinarians and veterinary parasitologists who responded to the survey are trained experts who regularly interact with other veterinarians, clients, and their animals, thus providing a valuable, integrative view of relatively current field conditions. The veterinary community is also a key resource for disseminating animal health recommendations and so their perceptions have an important effect on parasite management at a local level.

V. EXECUTIVE SUMMARY

The survey (see Attachment A) was conceptually divided into five sections:

- Part I included demographic questions designed to provide informed consent, collect background information on the respondents, determine eligibility to complete the survey, and determine categorical placement of observations during data analysis. These questions captured data on credential type (veterinary degrees and/or advanced degrees in veterinary parasitology), employment type, geographic region in which experience was based, and the percentage of practice experience devoted to various domestic species. Respondents with experience only in regions outside the US, those with companion animal predominant or exclusive experience, and those without experience with cattle, small ruminants, or horses were excluded from completing the survey beyond the demographic questions.

- Part II included questions related to respondents' perceived awareness of, concern about, and experience with antiparasitic resistance in cattle, sheep,

goats, and/or horses. Respondents' perceived awareness is what they think the prevalence of antiparasitic resistance is in a species or class of animals based on their personal experience and knowledge, not necessarily the true prevalence.

- For Parts III and IV, respondents were initially directed to answer questions related to the species with which they had the most experience and were then allowed to repeat these sections of the survey to answer questions related to another species, as appropriate for their stated practice or focus area.

- Part III included questions designed to collect information on how respondents decide which antiparasitic drugs to use in cattle, small ruminants, and/or horses.

- Part IV included questions which were designed to collect information on the methods used to detect and manage antiparasitic resistance in cattle, small ruminants, and/or horses.

- Part V included questions designed to collect respondents' opinions about the best ways to help ensure antiparasitic drugs are used safely and effectively by end users (veterinarians, producers, or horse owners).

A total of 435 respondents completed one or more parts of the survey. The greatest percentage of the respondents were US veterinarians who self-identified as employed in private practice (n=274). The other 161 respondents self-identified as veterinarians and/or veterinary parasitologists not currently working in private practice (academia/research, government/regulatory, industry, retired, or students).

Sixty percent (217/359) of respondents reported an awareness of a high prevalence of antiparasitic resistance in sheep and 64% (226/355) of respondents reported an awareness of a high prevalence of antiparasitic resistance in goats. A high percentage of respondents also considered these species at greatest risk for further development of resistance [70% (246/353) and 73% (256/351) for sheep and goats, respectively]. By contrast, only 3% (11/354) and 1% (5/353) of respondents reported an awareness of a high prevalence of resistance in beef cow-calf operations and dairy cattle, respectively. Forty-five percent (160/352) of respondents stated that they were unable to evaluate the prevalence of resistance in feedlot cattle. Thirty-two percent (114/356) of respondents reported an awareness of a moderate prevalence of resistance in adult horses. Similar percentages of respondents reported an awareness of low/no prevalence or were unable to evaluate the level of resistance in adult horses [27% (95/356) and 28% (100/356), respectively]. The results were similar for young horses.

Among all respondents, 73% (259/356) stated that they had experienced or witnessed antiparasitic resistance in horses, cattle, or small ruminants in the US in the past three years.

Around 70% of all respondents who answered the species-specific questions in Parts III and IV selected veterinary continuing education conferences as a preferred source of information to determine which antiparasitic drug to use or recommend. Seventy-two percent (109/152) of respondents with small ruminant experience and 73% (55/75) of respondents with horse experience also indicated that they decide which antiparasitic drug to use or recommend by first testing the drug in an animal population and then determining its effectiveness based on a fecal egg count (FEC).

Seventy-one percent (53/75) of respondents with horse experience selected the fecal egg count reduction test (FECRT) as the method of choice to determine if an antiparasitic drug is effective. Fifty-seven percent (74/129) of respondents with cattle experience selected resolution of clinical signs. The two most frequently selected choices for respondents with small ruminant experience were the FECRT [74% (112/151)] and resolution of clinical signs [72% (109/151)].

Respondents were asked to indicate their top two initial recommendations (ranked as first and second choices) for an animal owner for situations in which an antiparasitic drug was ineffective. Fifty-six percent of respondents with cattle experience selected the use of another antiparasitic drug as their first choice. Forty-four percent of respondents with horse experience selected a change to a selective treatment program as their first choice. For respondents with small ruminant experience, 32% selected animal management changes and 34% selected treatment with another antiparasitic drug as their first choice. A recommendation for pasture management changes was selected by 55%, 40%, and 56% of respondents with cattle, horse, and small ruminant experience, respectively, as their first or second choice.

Over half [62% 76/123)] of respondents with cattle experience routinely dewormed cattle less than 18 months of age more than once per year. Approximately one-third of these respondents recommended rotational deworming regardless of the age of the cattle.

Slightly less than half [46% (32/70)] of respondents with horse experience dewormed horses less than three years of age three to four times per year, and 40% (27/67) recommended rotating antiparasitic drugs multiple times per year in these young horses.

Sixty-four percent (87/136) of respondents with small ruminant experience used FECs, FAMACHA©, or other individualized treatment plans to determine the number of deworming treatments to give to small ruminants less than 1 year of age. Over half of these respondents never recommended rotating antiparasitic drugs for small ruminants regardless of age.

Thirty-four percent (24/71) of respondents with horse experience, 40% (49/123) of respondents with cattle experience, and 49% (70/144) of respondents with small ruminant experience reported using two or more antiparasitic drugs at the same time.

When asked whether they performed or recommended specific procedures to detect and/or quantify parasite eggs in feces, respondents with cattle experience reported the lowest use of fecal evaluation procedures [76% (105/138)]. In comparison, 99% (151/153) of respondents with small ruminant experience and 93% (69/74) of those with horse experience reported using or recommending fecal evaluation procedures.

Six percent (4/69) of respondents with horse experience, 12% (17/147) of respondents with small ruminant experience, and 17% (17/103) of respondents with cattle experience reported that they used or recommended larval culture to identify parasite species.

Eighty-one percent (56/69) of respondents with horse experience, 86% (126/146) of respondents with small ruminant experience, and 60% (62/103) of respondents with cattle experience reported using or recommending the FECRT to determine the effectiveness of an antiparasitic drug.

Seventy-one percent (95/133) of respondents with cattle experience and 72% (54/75) of those with horse experience selected strategic deworming as one of their top management practices they implement or recommend for a parasite control program. Seventy-six percent (113/149) of respondents with small ruminant experience reported using pasture management. Refugia was selected by 54% (81/149) of respondents with small ruminant experience compared to 24% (32/133) of respondents with cattle experience and 29% (22/75) of respondents with horse experience.

Only 38% (109/290) of all respondents stated that they were aware of the availability of Freedom of Information (FOI) Summaries for approved animal drugs on the FDA website.

Seventy-eight percent (215/274) of all respondents reported that approved combinations of antiparasitic drugs should be available only by prescription in the US. In contrast, only 12% (31/258) of all respondents reported that these products should be over-the-counter.

The results of this survey provide insight into the US veterinary community's perceived awareness and perceived risk of antiparasitic resistance in cattle, small ruminants, and horses. It also provides information about how US veterinarians currently use antiparasitic drugs, manage parasites, and detect and manage antiparasitic resistance in grazing animals.

VI. SECTION 1: DEMOGRAPHICS

A. Summary of overall demographic data

Respondents were asked to report their credentials, current employment type, regions in which their professional experience is based, and the percentage of their practice or research focus area with the following groups of animals: equine pleasure/performance, equine racetrack, beef cattle, dairy cattle, swine, poultry, sheep, goats, small animal (cats/dogs), or other. Respondents that did not report any professional experience in the United States, who reported a companion animal predominant or exclusive practice or focus area, or did not have any experience with horses, cattle, or small ruminants, were directed to a "survey exclusion" page which explained that FDA CVM was restricting the collection of information to those that have experience with horses, cattle, or small ruminants in the United States. These respondents did not complete the survey beyond the demographic questions.

Most respondents were veterinarians in private practice: 63% of respondents (274/435) who provided information on their employment type self-identified as being in private practice. The other 161 respondents self-identified as veterinarians and/or veterinary parasitologists not currently working in private practice (academia/research, government/regulatory, industry, retired, or students). Ninety percent (389/434) reported having a DVM degree (alone or along with a PhD or MS in veterinary parasitology). Respondents with VMD degrees who reported as "other" were included in the DVM category.

Respondents were widely distributed across the US with the greatest number from the following regions: Northeast (21% [82/399]), Upper Midwest (16% [62/399]), Ohio Valley (15% [59/399]), South (13% [53/399]), and Southeast (14%

[55/399]). Responses to individual questions throughout the survey could not be analyzed by climatic region because respondent numbers were too low.
During the data analysis, the authors subcategorized the responses by practice experience. The subcategories included respondents with ≥ 30%, ≥90%, or ≤10% of their practice or research focus area devoted to cattle, horses, or small ruminants. These categories loosely represent respondents that typically specialize in a species (≥90%); deal with the species to a small extent (≤10%), or, deal with the species on a regular basis, including potentially specializing in that species (≥ 30%). Sixty-six percent, 35%, and 21% of respondents were classified as having ≥ 30% of their practice or research focus devoted to cattle, horses, and small ruminants, respectively.

Demographic data summary of respondents

Table VI.1. n (%) of respondents sorted by credential type

Credential Type n=434	**n**	**%**
DVM	368	85
PhD or MS in Veterinary Parasitology	30	7
Both	21	5
Other	15	3

Table VI.2. n (%) of respondents sorted by employment type

Employment Type n=435	**n**	**%**
Academia/ Research	82	19
Government/ Regulatory	19	4
Industry	35	8
Private practice	274	63
Retired/ Not actively employed	11	3
Student	14	3

Table VI.3. n (%) of respondents sorted by region of the world

Region of World n=431	**n**	**%**
Region of the world other than the United States	36	8
United States	363	84
United States and another region of the world	32	7

Table VI.4. n (%) of respondents sorted by region of the United States/Canada

Region of the United States/Canada n=399	n	%
Canada	5	1
Multiple locations in the US	8	2
New England/ Mid-Atlantic - ME, NH, VT, NY, MA, RI, CT, NJ, DE, MD, PA	82	21
Northern Rockies and Plains - MT, WY, ND, SD, NE	19	5
Northwest- WA, OR, ID	17	4
Ohio Valley - MO, IL, IN, OH, WV, KY, TN	59	15
Puerto Rico, US Virgin Islands	2	1
South- KS, OK, TX, AR, LA, MS	53	13
Southeast - VA, NC, SC, GA, AL, FL	55	14
Southwest - UT, CO, AZ, NM	15	4
Upper Midwest - MN, WI, MI, IA	62	16
West - CA, NV	22	6

Table VI.5. n (%) of respondents sorted by practice experience

Practice Experience	n	%
Percent of respondents reporting >=30% of practice experience with cattle (n=307)	203	66
Percent >=30% Horses (n=252)	87	35
Percent >=30% Small Ruminants (Sheep or Goats) (n=261)	56	21

B. Education (Credentials) sorted by employment type

Table VI.6. n (%) of respondents sorted by education and credentials

n=434 *Employment Type*	DVM n (%)	PhD/MS n (%)	Both n (%)	Other n (%)
Academia/ Research	46 (13)	20 (67)	11 (52)	5 (33)
Government/ Regulatory	17 (5)	0 (0)	1 (5)	1 (7)
Industry	22 (6)	5 (17)	6 (29)	2 (13)
Private practice	268 (73)	2 (7)	2 (10)	1 (7)
Retired/ Not actively employed	8 (2)	2 (7)	1 (5)	0 (0)
Student	7 (2)	1 (3)	0 (0)	6 (40)

VII. SECTION 2: RISK AND AWARENESS OF ANTIPARASITIC RESISTANCE

A. Awareness of resistance

Respondents were asked about their perceived awareness of the extent of antiparasitic drug resistance in sheep, goats, adult and young horses, and various classes of cattle in the United States. Respondents were asked to gauge their perceived awareness as “high”, “moderate”, or “low” and to select “unable to evaluate” if they did not have sufficient experience with a species to evaluate perceived prevalence or did not know if there was resistance. The categories of high, moderate, and low were not defined for respondents in the survey and should be considered subjective.

Among all respondents (Table VII.1), 60% (217/359) and 64% (226/355) perceived a high prevalence of antiparasitic resistance in sheep and goats, respectively. By contrast, only 3% (11/354) and 1% (5/353) of respondents perceived a high prevalence of resistance in beef cow-calf operations and dairy cattle, respectively. Thirty-two percent (114/356) of respondents perceived a moderate prevalence of resistance in adult horses. A similar percentage, 27% (95/356), perceived low/no prevalence of resistance in adult horses. The results were similar for young horses. Forty-five percent and 40% of all respondents were unable to evaluate the level of resistance in feedlot cattle and dairy cattle, respectively. Among respondents identifying their employment type as private practice, similar trends were reported (Table VII.2).

Table VII.1. Awareness of resistance among all respondents (presented as number (n) and percentage (%) of respondents)

Species/class (n)	High Prevalence n (%)	Moderate Prevalence n (%)	Low/ No Prevalence n (%)	Unable to Evaluate n (%)
Adult horses (n=356)	47(13)	114(32)	95(27)	100(28)
Young horses (n=356)	49(14)	104(29)	89(25)	114(32)
Dairy cattle (n=353)	5(1)	42(12)	164(46)	142(40)
Cow-calf (n=354)	11(3)	100(28)	150(42)	93(26)
Backgrounders/ stockers (n=354)	20(6)	90(25)	121(34)	123(35)
Feedlot (n=352)	12(3)	66(19)	114(32)	160(45)
Sheep (n=359)	217(60)	69(19)	17(5)	56(16)
Goats (n=355)	226(64)	61(17)	16(5)	52(15)

Table VII.2. Awareness of resistance among respondents identifying their employment type as private practice. The table presents the number of respondents (n), the percentage (%) of respondents, and the 95% confidence interval (95% CI) for this percentage of respondents

Species/ class (n)	High Prevalence n % (95% CI)	Moderate Prevalence n % (95% CI)	Low/No Prevalence n % (95% CI)	Unable to Evaluate n % (95% CI)
Adult horses n=239	21 9 (6-13)	78 33 (27-39)	80 33 (28-40)	60 25 (20-31)
Young horses n=238	25 11 (7-15)	68 29 (23-35)	77 32 (26-39)	68 29 (23-35)
Dairy cattle n=236	4 2 (0-4)	21 9 (6-13)	110 47 (40-53)	101 43 (36-49)
Beef cow-calf n=236	4 2 (0-4)	53 22 (17-28)	111 47 (41-54)	68 29 (23-35)
Background/ stockers n=237	6 3 (1-5)	49 21 (16-26)	88 37 (31-44)	94 40 (33-46)
Feedlot cattle n=235	6 3 (1-5)	30 13 (9-18)	79 34 (28-40)	120 51 (44-58)
Sheep n=239	125 52 (46-59)	56 23 (18-29)	14 6 (3-10)	44 18 (14-24)
Goats n=236	140 59 (53-66)	46 19 (15-25)	13 6 (3-9)	37 16 (11-21)

When respondents who did not report <u>any portion</u> of their practice, employment, or research devoted to the species were removed from the dataset, similar results were noted. However, a lower percentage stated that they were unable to evaluate their awareness of the prevalence of resistance.

Table VII.3. Data from respondents who reported having experience with the species (i.e., respondents with 0% of practice, employment, or research devoted to the species grouping of interest <u>were removed</u> from the dataset). Data are presented as number (n) and percentage (%) of respondents

Species/class (n)	High Prevalence n (%)	Moderate Prevalence n (%)	Low/ No Prevalence n (%)	Unable to Evaluate n (%)
Adult horses (n=242)	34(14)	94(39)	88(36)	26(11)
Young horses (n=242)	41(17)	84(35)	82(34)	35(14)
Dairy cattle (n=287)	5(2)	33(11)	156(54)	93(32)
Cow-calf (n=288)	10(3)	89(31)	143(50)	46(16)
Backgrounders/ stockers (n=288)	17(6)	81(28)	113(39)	77(27)
Feedlot (n=286)	8(3)	58(20)	108(38)	112(39)
Sheep (n=250)	164(66)	61(24)	13(5)	12(5)
Goats (n=250)	175(70)	53(21)	12(5)	10(4)

Responses were further divided into three categories based on the reported percentage of practice, employment, or research devoted to that species from the demographic section of the survey. Reported percentages were grouped into categories of ≥90%, ≥ 30%, or ≤10%. The results in Tables VII.4., VII.5. and VII.6., only show the results for respondents reporting ≥90%, ≥ 30%, or ≤10%, respectively, of their experience dedicated to the species listed. For example, in Table VII.4., 10 out of 36 respondents (28%) with at least 90% of their practice or research experience devoted to horses stated that they were aware of a high prevalence of antiparasitic resistance in adult horses.

Table VII.4. Level of awareness in respondents with ≥90% of focus area in horses, cattle, or small ruminants, respectively. Data are presented as number (n) and percentage (%) of respondents

Species/class (n)	**High Prevalence n (%)**	**Moderate Prevalence n (%)**	**Low/ No Prevalence n (%)**
Adult horses (n=36)	10(28)	14(39)	12(33)
Young horses (n=36)	10(28)	19(53)	6(17)
Dairy cattle (n=48)	1(2)	9(19)	26(54)
Cow-calf (n=47)	4(9)	15(32)	19(40)
Backgrounders/ stockers (n=47)	6(13)	17(36)	10(21)
Feedlot (n=47)	3(6)	10(21)	18(38)
Sheep (n=8)	5(63)	2(25)	0(0)
Goats (n=8)	6(75)	1(13)	0(0)

Table VII.5. Level of awareness in respondents with ≥30% of focus area in horses, cattle, or small ruminants, respectively. Data are presented as number (n) and percentage (%) of respondents

Species/class (n)	**High Prevalence n (%)**	**Moderate Prevalence n (%)**	**Low/ No Prevalence n (%)**
Adult horses (n=85)	19(22)	35(41)	31(36)
Young horses (n=85)	22(26)	37(44)	23(27)
Dairy cattle (n=189)	4(2)	24(13)	113(60)
Cow-calf (n=189)	8(4)	57(30)	101(53)
Backgrounders/ stockers (n=189)	13(7)	53(28)	82(43)
Feedlot (n=187)	8(4)	40(21)	78(42)
Sheep (n=54)	40(74)	12(22)	1(2)
Goats (n=54)	40(74)	10(19)	1(2)

Table VII.6 Level of awareness in respondents with ≤10% of focus area in horses, cattle, or small ruminants, respectively. Data are presented as number (n) and percentage (%) of respondents

Species/class (n)	High Prevalence n (%)	Moderate Prevalence n (%)	Low/ No Prevalence n (%)
Adult horses (n=124)	12(10)	46(37)	44(35)
Young horses (n=124)	16(13)	42(34)	39(31)
Dairy cattle (n=60)	1(2)	4(7)	22(37)
Cow-calf (n=61)	2(3)	19(31)	20(33)
Backgrounders/ stockers (n=61)	3(5)	16(26)	15(25)
Feedlot (n=61)	0(0)	10(16)	15(25)
Sheep (n=145)	87(60)	40(28)	8(6)
Goats (n=145)	97(67)	36(25)	8(6)

B. Characterization of the level of risk of development or expansion of resistance in the US

Respondents were asked to assess risk (high, moderate, or low) of development or expansion of antiparasitic resistance in sheep, goats, adult and young horses, and various classes of cattle in the United States. Respondents were asked to select “unable to evaluate” if they did not have sufficient experience with a species to evaluate the level of risk or did not know if there was resistance in a species.

Respondents considered sheep (70% [246/353]) and goats (73% [256/351]) as having high risk; and feedlot cattle (31% [106/347]) and dairy cattle (34% [121/351]) as having low risk. Forty percent of respondents were unable to evaluate the risk in feedlot cattle (139/347) (see Table VII.7.).

Table VII.7. Number (n) and percentage (%) of all respondents classifying the risk of resistance in each species/class. Data are presented as number (n) and percentage (%) of respondents

Species/class (n)	High Risk n (%)	Moderate Risk n (%)	Low Risk n (%)	Unable to Evaluate n (%)
Adult horses (n=349)	102(29)	124(36)	37(11)	86(25)
Young horses (n=350)	102(29)	138(39)	21(6)	89(25)
Dairy cattle (n=351)	26(7)	88(25)	121(34)	116(33)
Cow-calf (n=351)	52(15)	143(41)	72(21)	84(24)
Backgrounders/ stockers (n=348)	60(17)	124(36)	54(16)	110(32)
Feedlot (n=347)	39(11)	63(18)	106(31)	139(40)
Sheep (n=353)	246(70)	50(14)	7(2)	50(14)
Goats (n=351)	256(73)	34(10)	8(2)	53(15)

In most cases, respondents employed in academia/research or industry considered the various species/class categories at higher risk than respondents in other employment categories. Results from respondents identifying their employment type as private practice are provided in more detail in Table VII.8.

Table VII.8. Number (n), percentage (%), and associated 95% confidence interval (95% CI) of respondents identifying their employment type as private practice classifying the risk of resistance in each species/class

Species/class (n)	High Risk n % (95%CI)	Moderate Risk n % (95%CI)	Low Risk n % (95%CI)	Unable to Evaluate n % (95%CI)
Adult horses n=233	62 27 (21-33)	92 39 (33-46)	27 12 (8-16)	52 22 (17-28)
Young horses n=234	57 24 (19-30)	105 45 (38-51)	18 8 (5-12)	54 23 (18-29)
Dairy cattle n=234	12 5 (3-9)	53 23 (17-29)	84 36 (30-42)	85 36 (30-43)
Beef cow-calf n=234	24 10 (7-15)	92 39 (33-46)	54 23 (18-29)	64 27 (22-34)
Background/ stockers n=231	21 9 (6-14)	85 37 (31-43)	39 17 (12-22)	86 37 (31-44)
Feedlot cattle n=231	16 7 (4-11)	43 19 (14-24)	67 29 (23-35)	105 45 (39-52)
Sheep n=236	155 66 (59-72)	32 14 (9-19)	7 3 (1-6)	42 18 (13-23)
Goats n=235	166 71 (64-76)	22 9 (6-14)	7 3 (1-6)	40 17 (12-22)

Table VII.9. Association between employment type and level of risk (presented as number (n) and percentage (%) of respondents) relative to resistance in adult horses

Employment Type (n=349)	High Risk n (%)	Moderate Risk n (%)	Low Risk n (%)	Unable to Evaluate n (%)
Academia/ Research	26(39)	16(24)	5(7)	20(30)
Government/ Regulatory	4(29)	3(21)	4(29)	3(21)
Industry	6(29)	9(43)	0(0)	6(29)
Private practice	62(27)	92(39)	27(12)	52(22)
Retired/ Not actively employed	1(13)	3(38)	0(0)	4(50)
Student	3(50)	1(17)	1(17)	1(17)

Table VII.10. Association between employment type and level of risk (presented as number (n) and percentage (%) of respondents) relative to resistance in young horses

Employment Type (n=350)	High Risk n (%)	Moderate Risk n (%)	Low Risk n (%)	Unable to Evaluate n (%)
Academia/ Research	30(45)	15(22)	1(1)	21(31)
Government/ Regulatory	4(29)	4(29)	1(7)	5(36)
Industry	8(38)	7(33)	0(0)	6(29)
Private practice	57(24)	105(45)	18(8)	54(23)
Retired/ Not actively employed	1(13)	5(63)	0(0)	2(25)
Student	2(33)	2(33)	1(17)	1(17)

Table VII.11. Association between employment type and level of risk (presented as number (n) and percentage (%) of respondents) relative to resistance in dairy cattle

Employment Type (n=351)	High Risk n (%)	Moderate Risk n (%)	Low Risk n (%)	Unable to Evaluate n (%)
Academia/ Research	10(15)	23(34)	18(27)	16(24)
Government/ Regulatory	1(7)	2(14)	7(50)	4(29)
Industry	1(5)	6(27)	8(36)	7(32)
Private practice	12(5)	53(23)	84(36)	85(36)
Retired/ Not actively employed	0(0)	1(13)	4(50)	3(38)
Student	2(33)	3(50)	0(0)	1(17)

Table VII.12. Association between employment type and level of risk (presented as number (n) and percentage (%) of respondents) relative to resistance in beef cow-calf

Employment Type (n=351)	High Risk n (%)	Moderate Risk n (%)	Low Risk n (%)	Unable to Evaluate n (%)
Academia/ Research	19(28)	30(45)	8(12)	10(15)
Government/ Regulatory	1(7)	8(57)	3(21)	2(14)
Industry	5(23)	7(32)	4(18)	6(27)
Private practice	24(10)	92(39)	54(23)	64(27)
Retired/ Not actively employed	1(13)	3(38)	3(38)	1(13)
Student	2(33)	3(50)	0(0)	1(17)

Table VII.13. Association between employment type and level of risk (presented as number (n) and percentage (%) of respondents) relative to resistance in backgrounders/stocker cattle

Employment Type (n=348)	High Risk n (%)	Moderate Risk n (%)	Low Risk n (%)	Unable to Evaluate n (%)
Academia/ Research	25(37)	23(34)	6(9)	13(19)
Government/ Regulatory	2(14)	4(29)	4(29)	4(29)
Industry	9(41)	7(32)	1(5)	5(23)
Private practice	21(9)	85(37)	39(17)	86(37)
Retired/ Not actively employed	1(13)	2(25)	4(50)	1(13)
Student	2(33)	3(50)	0(0)	1(17)

Table VII.14. Association between employment type and level of risk (presented as number (n) and percentage (%) of respondents) relative to resistance in feedlot cattle

Employment Type (n=347)	High Risk n (%)	Moderate Risk n (%)	Low Risk n (%)	Unable to Evaluate n (%)
Academia/ Research	13(19)	15(22)	18(27)	21(31)
Government/ Regulatory	1(7)	0(0)	8(57)	5(36)
Industry	5(24)	1(5)	10(48)	5(24)
Private practice	16(7)	43(19)	67(29)	105(45)
Retired/ Not actively employed	1(13)	1(13)	3(38)	3(38)
Student	3(50)	3(50)	0(0)	0(0)

Table VII.15. Association between employment type and level of risk (presented as number (n) and percentage (%) of respondents) relative to resistance in sheep

Employment (n=353)	High Risk n (%)	Moderate Risk n (%)	Low Risk n (%)	Unable to Evaluate n (%)
Academia/ Research	56(84)	9(13)	0(0)	2(3)
Government/ Regulatory	9(64)	4(29)	0(0)	1(7)
Industry	16(73)	1(5)	0(0)	5(23)
Private practice	155(66)	32(14)	7(3)	42(18)
Retired/ Not actively employed	6(75)	2(25)	0(0)	0(0)
Student	4(67)	2(33)	0(0)	0(0)

Table VII.16. Association between employment type and level of risk (presented as number (n) and percentage (%) of respondents) relative to resistance in goats

Employment Type (n=351)	High Risk n (%)	Moderate Risk n (%)	Low Risk n (%)	Unable to Evaluate n (%)
Academia/ Research	57(85)	7(10)	0(0)	3(4)
Government/ Regulatory	10(71)	3(21)	0(0)	1(7)
Industry	15(71)	1(5)	0(0)	5(24)
Private practice	166(71)	22(9)	7(3)	40(17)
Retired/ Not actively employed	4(50)	1(13)	0(0)	3(38)
Student	4(67)	0(0)	1(17)	1(17)

Responses were further divided into three categories based on the reported percentage of practice, employment, or research devoted to that species. Reported percentages were grouped into categories of ≥90%, ≥30%, or ≤10%. The results in Tables VII.17., VII.18. and VII.19., only show the results for respondents with ≥90%, ≥ 30%, or ≤10%, respectively, of their experience dedicated to the species listed. For example, in Table VII.17., out of 35 respondents with at least 90% of their practice or research experience devoted to horses, 51% (18/35) stated that they were aware of a high risk of development of antiparasitic resistance in adult horses.

Table VII.17. Level of risk reported by respondents with ≥90% of focus area in horses, cattle, and small ruminants, respectively (presented as number (n) and percentage (%) of respondents)

Species/class (n)	High Risk n (%)	Moderate Risk n (%)	Low Risk n (%)
Adult horses (n=35)	18(51)	16(46)	1(3)
Young horses (n=35)	20(57)	12(34)	2(6)
Dairy cattle (n=49)	5(10)	13(27)	24(49)
Cow-calf (n=47)	11(23)	21(45)	9(19)
Backgrounders/ stockers (n=47)	11(23)	18(38)	8(17)
Feedlot (n=46)	5(11)	9(20)	20(43)
Sheep (n=7)	6(86)	1(14)	0(0)
Goats (n=7)	7(100)	0(0)	0(0)

Table VII.18. Level of risk reported by respondents with ≥30% of focus area in horses, cattle, and small ruminants, respectively (presented as number (n) and percentage (%) of respondents)

Species/class (n)	High Risk n (%)	Moderate Risk n (%)	Low Risk n (%)
Adult horses (n=82)	34(41)	39(48)	8(10)
Young horses (n=83)	39(47)	37(45)	5(6)
Dairy cattle (n=191)	13(7)	57(30)	93(49)
Cow-calf (n=190)	26(14)	101(53)	48(25)
Backgrounders/ stockers (n=190)	34(18)	88(46)	39(21)
Feedlot (n=188)	18(10)	40(21)	80(43)
Sheep (n=52)	44(85)	8(15)	0(0)
Goats (n=52)	45(87)	5(10)	0(0)

Table VII.19. Level of risk reported by respondents with ≤10% of focus area in horses, cattle, and small ruminants, respectively (presented as number (n) and percentage (%) of respondents)

Species/class (n)	High Risk n (%)	Moderate Risk n (%)	Low Risk n (%)
Adult horses (n=122)	35(29)	53(43)	21(17)
Young horses (n=122)	36(30)	60(49)	12(10)
Dairy cattle (n=59)	3(5)	17(29)	9(15)
Cow-calf (n=60)	14(23)	17(28)	9(15)
Backgrounders/ stockers (n=57)	10(18)	16(28)	4(7)
Feedlot (n=58)	8(14)	9(16)	10(17)
Sheep (n=141)	111(79)	19(13)	4(3)
Goats (n=141)	117(83)	16(11)	4(3)

C. Experience with resistance

Respondents were given a definition of antiparasitic drug resistance* and asked if they had experienced or witnessed antiparasitic drug resistance in horses, cattle, or small ruminants in the United States in the past three years.

*The survey question stated, “For the purposes of this survey, antiparasitic drug resistance is defined as the decreased effectiveness of an antiparasitic drug for parasite species and stages for which it was previously effective. This may include a moderate decline in how well the drug works initially, a shorter duration of efficacy requiring more frequent treatments, or a complete failure of the therapeutic regimen.”

Among all respondents, 73% (259/356) stated that they had experienced or witnessed antiparasitic drug resistance in at least one of these species in the United States in the past three years (Table VII.20).

Table VII.20. Experience with resistance among all respondents. Data are presented as number (n) and percentage (%) of respondents

Experiencing or witnessing Antiparasitic drug resistance n=356	**Number and Percent of Respondents n (%)**
Yes	259(73)
No	64(18)
Uncertain	33(9)

The greatest percentage of respondents reporting experience with resistance were employed in academia/research and industry, followed by private practice (see Table VII.21.).

Table VII.21. Relationship between employment type and experience of resistance (presented as number (n) and percentage (%) of respondents)

Experiencing or witnessing antiparasitic drug resistance, sorted by stated employment type n=356	**Yes n (%)**	**No n (%)**	**Uncertain n (%)**
Academia/ Research	55(82)	6(9)	6(9)
Government/ Regulatory	9(64)	2(14)	3(21)
Industry	19(86)	2(9)	1(5)
Private practice	171(72)	48(20)	20(8)
Retired/ Not actively employed	2(25)	4(50)	2(25)
Student	3(50)	2(33)	1(17)

D. Examples of antiparasitic resistance cases

Respondents that stated they had experienced or witnessed antiparasitic drug resistance in horses, cattle, or small ruminants in the United States within the past three years were further asked to provide examples including species/classes, drug or drug class, route of administration, and parasite. No distinction was made between pioneer (brand name) and generic products in this question and these reports should **not** be interpreted as indicative of current prevalence of resistance in the United States. The data provides insight into the experiences of the survey respondents with antiparasitic resistance in the three years prior to completing the survey (November 2012 through November 2015).

Table VII.22. Number (n) and percentage[a] (%) of total reports within a target animal class reporting a parasite resistance relationship in a drug or drug class

Drug or drug class	**Adult Horses n (%)**	**Young horses n (%)**	**Dairy Cattle n (%)**	**Cow-calf n (%)**	**Background /stockers n (%)**	**Feedlot n (%)**	**Sheep n (%)**	**Goats n (%)**
Fenbendazole	22(21)	16(18)	1(5)	3(5)	3(6)	0(0)	39(21)	58(19)
Multiple benzimidazoles	17(16)	11(13)	0(0)	1(2)	2(4)	0(0)	43(23)	60(19)
Oxfendazole	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	2(1)	2(1)
Albendazole	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	5(3)	5(2)
Multiple macrocyclic lactones	3(3)	8(9)	2(11)	11(18)	21(40)	4(31)	39(21)	52(17)
Ivermectin	38(36)	32(37)	4(21)	34(57)	13(25)	9(69)	47(25)	80(26)
Eprinomectin	0(0)	0(0)	5(26)	7(12)	6(11)	0(0)	1(1)	1(0)
Moxidectin	4(4)	3(3)	2(11)	3(5)	2(4)	0(0)	5(3)	21(7)
Doramectin	0(0)	0(0)	3(16)	0(0)	5(9)	0(0)	1(1)	3(1)
Pyrantel	18(17)	15(17)	0(0)	0(0)	1(2)	0(0)	1(1)	7(2)
Morantel	1(1)	0(0)	0(0)	0(0)	0(0)	0(0)	1(1)	6(2)
Levamisole	1(1)	0(0)	0(0)	0(0)	0(0)	0(0)	4(2)	14(4)
Piperazine	0(0)	1(1)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
Other	1(1)	0(0)	1(5)	0(0)	0(0)	0(0)	0(0)	1(0)
Not determined	0(0)	1(1)	1(5)	1(2)	0(0)	0(0)	1(1)	2(1)
Total reports	105	87	19	60	53	13	189	312

[a] The denominator is the total number of reports within each species grouping (horses, cattle, or sheep and goats)

Table VII.23. Number (n) and percentage[a] (%) of total reports within a target animal class reporting a parasite resistance relationship for a particular route of administration

Route of Administration	**Adult Horses n (%)**	**Young horses n (%)**	**Dairy Cattle n (%)**	**Cow-calf n (%)**	**Background /stockers n (%)**	**Feedlot n (%)**	**Sheep n (%)**	**Goats n (%)**
Oral	102(100)	85(99)	3(18)	4(7)	6(12)	1(8)	146(81)	254(84)
Pour-on	0(0)	0(0)	12(71)	42(71)	24(48)	5(42)	5(3)	6(2)
Injection	0(0)	1(1)	2(12)	13(22)	20(40)	6(50)	30(17)	42(14)
Total Reports	102	86	17	59	50	12	181	302

[a] The denominator is the total number of reports within each species grouping (horses, cattle, or sheep and goats)

Table VII.24. Number (n) and percentage[a] (%) of total reports within a target animal class reporting a parasite resistance relationship for certain parasites

Parasite	**Adult Horses n (%)**	**Young horses n (%)**	**Dairy Cattle n (%)**	**Cow-calf n (%)**	**Background /stockers n (%)**	**Feedlot n (%)**	**Sheep n (%)**	**Goats n (%)**
Large strongyles	20(20)	10(12)	1(8)	0(0)	1(2)	0(0)	9(5)	10(3)
Small strongyles (Cyathostomes)	53(54)	25(30)	0(0)	2(4)	0(0)	0(0)	3(2)	3(1)
Parascaris equorum	4(4)	46(55)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
Oxyuris equi	7(7)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
Strongyloides	2(2)	1(1)	0(0)	1(2)	2(4)	0(0)	2(1)	3(1)
Ostertagia	0(0)	0(0)	4(31)	20(35)	7(14)	4(33)	0(0)	1(0)
Nematodirus	0(0)	0(0)	2(15)	3(5)	0(0)	0(0)	4(2)	5(2)
Cooperia	0(0)	0(0)	3(23)	10(18)	23(45)	6(50)	0(0)	1(0)
Haemonchus	0(0)	0(0)	1(8)	7(12)	12(24)	1(8)	143(81)	247(84)
Teladorsagia	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	2(1)
Trichostrongylus	1(1)	0(0)	0(0)	2(4)	0(0)	0(0)	5(3)	4(1)
Bunostomum	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
Ascaris	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
Oesophagostomum	0(0)	0(0)	0(0)	0(0)	1(2)	0(0)	0(0)	0(0)
Hyostrongylus	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
Trichuris	1(1)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	1(0)
Whipworms	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
Other	2(2)	0(0)	2(15)	1(2)	0(0)	0(0)	0(0)	3(1)
Not determined	8(8)	2(2)	0(0)	11(19)	5(10)	1(8)	10(6)	13(4)
Total Reports	98	84	13	57	51	12	176	293

[a] The denominator is the total number of reports within each species grouping (horses, cattle, or sheep and goats)

E. Discussion

Our survey found that, in general, while respondents currently are aware of or experiencing a low to moderate level of antiparasitic resistance in some species and classes, they also perceived a higher risk for the future development or expansion of antiparasitic resistance in those same species and classes. The perceived higher awareness of antiparasitic resistance for small ruminants and lower awareness for certain classes of cattle matches reports of antiparasitic resistance in the literature from the past few decades. In the US, the first species for which antiparasitic resistance was documented were sheep in 1957 and 1964 (Conway, 1964; Drudge et al., 1957) and horses in 1965 (Nielsen et al., 2014a). Antiparasitic resistance in goats in the US was first reported in 1988 (Mortensen et al., 2003). Reports of antiparasitic resistance in both small ruminants and horses continue to appear in the scientific literature with relatively high frequency. There are relatively few FDA-approved antiparasitic drugs for sheep and goats (FDA, 2018) compared to horses and cattle, and several published reports document resistance to these approved drugs on a high number of sheep and goat farms in the US (Crook et al., 2016; Mortensen et al., 2003; Torres-Acosta et al., 2012). In contrast to small ruminants and horses, reports of antiparasitic resistance in beef cattle have only appeared in the scientific literature with increasing regularity within the past ten years (Gasbarre, 2014). Particularly concerning are reports of the potential emergence of resistance of *Ostertagia ostertagi*, a parasite of clinical significance in cattle (Edmonds et al., 2010; Maday, 2017).

It is possible that the number of reports of resistance in scientific literature impacts a veterinarian's awareness of the problem, either through direct reading of the literature or the literature's impact on continuing education conference programming and veterinary school curricula. It is also possible that such reports may have minimal impact on a veterinarian's awareness of and concern about resistance until it begins to have a clinical impact on clients' animals. Antiparasitic resistance may not be evident clinically in the early stages of development and may remain unrecognized unless veterinarians are using available monitoring tools, such as the FECRT, to monitor treatment effectiveness over time.

For certain classes of cattle, particularly dairy, feedlot, and background/stocker cattle, relatively high percentages of private practitioners in our survey indicated they did not have sufficient experience or knowledge to evaluate the prevalence or risk for development of antiparasitic resistance, or they did not know if resistance was present in these classes.

Veterinary parasitologists have assessed the potential for development of resistance under different management systems in cattle (Gasbarre, 2014). Confined dairy cattle are considered to be at low risk for developing antiparasitic resistance because these animals are not frequently treated with antiparasitic drugs and, unless on pasture, they have minimal exposure to infective larvae (Gasbarre, 2014). Similarly for feedlot cattle, the dry lot environment is not conducive for eggs of most parasite species to develop into infective larvae and all animals are eventually slaughtered; therefore, resistant parasites don't survive to infect other animals (Gasbarre, 2014). Conversely, background/stocker cattle, particularly those raised in intensive grazing conditions, may be at high risk for developing antiparasitic resistance for several reasons. First, many producers focus more on potential short-term weight gain benefits due to control of parasites rather than on long-term parasite management. Second, producers often purchase and comingle these cattle from different geographical locations and they may have unrecognized parasitic infections. Producers may unknowingly bring resistant parasites onto their farm in these cattle. And third, producers often find it difficult to implement many of the recommended parasite management strategies because they may be time or labor intensive (e.g., pasture management) or lead to added short-term expenses (e.g., monitoring FECs to selectively treat animals with high counts) (Gasbarre, 2014).

VIII. SECTION 3: ANTIPARASITIC TREATMENT DECISIONS

All questions summarized in Section 3 were divided into sets of species-specific questions; respondents chose to answer one or more series of questions (cattle, horses, and/or small ruminants) depending on their experience. Therefore, a different number of people answered the questions for each species grouping. The questions were generally the same for each species grouping; however, a few questions and answers were modified due to species-specific considerations. See the full survey in Attachment A.

A. Client involvement in treatment and control decisions

Respondents were asked to categorize the percentage of their clients that involve them in decisions about treatment and control into one of four categories: less than 25%, 25% to less than 50%, 50% to less than 75%, or 75% or more. A choice of "this question does not apply to me" was given for those respondents that may not deal directly with clients. Tables VIII.1, VIII.2, and VIII.3 provide

the results by species for all respondents and for categories of credential type and employment type (private practice only). Figure VIII.1 provides the results across all species for respondents identifying their employment type as private practice.

Among all respondents, 17% (26/154) of those answering the small ruminant specific question estimated that over three-fourths of their clients involved them in decisions about parasite treatment and control (Table VIII.3). By comparison, 23% (17/75) of respondents answering the horse specific question (Table VIII.2) and 30% (39/132) of respondents answering the cattle specific question (Table VIII.1) reported that over three-fourths of their clients involved them in these decisions. Similar results were noted by private practitioner respondents (Figure VIII.1).

Table VIII.1. Respondents answering the cattle specific question that reported various percentages of clients that involve their veterinarians in antiparasitic use decisions (presented as number (n) and percentage (%) of respondents)

Respondent characteristics (n)	**<25% n (%)**	**25% to <50% n (%)**	**50% to <75% n (%)**	**≥75% n (%)**
Across all respondents (n=132)	26(20)	29(22)	28(21)	39(30)
Credential Type-DVM	22(18)	27(22)	27(22)	39(32)
Credential Type-DVM and MS/PhD or MS/PhD in Veterinary Parasitology	4(44)	1(11)	1(11)	0(0)
Employment type Private practice	14(15)	24(26)	22(23)	33(35)

Table VIII.2. Respondents answering the horse specific question that reported various percentages of clients that involve their veterinarians in antiparasitic use decisions (presented as number (n) and percentage (%) of respondents)

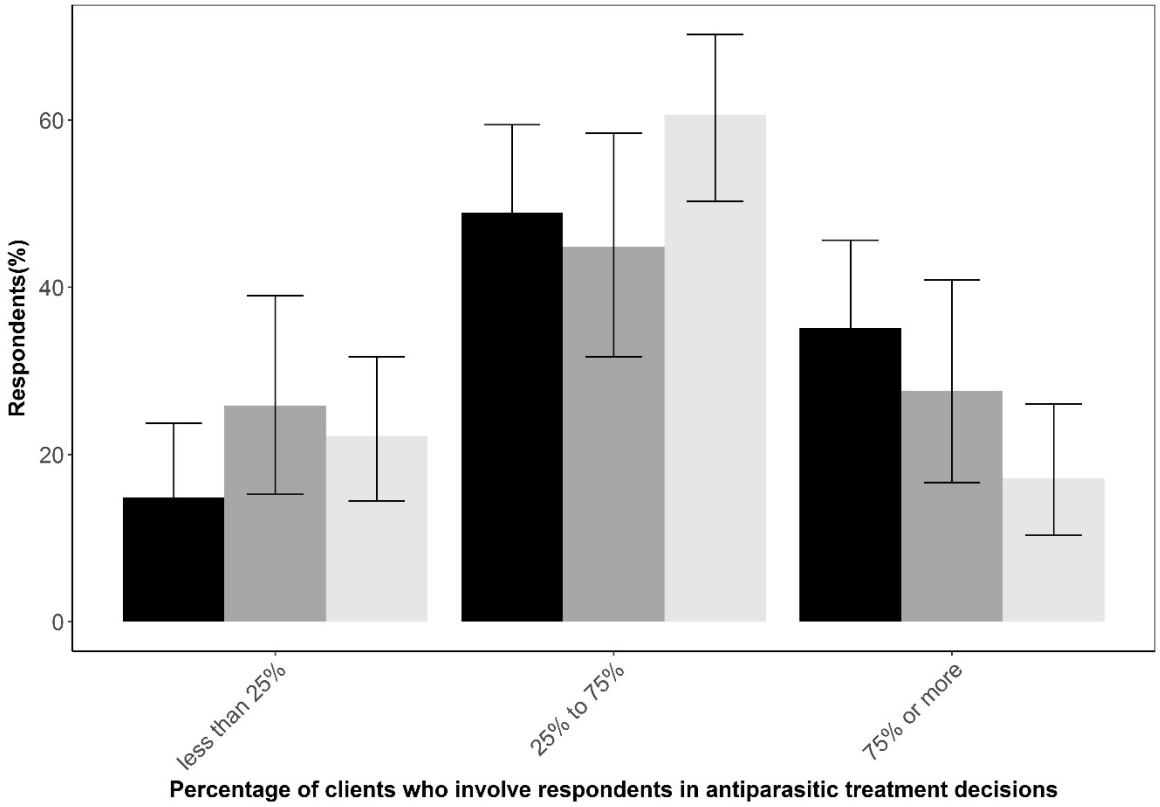
Respondent characteristics (n)	**<25% n (%)**	**25% to <50% n (%)**	**50% to <75% n (%)**	**≥75% n (%)**
Across all respondents (n=75)	19(25)	16(21)	13(17)	17(23)
Credential Type-DVM	19(28)	14(21)	13(19)	16(24)
Credential Type-DVM and MS/PhD or MS/PhD in Veterinary Parasitology	0(0)	1(17)	0(0)	1(17)
Employment type: Private practice	*15(26)*	*15(26)*	*11(19)*	*16(28)*

Table VIII.3. Respondents answering the small ruminant specific question that reported various percentages of clients that involve their veterinarians in antiparasitic use decisions (presented as number (n) and percentage (%) of respondents)

Respondent characteristics (n)	**<25% n (%)**	**25% to <50% n (%)**	**50% to <75% n (%)**	**≥75% n (%)**
Across all respondents (n=154)	35(23)	42(27)	37(24)	26(17)
Credential Type-DVM	30(22)	39(29)	35(26)	24(18)
Credential Type-DVM and MS/PhD or MS/PhD in Veterinary Parasitology	3(23)	2(15)	2(15)	2(15)
Employment type: "Private practice"	22(22)	31(31)	29(29)	17(17)

Figure VIII.1: Estimates of the percentage of clients who involved private practitioner respondents in decisions about parasite treatment and control.

Results are presented as the percentage of respondents with cattle experience (black bars); horse experience (dark gray bars); and small ruminant experience (light gray bars); 95% confidence intervals are represented by error bars. Client involvement is divided into three categories: less than 25%, 25% to less than 75%, and 75% or more.



Discussion:

Although antiparasitic resistance is more widespread in small ruminants than in other grazing species (Crook et al., 2016; Kaplan and Vidyashankar, 2012), the percentage of respondents with small ruminant experience who reported that three-fourths or more of their clients involve them in decisions about parasite treatment and control was very low (17%). This is consistent with information from the National Animal Health Monitoring System (NAHMS) Goat 2009 (USDA, 2011) and Sheep 2011 studies which reported only 38% of goat operations and 45% of sheep operations had involved a veterinarian in parasite treatment decisions. Producers may not involve veterinarians due to cost, lack of access to veterinarians with small ruminant expertise (Burns, 2017), or because there are other sources of information on parasite management and antiparasitic resistance, such as educational materials from the American Consortium for Small Ruminant Parasite Control (ACSRPC).

B. How respondents determine which antiparasitic drug to use or recommend

Respondents were asked to select *up to three* of the following sources they most commonly used to gain information about which antiparasitic drug to recommend to their clients: 1) information from veterinary continuing education (CE) conferences; 2) marketing and promotional materials for antiparasitic drugs; 3) product labeling indications to determine if the drug is expected to work for the parasites needing to treat; 4) experience of other veterinarians in the respondents' practice or institution; 5) use what the respondent previously used for the animal(s) unless the animal owner gives information to suggest that the drug is not working anymore; 6) peer-reviewed scientific journal articles; and 7) test the drug in the animal population and determine its effectiveness based on a fecal egg count.

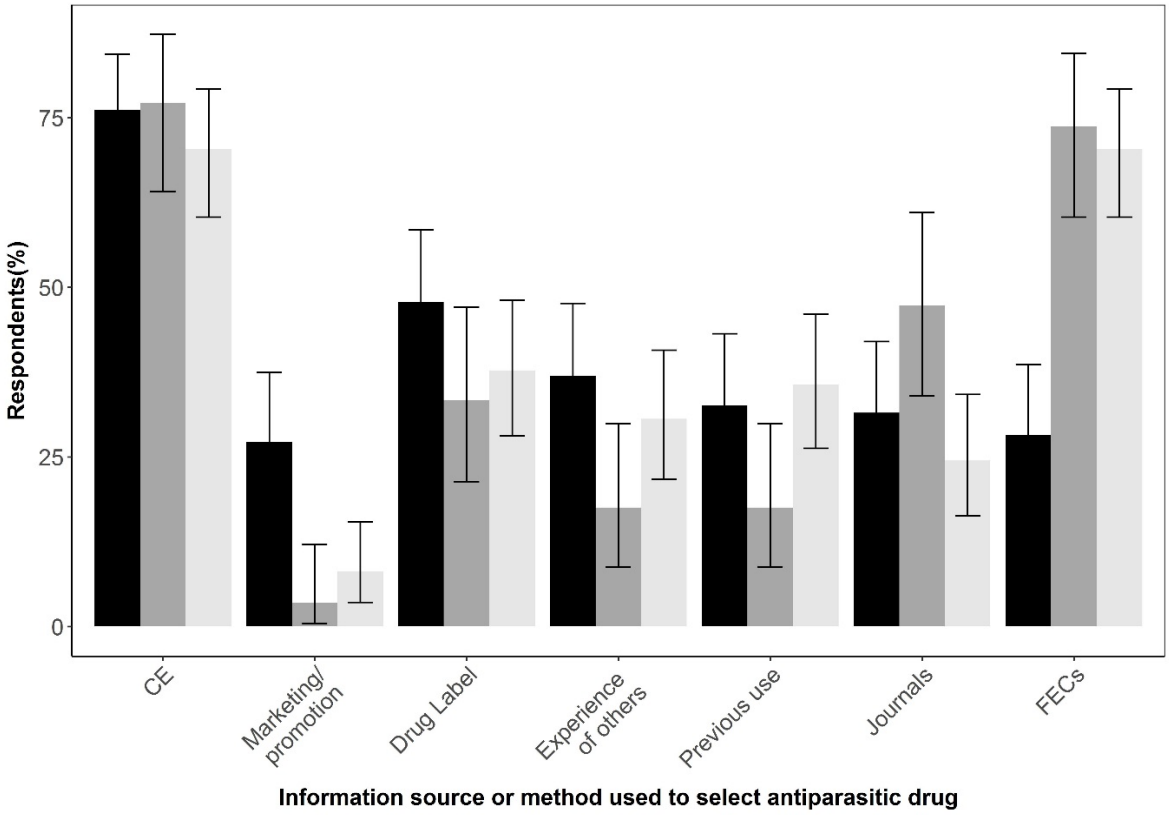
For ease of interpretation, results are shown in Table VIII.4. and Figure VIII.2. using the number of respondents, rather than the number of responses, as the denominator. The results account for the fact that respondents could choose one, two, or three answers to the question. Respondents were not asked to order their responses if they selected more than one answer.

Around 70% of all respondents within each species selected veterinary continuing education conferences as a preferred source of information (Table VIII.4.). A similar percentage (around 72 to 73%) of respondents answering small ruminant or horse specific questions also selected testing the drug in an animal population and then determining its effectiveness based on a FEC evaluation. By contrast, 37% (48/130) of all respondents answering the cattle specific question chose the use of a FEC. The percentage of respondents who selected marketing and promotional materials was lowest for those answering small ruminant or horse specific questions (7% [11/152] and 4% [3/75], respectively). Results among respondents identifying their employment type as private practice are also provided in Table VIII.4 and Figure VIII.2.

Table VIII.4. Sources of information used to determine which antiparasitic drug to use or recommend (presented as number (n) and percentage (%) of respondents that answered the series of questions specific to the species)

Category of respondent (n)	CE n (%)	Promo n (%)	Label n (%)	Other vets n (%)	Prev used n (%)	Journals n (%)	FEC n (%)
Cattle (n=130)	92(71)	30(23)	54(42)	44(34)	34(26)	51(39)	48(37)
Horses (n=75)	54(72)	3(4)	21(28)	16(21)	11(15)	36(48)	55(73)
Small Ruminants (n=152)	106(70)	11(7)	50(33)	42(28)	44(29)	56(37)	109(72)
Within Private practice: Cattle (n=92)	70(76)	25(27)	44(48)	34(37)	30(33)	29(32)	26(28)
Within Private practice: Horses (n=57)	44(77)	2(4)	19(33)	10(18)	10(18)	27(47)	42(74)
Within Private practice: Small Ruminants (n=98)	69(70)	8(8)	37(38)	30(31)	35(36)	24(24)	69(70)

Figure VIII.2. Sources of information or methods used by private practitioner respondents to determine which antiparasitic drug to use or recommend. Respondents selected up three choices. Results are presented as the percentage of respondents answering the cattle specific question (black bars); the horse specific question (dark gray bars); and the small ruminant specific question (light gray bars); 95% confidence intervals are represented by error bars.



Discussion:

The results of our survey suggest that the US veterinary community relies on information from continuing education conferences and, for small ruminant and horse practitioners, FEC testing more than the product labeling indications to determine which antiparasitic drug to use or recommend. This reliance on continuing education highlights the importance of including timely, practical programs related to antiparasitic resistance in veterinary conferences and the potential for these programs to influence treatment decisions of veterinarians.

However, the importance of drug labeling should not be minimized. The labeling for an FDA-approved antiparasitic drug lists the genus, and in most cases the species, of parasite(s) against which the drug has been demonstrated to be effective. It is critical that veterinarians and producers know what parasites are infecting their animals in order to select the most appropriate antiparasitic drug. Standard fecal analysis procedures cannot usually distinguish between the eggs of certain nematode species (e.g., trichostrongyles in cattle); therefore, other tests such as coproculture are necessary to identify the species present. In the future, polymerase chain reaction methods may become more widely available to identify parasite species more quickly and with greater specificity and sensitivity (Drag et al., 2016; Gasbarre et al., 2015; Harmon et al., 2007; Höglund et al., 2013).

The drug labeling also provides other information to enable the end user to safely and effectively use the product, including instructions for dosing and administering the drug; warnings related to drug residues in food products derived from treated animals; precautions, warnings, and contraindications pertaining to safety and effectiveness; user safety warnings; and in some cases, pharmacokinetic information.

C. Methods used by respondents to determine if an antiparasitic drug is effective

Respondents were asked to select *up to three* methods they used or recommended most often to determine the effectiveness of an antiparasitic drug. Options included: 1) if there is no evidence of parasitism after treatment, conclude that the drug was effective; 2) rely on the opinion of the farmer/producer/animal owner regarding the effectiveness of the antiparasitic drug; 3) conduct a fecal analysis after treatment (without a FEC); 4) evaluate FECs pre- OR post-treatment; 5) evaluate FECs pre- AND post-treatment (e.g., FECRT); 6) base the determination on resolution of clinical signs of parasitism if present at the time of treatment; and 7) use production data (e.g., milk production, weight gains, reproductive parameters, etc.). Choice #7 pertained only to cattle and small ruminants.

For ease of interpretation, results are shown using the number of respondents, rather than the number of responses, as the denominator. The results account for the fact that respondents could choose one, two, or three answers to the question. Respondents were not asked to order their responses if they selected more than one answer.

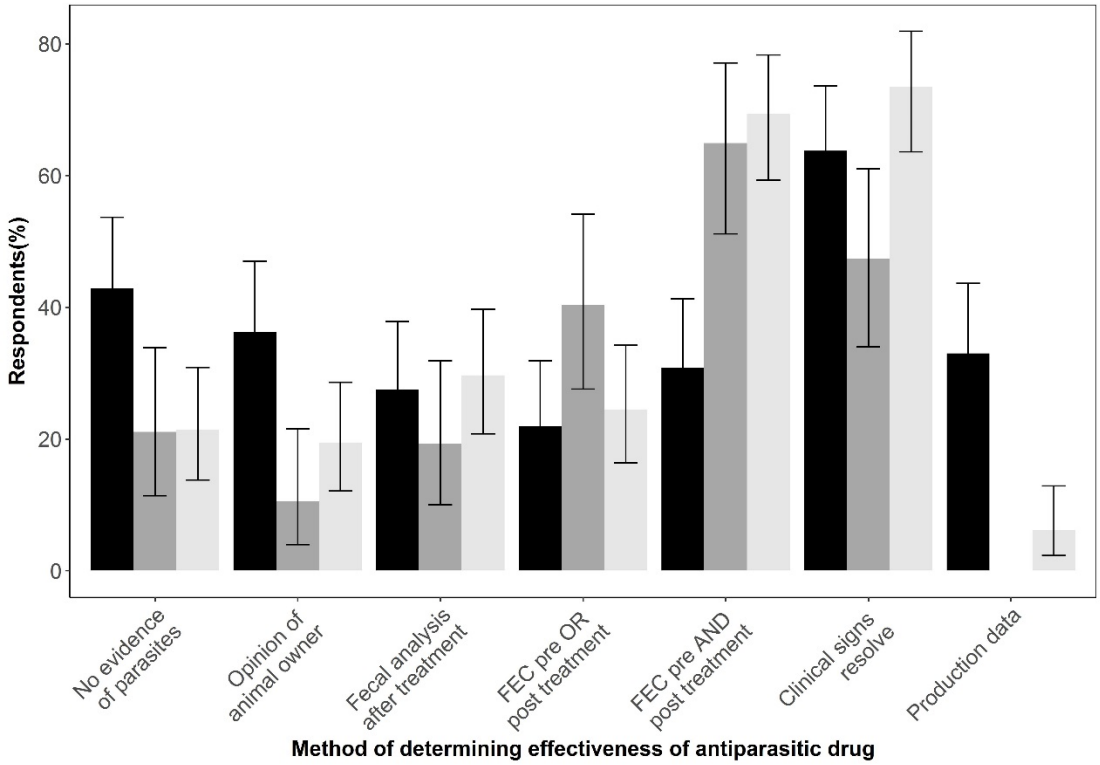
Respondents answering the horse specific question most commonly selected the FECRT (71% [53/75]) while respondents answering the cattle specific question most commonly selected resolution of clinical signs (57% [74/129]). A similar

number of respondents answering the small ruminant specific question selected the FECRT and resolution of clinical signs (74% [112/151] and 72% [109/151]). Compared to other respondents, fewer respondents with cattle experience chose the FECRT (43% [55/129]). More respondents answering the cattle specific question reported that they used production data than respondents answering the small ruminant specific question (36% versus 5%). Results among respondents identifying their employment type as private practice are provided in Table VIII.5 and Figure VIII.3.

Table VIII.5. Methods used to determine if an antiparasitic drug is effective (presented as number (n) and percentage (%) of respondents that answered the series of questions specific to the species)

Category of respondent (n)	**No evid n (%)**	**Opinion owner n (%)**	**Fecal analy n (%)**	**FEC pre or post n (%)**	**FEC pre and post (FECRT) n (%)**	**Res. CS n (%)**	**Prod. Data n (%)**
Cattle (n=129)	48(37)	42(33)	30(23)	30(23)	55(43)	74(57)	46(36)
Horses (n=75)	14(19)	8(11)	12(16)	24(32)	53(71)	33(44)	N/A
Small Ruminants (n=151)	32(21)	26(17)	37(25)	38(25)	112(74)	109(72)	8(5)
Within Private practice: Cattle (n=91)	39(43)	33(36)	25(27)	20(22)	28(31)	58(64)	30(33)
Within Private practice: Horses (n=57)	12(21)	6(11)	11(19)	23(40)	37(65)	27(47)	N/A
Within Private practice: Small Ruminants (n=98)	21(21)	19(19)	29(30)	24(24)	68(69)	72(73)	6(6)

Figure VIII.3. Methods used or recommended by private practitioner respondents to determine the effectiveness of an antiparasitic drug. Results are presented as the percentage of respondents answering the cattle specific question (black bars); the horse specific question (dark gray bars); and the small ruminant specific question (light gray bars); 95% confidence intervals are represented by error bars.



D. Initial recommendations in response to determination that an antiparasitic drug is not effective

Respondents were asked to indicate their *top two* initial recommendations (ranked as first and second choices) for an animal owner for situations in which an antiparasitic drug was ineffective. The options included: 1) recommend animal management changes; 2) recommend pasture management changes; 3) change to a selective treatment program in which treatments are given based on FECs; 4) start or continue fecal analysis as needed; 5) recommend treatment with another antiparasitic drug; 6) other (respondents were asked to specify). The survey gave species-specific examples of animal and pasture management strategies to help respondents better interpret the relevant questions. Choice #3 pertained to horses only. Choice #4 did not refer to a specific fecal test but rather any qualitative or quantitative evaluation of the feces. For ease of interpretation, results are shown using the number of respondents, rather than the number of responses, as the denominator. The results account for the fact that respondents could choose one or two answers to the question.

Fifty-six percent of respondents answering the cattle specific question selected treatment with another antiparasitic drug as their first choice in response to an ineffective drug. Forty-four percent of respondents answering the horse specific

question selected a change to a selective treatment program as their first choice; when responses for first and second choices were combined, 60% and 58% of respondents answering the horse specific question selected a change to a selective treatment program or the use of another antiparasitic drug. Among respondents answering the small ruminant specific question, 64% (94/148) and 52% (77/148), respectively, selected animal management changes, such as culling animals, quarantining animals on arrival, and implementing the use of FAMACHA©; or treatment with another antiparasitic drug as their first or second choice. A recommendation for pasture management changes was selected by 55% (69/125), 40% (29/72), and 56% (83/148) of respondents answering the cattle, horse, and small ruminant specific questions, respectively, as their first or second choice.

Results among respondents identifying their employment type as private practice are provided in Tables VIII.6., VIII.7, and VIII.8., but only provide results that reflect responses chosen as either a first or second choice. Table VIII.9 provides more detailed results from the private practitioner respondents which show the priority placed on each choice for each species.

Table VIII.6. Respondents answering the cattle specific question that selected an answer as the first or second choice (presented as number (n) and percentage (%) of respondents)

Response Type	Animal Management Changes n (%)	Pasture Management Changes n (%)	Start or continue fecal analysis n (%)	Treatment with another antiparasitic drug n (%)
First or second choice (n=125)	22(18)	69(55)	52(42)	91(73)
First choice	5(4)	19(15)	29(23)	70(56)
Second choice	17(14)	50(40)	23(18)	21(17)
First or second choice within respondents that identified current employment type as private practice (n=89)	17(19)	48(54)	32(36)	69(78)

Table VIII.7. Respondents answering the horse specific question that selected an answer as the first or second choice (presented as number (n) and percentage (%) of respondents)

Response Type	Animal Management Changes n (%)	Pasture Management Changes n (%)	Change to selective treatment program n (%)	Start or continue fecal analysis n (%)	Treatment with another antiparasitic drug n (%)
First or second choice (n=72)	12(17)	29(40)	43(60)	13(18)	42(58)
First choice	1(1)	10(14)	32(44)	5(7)	24(33)
Second choice	11(15)	19(26)	11(15)	8(11)	18(25)
First or second choice within respondents that identified current employment type as private practice (n=55)	7(13)	21(38)	35(64)	10(18)	33(60)

Table VIII.8. Respondents answering the small ruminant specific question that selected an answer as the first or second choice (presented as number (n) and percentage (%) of respondents)

Response Type	Animal Management Changes n (%)	Pasture Management Changes n (%)	Start or continue fecal analysis n (%)	Treatment with another antiparasitic drug n (%)
First or second choice (n=148)	94(64)	83(56)	37(25)	77(52)
First choice	48(32)	33(22)	17(11)	50(34)
Second choice	46(31)	50(34)	20(14)	27(18)
First or second choice within respondents that identified current employment type as private practice (n=96)	58(60)	54(56)	21(22)	57(59)

Table VIII.9. Initial recommendations by private practitioner respondents when an antiparasitic drug was determined to be ineffective. The table presents the number of respondents (n), the percentage (%) of respondents, and the 95% confidence interval for this percentage of respondents reporting each recommendation as their first or second choice

Category of respondent (n)	Animal Management Changes n % (95% CI)	Pasture Management Changes n % (95% CI)	Selective treatment (horse-only) n % (95% CI)	Start or continue fecal analysis n % (95% CI)	Treatment with another drug n % (95% CI)
Cattle (first choice) n=89	5 6(2-13)	9 10(5-18)	N/A	16 18(11-28)	58 65(54-75)
Cattle (second choice) n=89	12 13(7-22)	39 44(33-55)	N/A	16 18(11-28)	11 12(6-21)
Horse (first choice) n=55	1 2(0-10)	8 15(6-27)	26 47(34-61)	2 4(0-13)	18 33(21-47)
Horse (second choice) n=55	6 11(4-22)	13 24(13-37)	9 16(8-29)	8 15(6-27)	15 27(16-41)
Small Ruminant (first choice) n=96	31 32(23-43)	18 19(12-28)	N/A	7 7(3-14)	40 42(32-52)
Small Ruminant (second choice) n=96	27 28(19-38)	36 38(28-48)	N/A	14 15(8-23)	17 18(11-27)

Discussion:

A higher percentage of respondents answering the small ruminant specific question selected they would recommend animal management changes in response to an ineffective antiparasitic drug compared to respondents answering the cattle or horse specific questions. Resistance to multiple antiparasitic drugs and even total drug failure in which no antiparasitic drug was effective have been reported in small ruminants in the US (Crook et al., 2016), thereby necessitating the use of animal management strategies to control parasites. Animal management strategies, such as selecting and breeding parasite-resistant animals, using FAMACHA© scores to determine which animals to treat, using appropriate quarantine procedures, and housing animals on dry lots, are suggested strategies to address the lack of effectiveness of antiparasitic drugs and to minimize the risk of resistance (Kearney et al., 2016; Zvinorova et al., 2016). These strategies reduce reliance on antiparasitic drugs and/or help to preserve refugia on the farm.

In situations where an antiparasitic drug was ineffective, 60% of all respondents answering the horse specific question chose (as their first or second choice) a change to a selective treatment program in which treatments are given based on FECs. This response likely reflects the availability of educational outreach programs and guidelines about parasite control in horses from AAEP, university extension agents, and veterinary parasitologists that recommend focusing treatment on the horses shedding the most strongyle eggs. However, this finding should be interpreted with caution because of the low overall response rate for the horse specific questions.

Although equine veterinarians may recommend FEC testing, clients may be slow to change their parasite control practices as a result of such recommendations. In a 2013 survey of members of the Kentucky Thoroughbred Farm Managers' Club, 70% of respondents consulted a veterinarian to develop their deworming program and 81% were aware of antiparasitic resistance in horses, but 68% still reported using only rotational deworming without any FEC testing (Robert et al., 2015). The NAHMS Equine 2015 study found that equine operations whose veterinarians recommended FECs used this test more than equine operations whose veterinarians did not recommend FECs. However, overall, only about 22% of equine operations used FECs and less than 10% reported that they based their deworming practices on the results of FEC testing (Nielsen et al., 2018). Similar results were reported among US respondents in a multinational survey of horse owners (Becher et al., 2018).

Finally, FDA encourages veterinarians, animal producers, and animal owners to report adverse drug experiences, which can include side effects or other problems, such as the drug appears ineffective. Instructions for reporting adverse drug experiences are available on the FDA website: www.fda.gov/reportanimalae.

E. Number of treatments recommended per year for routine deworming

1. Cattle: Respondents answering the cattle specific question were asked to choose one of the following four options for cattle less than 18 months of age and cattle 18 months of age or older: 1) less than one treatment per year, 2) one treatment per year, 3) more than one treatment per year, or 4) not

applicable, treatment depends on fecal egg count or other individualized treatment plan.

Over half (62%) of all respondents answering the cattle specific question routinely dewormed cattle less than 18 months of age more than once per year (Table VIII.10). Approximately half of all respondents (48%) treated cattle 18 months of age or older once per year, and 27% of all respondents treated cattle 18 months of age or older more than once per year (Table VIII.11). Trends were similar within the results for respondents reporting their employment type as private practice.

Table VIII.10. Number of treatments recommended for cattle less than 18 months of age (presented as number (n) and percentage (%) of respondents that answered the cattle specific question)

Respondent characteristics	**<1 per year n (%)**	**1 per year n (%)**	**>1 per year n (%)**	**N/A n (%)**
Overall (n=123)	2(2)	29(24)	76(62)	16(13)
Respondents employed in private practice (n=88)	1(1)	24(27)	57(65)	6(7)

Table VIII.11. Number of treatments recommended for cattle 18 months of age or older (presented as number (n) and percentage (%) of respondents that answered the cattle specific question)

Respondent characteristics	**<1 per year n (%)**	**1 per year n (%)**	**>1 per year n (%)**	**N/A n (%)**
Overall (n=123)	12(10)	59(48)	33(27)	19(15)
Respondents employed in private practice (n=88)	7(8)	44(50)	26(30)	11(13)

2. Horses: Respondents answering the horse specific question were asked to choose one of the following five options for horses less than three years of age and horses three years of age and older: a) one to two treatments per year; b) three to four treatments per year; c) five to six treatments per year; d) seven or more treatments per year; or e) not applicable/treatment depends on fecal egg count or other individualized treatment plan.

   Forty-six percent of all respondents dewormed horses less than three years of age three to four times per year (Table VIII.12). Almost the same percentage (45%) of all respondents reported that they dewormed horses three years of age or older one to two times per year (Table VIII.13). Approximately 20% and 40% of respondents used individualized treatment plans to determine the number of deworming treatments per year for horses younger than three years of age and horses three years of age or older, respectively. Trends were similar within the results for respondents reporting their employment type as private practice.

Table VIII.12. Number of treatments recommended for horses less than three years of age (presented as number (n) and percentage (%) of respondents that answered the horse specific question)

Respondent characteristics	1-2 per year n (%)	3-4 per year n (%)	5-6 per year n (%)	7 + per year n (%)	N/A n (%)
Overall (n=70)	9(13)	32(46)	13(19)	1(1)	15(21)
Respondents employed in private practice (n=54)	7(13)	23(43)	12(22)	0(0)	12(22)

Table VIII.13. Number of treatments recommended for horses three years of age and older (presented as number (n) and percentage (%) of respondents that answered the horse specific question)

Respondent characteristics	1-2 per year n (%)	3-4 per year n (%)	5-6 per year n (%)	7 + per year n (%)	N/A n (%)
Overall (n=70)	31(45)	8(12)	2(3)	1(1)	27(39)
Respondents employed in private practice (n=53)	22(42)	7(13)	1(2)	1(2)	22(42)

3. Small Ruminants: Respondents answering the small ruminant specific question were asked to choose one of the following five options for small ruminants less than one year of age and small ruminants one year of age and older: a) less than one treatment per year; b) one treatment per year; c) two treatments per year; d) three or more treatments per year; or e) not applicable -treatment depends on FEC, FAMACHA©, or other individualized treatment plan.

   Over 60% of all respondents used FEC, FAMACHA©, or other individualized treatment plans to determine the number of deworming treatments to give to small ruminants less than a year of age (Table VIII.14). This percentage rose to over 70% of all respondents for small ruminants one year of age or older (Table VIII.15).

   Table VIII.14. Number of treatments recommended for small ruminants less than one year of age (presented as number (n) and percentage (%) of respondents that answered the small ruminant specific question)

Respondent characteristics	<1 per year n(%)	1 per year n(%)	2 per year n(%)	3+ per year n(%)	N/A n (%)
Overall (n=136)	2(1)	12(9)	16(12)	19(14)	87(64)
Respondents employed in private practice (n=89)	2(2)	6(7)	14(16)	13(15)	54(61)

Table VIII.15. Number of treatments recommended for small ruminants one year of age and older (presented as number (n) and percentage (%) of respondents that answered the small ruminant specific question)

Respondent characteristics	<1 per year n (%)	1 per year n (%)	2 per year n (%)	3+ per year n (%)	N/A n (%)
Overall (n=136)	2(1)	12(9)	13(10)	7(5)	102(75)
Respondents employed in private practice (n=89)	2(2)	6(7)	10(11)	5(6)	66(74)

F. Rotational deworming recommendations

1. Cattle: Respondents answering the cattle specific question were if they recommended rotating antiparasitic drugs for routine deworming for cattle less than 18 months of age and cattle 18 months of age or older. Two options were provided: 1) yes, I recommend rotation, or 2) no, I do not recommend rotation.

   Approximately one-third of all respondents, including the private practitioner respondents, recommended rotational deworming, regardless of the age of the cattle.

   Table VIII.16. Rotational deworming recommendations for cattle less than 18 months of age (presented as number (n) and percentage (%) of respondents that answered the cattle specific question)

Respondent characteristics	Yes n (%)	No n (%)
Overall (n=122)	39(32)	83(68)
Respondents employed in private practice (n=87)	27(31)	60(69)

   Table VIII.17. Rotational deworming recommendations for cattle 18 months of age or older (presented as number (n) and percentage (%) of respondents that answered the cattle specific question)

Respondent characteristics	Yes n (%)	No n (%)
Overall (n=119)	43(36)	76(64)
Respondents employed in private practice (n=84)	28(33)	56(67)

2. Horses: Respondents answering the horse specific question were asked how frequently they rotated or recommended that an animal owner rotate antiparasitic drugs for routine deworming for horses less than three years of age and horses three years of age and older. Four options were provided: a) multiple times per year, b) yearly, c) less frequently than yearly, or d) never.

   Around 40% of all respondents (and 45% of private practitioner respondents) recommended rotating antiparasitic drugs multiple times per year for horses less than three years of age, while approximately one third of all respondents never recommended rotating antiparasitic drugs in this age group of horses (Table VIII.18). For horses three years of age and older, 43% of all

respondents (and 40% of private practitioner respondents) never recommended rotating antiparasitic drugs, while nearly one third of respondents still recommended rotating antiparasitic drugs multiple times per year (Table VIII.19).

Table VIII.18. Rotational deworming frequency for horses less than three years of age (presented as number (n) and percentage (%) of respondents that answered the horse specific question)

Respondent characteristics	Multiple times per year n (%)	Yearly n (%)	< yearly n (%)	Never
Overall (n=67)	27(40)	6(9)	12(18)	22(33)
Respondents employed in private practice (n=51)	23(45)	6(12)	9(18)	13(25)

Table VIII.19. Rotational deworming frequency for horses three years of age and older (presented as number (n) and percentage (%) of respondents that answered the horse specific question)

Respondent characteristics	Multiple times per year n (%)	Yearly n (%)	< yearly n (%)	Never
Overall (n=69)	19(28)	5(7)	15(22)	30(43)
Respondents employed in private practice (n=53)	17(32)	3(6)	12(23)	21(40)

3. Small Ruminants: Respondents answering the small ruminant specific question were asked how frequently they rotated or recommended that an animal owner rotate antiparasitic drugs for routine deworming for small ruminants less than one year of age and small ruminants one year of age and older. Four options were provided: a) multiple times per year, b) yearly, c) less frequently than yearly, or d) never.

   Results from all respondents were similar for both age groups. Approximately half of respondents never recommended rotating antiparasitic drugs (see Tables VIII.20 and VIII.21).

   Table VIII.20. Rotational deworming frequency for small ruminants less than one year of age (presented as number (n) and percentage (%) of respondents that answered the small ruminant specific question)

Respondent characteristics	Multiple times per year n (%)	Yearly n (%)	< yearly n (%)	Never
Overall (n=134)	16(12)	13(10)	30(22)	75(56)
Respondents employed in private practice (n=90)	13(14)	9(10)	24(27)	44(49)

Table VIII.21. Rotational deworming frequency for small ruminants one year of age and older (presented as number (n) and percentage (%) of respondents that answered the small ruminant specific question)

Respondent characteristics	Multiple times per year n (%)	Yearly n (%)	< yearly n (%)	Never
All respondents (n=133)	14(11)	14(11)	32(24)	73(55)
Respondents employed in private practice (n=89)	10(11)	11(12)	25(28)	43(48)

G. Concurrent use of antiparasitics

Respondents were asked whether they used or recommended the use of two or more antiparasitic drugs at the same time in individual animals. If the respondent answered “yes”, they were given the opportunity to list the drugs that they used together.

Thirty-four percent of all respondents answering the horse specific question, 40% of respondents answering the cattle specific question, and 49% of respondents answering the small ruminant specific question reported using two or more antiparasitic drugs at the same time. Note that for horses, almost half of the written responses included two active ingredients that are currently available in FDA-approved, fixed combination products (see Appendix A). In these products (a macrocyclic lactone in combination with praziquantel), the two active ingredients do not have highly overlapping spectra of activity.

Table VIII.22. Percent of respondents answering the cattle specific question that use two or more antiparasitic drugs at the same time (presented as number (n) and percentage (%) of respondents)

Respondent category	Yes n (%)	No n (%)
All respondents (n=123)	49(40)	74(60)
Respondents employed in private practice (n=87)	28(32)	59(68)

Table VIII.23. Percent of respondents answering the horse specific question that use two or more antiparasitic drugs at the same time (presented as number (n) and percentage (%) of respondents)

Respondent category	Yes n (%)	No n (%)
All respondents (n=71)	24(34)	47(66)
Respondents employed in private practice (n=55)	19(35)	36(65)

Table VIII.24. Percent of respondents answering the small ruminant specific question that use two or more antiparasitic drugs at the same time (presented as number (n) and percentage (%) of respondents)

Respondent category	Yes n (%)	No n (%)
All respondents (n=144)	70(49)	74(51)
Respondents employed in private practice (n=94)	41(44)	53(56)

Examples of concurrently used antiparasitic drugs provided by respondents are provided in Appendix A of this report.

Discussion:

Many experts cite the use of antiparasitic drug combinations that contain two or more active ingredients with highly overlapping spectrums of activity as an effective method of slowing or preventing antiparasitic resistance in nematodes (Bartram et al., 2012; Canton et al., 2017; Geary et al., 2012; Leathwick, 2013; Leathwick and Besier, 2014; Leathwick et al., 2015; Leathwick et al., 2017; Leathwick et al., 2012). Antiparasitic drug combinations include fixed combinations (the active ingredients are combined into a single formulation) or antiparasitic drugs used concurrently. Decisions about which drugs to use should be based on the compatible and complementary characteristics of each drug product (Bartram et al., 2012; Geary et al., 2012). Veterinary parasitologists generally agree that the use of combinations is less effective if antiparasitic drugs are inappropriately combined or used in the absence of an appropriate overall parasite control program (Geary et al., 2012; Leathwick and Besier, 2014). In fact, the use of antiparasitic drug combinations without adequate refugia may select for antiparasitic resistance to several drugs at the same time (Geary et al., 2012; Leathwick and Besier, 2014).

There are currently no FDA-approved antiparasitic drug combinations containing active ingredients with highly overlapping spectrums of activity against nematodes available for cattle, small ruminants, or horses in the US. If drug companies pursued and obtained FDA-approval of antiparasitic drug combinations in the US, veterinarians would have access to quality fixed combination drug products with established safety and effectiveness profiles and withdrawal times.

IX. SECTION 4: DETECTION AND MANAGEMENT OF RESISTANCE

All questions in Section 4 were divided into sets of species-specific questions; respondents chose to answer each series of questions (cattle, horses, and/or small ruminants) depending on their experience. Therefore, a different number of people answered the questions for each species.

A. Fecal examination procedures

Respondents were asked if they perform or recommend fecal examination procedures to detect and/or quantify parasite eggs.

Seventy-six percent of respondents answering the cattle specific question, 93% of respondents answering the horse specific question, and 99% of respondents answering the small ruminant specific question reported performing or recommending fecal examination procedures.

Table IX.1. Respondents answering the cattle specific question that perform or recommend fecal examination procedures in cattle (presented as number (n) and percentage (%) of respondents)

Respondent category	Yes n (%)	No n (%)
All respondents (n=138)	105(76)	33(24)
Respondents employed in private practice (n=91)	68(75)	23(25)

Table IX.2. Respondents answering the horse specific question that perform or recommend fecal examination procedures in horses (presented as number (n) and percentage (%) of respondents)

Respondent category	Yes n (%)	No n (%)
All respondents (n=74)	69(93)	5(7)
Respondents employed in private practice (n=56)	52(93)	4(7)

Table IX.3. Respondents answering small ruminant questions that perform or recommend fecal examination procedures in small ruminants (presented as number (n) and percentage (%) of respondents)

Respondent category	Yes n (%)	No n (%)
All respondents (n=153)	151(99)	2(1)
Employment type: Private practice (n=97)	96(99)	1(1)

Respondents that answered “yes” to the above question were directed to a series of follow-up questions related to their use of fecal examination procedures.

1. Fecal examination procedure methods

   Respondents provided information about the methodology they used to detect and/or quantify fecal eggs in cattle, horses, and small ruminants, including choices from the following options:

   - Solution: None-direct or saline smear; Zinc sulfate; Sheathers; Modified sheathers; Magnesium sulfate; Saturated salt; Sodium nitrate; Sugar-salt; Other; Unknown; or “Not sure what my lab uses”
   - Method: Direct smear; Saline smear; Simple flotation; Sedimentation; Centrifugation; McMasters; Modified McMasters; Wisconsin; Modified Wisconsin; FLOTAC; Other; Unknown; or “Not sure what my lab uses”

   The THREE most frequently selected responses in the categories of solutions, methods, and solution-method combinations are summarized in Tables IX.4. (respondents that answered the cattle specific question), IX.5. (respondents that answered the horse specific question), and IX.6. (respondents that answered the small ruminant specific question).

Table IX.4. Fecal identification and quantification methods used by respondents who answered the cattle specific question. Results are provided as the number (n) and percentage (%) of responses within each category of solution, method, or solution-method combinations.

Respondent category	Soln Sugar Sugar salt n (%)	Soln Not sure what my lab uses n (%)	Soln Sheathers n (%)	Method Simple float n (%)	Method Centrif-ugation n (%)	Method Modified Wisconsin n (%)	Soln-method Not sure / Not sure n (%)	Soln-method Sugar salt / Centrifugation n (%)	Soln-method Sodium nitrate / Simple flotation n (%)
All*	34(23)	27(18)	16(11)	29(23)	27(22)	23(18)	11(9)	10(8)	9(7)
Employment: Private practitioner	25(27)	16(17)	9(10)	26(33)	21(26)	9(11)	6(8)	10(13)	9(11)

* Solution (n=146); Method (n=125); Solution-method combinations (n=124)

Table IX.5. Fecal identification and quantification methods used by respondents who answered the horse specific question. Results are provided as the number (n) and percentage (%) of responses within each category of solution, method, or solution-method combinations

Respondent category	Soln Not sure what my lab uses n (%)	Soln Sugar salt n (%)	Soln Sodium nitrate n (%)	Method McMasters n (%)	Method Centrif-ugation n (%)	Method Modified McMasters n (%)	Soln-method Not sure / McMasters n (%)	Soln-method Not Sure / Not Sure n (%)	Soln-method Sodium nitrate / Simple flotation n (%)
All*	24(25)	16(17)	15(16)	20(22)	19(21)	16(17)	6(7)	6(7)	6(7)
Employment: Private practitioner	19(28)	7(10)	14(21)	15(23)	15(23)	9(14)	3(5)	6(9)	6(9)

* Solution (n=96); Method (n=92); Solution-method combinations (n=91)

Table IX.6. Fecal identification and quantification methods used by respondents who answered the small ruminant specific question. Results are provided as the number (n) and percentage (%) of responses within each category of solution, method, or solution-method combinations

Respondent category	Soln Zinc sulfate n (%)	Soln Sheathers n (%)	Soln Sodium nitrate n (%)	Method Centrifugation n (%)	Method Simple flotation n (%)	Method Modified McMasters n (%)	Soln-method Zinc sulfate / simple flotation n (%)	Soln-method Sheathers / Centrifugation n (%)	Soln-method Sugar salt / Centrifugation n (%)
All*	54(21)	37(14)	36(14)	57(23)	47(19)	46(19)	19(8)	15(6)	13(5)
Employment: Private practitioner	43(26)	23(14)	25(15)	45(29)	33(21)	19(12)	15(10)	11(7)	10(6)

* Solution (n=260); Method (n=243); Solution-method combinations (n=243)

2. Use of Larval Cultures

Respondents were asked if they used or recommended larval culture to identify parasite species. Options included a) yes, 2) no, or 3) I am not familiar with the use of larval culture.

Between 62% (respondents answering the horse specific question) and 73% (respondents answering the small ruminant specific question) of all respondents reported not using larval culture to identify parasite species. Respondents with horse experience reported the highest degree of unfamiliarity with the test (32% of all respondents).

Table IX.7. Respondents that answered the cattle specific question who use or recommend larval culture (results are provided as the number (n) and percentage (%) of respondents)

Respondent category	**Yes n (%)**	**No n (%)**	**Unfamiliar n (%)**
Across all respondents (n=103)	17(17)	69(67)	17(17)
Credential Type-DVM	12(13)	64(69)	17(18)
Credential Type-DVM and MS/PhD or MS/PhD in Veterinary Parasitology	5(56)	4(44)	0(0)

Table IX.8. Respondents that answered the horse specific question who use or recommend larval culture (results are provided as the number (n) and percentage (%) of respondents)

Respondent category	**Yes n (%)**	**No n (%)**	**Unfamiliar n (%)**
Across all respondents (n=69)	4(6)	43(62)	22(32)
Credential Type-DVM	1(2)	41(66)	20(32)
Credential Type-DVM and MS/PhD or MS/PhD in Veterinary Parasitology	3(43)	2(29)	2(29)

Table IX.9. Respondents who answered the small ruminant specific question who use or recommend larval culture (results are provided as the number (n) and percentage (%) of respondents)

Respondent category	**Yes n (%)**	**No n (%)**	**Unfamiliar n (%)**
Across all respondents (n=147)	17(12)	107(73)	23(16)
Credential Type-DVM	9(7)	97(75)	23(18)
Credential Type-DVM and MS/PhD or MS/PhD in Veterinary Parasitology	5(38)	8(62)	0(0)

3. Use of FECRT

Respondents were asked if they used or recommended the FECRT to determine treatment efficacy in [cattle, horses, small ruminants] that are treated with an antiparasitic drug. Options included a) yes, 2) no, or 3) I am not familiar with the FECRT. Results were subdivided by credential type, employment type, and between respondents who reported experience with resistance in the survey and those who did not.

The highest percentage of use was reported among all respondents answering the horse and small ruminant specific questions (81% and 86%, respectively). A higher percentage of respondents employed in academia or research reported using or recommending the FECRT than respondents employed in private practice. A higher percentage of respondents that reported experiencing or witnessing resistance in cattle, horses, or small ruminants reported using or recommending the FECRT than respondents who did not report such experience.

Table IX.10. Respondents answering the cattle specific question who use or recommend the FECRT (results are provided as the number (n) and percentage (%) of respondents)

Respondent category	**Yes n (%)**	**No n (%)**	**Unfamiliar n (%)**
Across all respondents (n=103)	62(60)	31(30)	10(10)
Credential Type: DVM	52(56)	31(33)	10(11)
Credential type: DVM and MS/PhD or MS/PhD in Veterinary Parasitology	9(100)	0(0)	0(0)
Employment type: Academia/ Research	17(85)	2(10)	1(5)
Employment type: Industry	8(73)	2(18)	1(9)
Employment type: Private practice	32(48)	26(39)	8(12)
Experience with resistance: Have experienced resistance	49(72)	17(25)	2(3)
Experience with resistance: Have not experienced resistance	9(39)	9(39)	5(22)

Table IX.11. Respondents answering the horse specific question who use or recommend the FECRT (results are provided as the number (n) and percentage (%) of respondents)

Respondent category	Yes n (%)	No n (%)	Unfamiliar n (%)
Across all respondents (n=69)	56(81)	10(14)	3(4)
Credential type			
DVM	51(82)	9(15)	2(3)
DVM and MS/PhD or MS/PhD in Veterinary Parasitology	5(71)	1(14)	1(14)
Employment type: Academia/ Research	9(90)	1(10)	0(0)
Employment type: Industry	5(71)	1(14)	1(14)
Employment type: Private practice	42(81)	8(15)	2(4)
Experience with resistance: Have experienced resistance	46(87)	6(11)	1(2)
Experience with resistance: Have not experienced resistance	7(70)	2(20)	1(10)

Table IX.12. Respondents answering the small ruminant specific question who use or recommend the FECRT (results are provided as the number (n) and percentage (%) of respondents)

Respondent category	Yes n (%)	No n (%)	Unfamiliar n (%)
Across all respondents (n=146)	126(86)	14(10)	6(4)
Credential type			
DVM	108(84)	14(11)	6(5)
DVM and MS/PhD or MS/PhD in Veterinary Parasitology	13(100)	0(0)	0(0)
Employment type: Academia/ Research	36(97)	0(0)	1(3)
Employment type: Industry	2(100)	0(0)	0(0)
Employment type: Private practice	78(83)	13(14)	3(3)
Experience with resistance: Have experienced resistance	108(89)	10(8)	3(2)
Experience with resistance: Have not experienced resistance	12(75)	2(13)	2(13)

Discussion:

The FECRT is considered the current test of choice to evaluate antiparasitic drug effectiveness and diagnose antiparasitic resistance in the field (Kaplan and Vidyashankar, 2012). However, this test has limitations. Only parasites currently laying eggs will contribute to the FEC, some parasites shed more eggs than others, and the counts often poorly correlate to actual parasite burdens. In addition, using a FEC method with less ability to detect low numbers of eggs, testing a low number of animals, or having a low pre-treatment FEC can reduce the reliability of the FECRT (Levecke et al., 2012; Paras et al., 2018). A lack of clarity regarding the proper calculation, analysis, and interpretation of FECRT data has also limited the widespread use of this

test. Guidelines for detecting resistance in sheep using the FECRT were first published in 1992 (Coles et al., 1992). No similar standardized FECRT guidelines are available for other grazing species, and although recommendations are offered (Dobson et al., 2012; George et al., 2017; Levecke et al., 2012; Love et al., 2017; McKenna, 2013; Nielsen et al., 2013), published standardized guidelines are still needed. Even though respondents answering the cattle specific question reported using the FECRT less than respondents with small ruminant or horse experience, the finding that 60% of these respondents reported using or recommending the FECRT is encouraging. A report of the 2007-2008 USDA NAHMS survey of beef cattle operations stated that the majority (85%) of beef producers use a schedule, and only 0.6% use “fecal tests,” as the primary factor to determine when to use antiparasitic drugs (USDA, 2010). It is possible that as bovine veterinarians increasingly recommend and use the FECRT, its use among beef producers may also increase.

4. FECRT methods, including calculations, fecal sampling, and interpretive cut-off

   a) Mathematical calculation

      Respondents were subsequently asked to choose one of the following statements that best represents the method they use or recommend to determine fecal egg count reduction in [cattle, horses, or small ruminants]: 1) FECRT based on a comparison of pre- and post- treatment fecal egg counts of a treated group/ animal; 2) FECRT based on a comparison of post-treatment fecal egg counts of a treated and an untreated-control group/ animal; 3) FECRT includes pre- and post-treatment fecal egg counts from both an untreated- control and treated group/ animal; or 4) Other (please specify).

   b) Sampling

      Respondents were asked whether they used or recommended 1) Composite fecal sample (fecal samples from individual animals mixed together); or 2) Fecal samples from individual animals, to conduct the FECRT.

   c) Interpretive cut-off

      Respondents were asked to pick one of the following FECRT calculation cut-off values they use or recommend to determine if treatment with an antiparasitic drug is effective in [cattle, horses, or small ruminants]: 1) Greater than or equal to 80%; 2) Greater than or equal to 85%; 3) Greater than or equal to 90%; 4) Greater than or equal to 95%; 5) Greater than or equal to a previous FECRT result; or 6) Other (please specify).

Results were similar between species, but particularly between respondents answering the cattle (Table IX.13) and small ruminant specific questions (Table IX.15). Approximately 80% of respondents answering the cattle and small ruminant specific question reported calculating the FECRT based on a comparison of pre- and post- treatment fecal egg counts of a treated group/ animal. Ninety-six percent of respondents with horse experience reported using this calculation. Around three-fourths of respondents answering the cattle and small ruminant questions reported using individual fecal samples;

98% of respondents answering the horse specific question reported using individual fecal samples to conduct the FECRT. Finally, between 44% and 52% of all respondents from each species reported using 90% as the interpretive cut-off to determine if treatment with an antiparasitic drug is effective.

Table IX.13. FECRT methods reported by respondents answering the cattle specific question

Respondent category	Calc: Pre/Post Treated n (%)	Calc: Post Treated vs. Control n (%)	Calc: Pre/Post Treated and Control n (%)	Sampl.: Composite n (%)	Sampl.: Individual n (%)	Interp: ≥80% n (%)	Interp: ≥85% n (%)	Interp: ≥90% n (%)	Interp: ≥95% n (%)	Greater than or equal to previous FECRT
Across all respondents (n= 62 for Calc., and Sampl; 49 for Interp)	50(81)	3(5)	9(15)	14(23)	48(77)	7(11)	3(5)	32(52)	17(27)	0(0)
Employment Type: Private practice	25(78)	2(6)	5(16)	11(34)	21(66)	6(19)	1(3)	16(50)	9(28)	0(0)

Table IX.14. FECRT methods reported by respondents answering the horse specific question

Respondent category	Calc: Pre/Post Treated n (%)	Calc: Post Treated vs. Control n (%)	Calc: Pre/Post Treated and Control n (%)	Sampl.: Composite n (%)	Sampl.: Individual n (%)	Interp: ≥80% n (%)	Interp: ≥85% n (%)	Interp: ≥90% n (%)	Interp: ≥95% n (%)	Greater than or equal to previous FECRT
Across all respondents (n= 56 for Calc. and Sampl, and 46 for Interp.)	54(96)	0(0)	2(4)	1(2)	55(98)	7(13)	1(2)	25(45)	12(21)	1(2)
Employment Type: Private practice	40(95)	0(0)	2(5)	1(2)	41(98)	5(12)	1(2)	21(50)	10(24)	1(2)

Table IX.15. FECRT methods reported by respondents answering the small ruminant specific question

Respondent category	Calc: Pre/Post Treated n (%)	Calc: Post Treated vs. Control n (%)	Calc: Pre/Post Treated and Control n (%)	Sampl.: Composite n (%)	Sampl.: Individual n (%)	Interp: ≥80% n (%)	Interp: ≥85% n (%)	Interp: ≥90% n (%)	Interp: ≥95% n (%)	Greater than or equal to previous FECRT
Across all respondents (n= 124 for Calc.; 126 for Sampl., and 117 for Interp.)	99(80)	2(2)	23(19)	25(20)	101(80)	19(15)	9(7)	55(44)	29(23)	5(4)
Employment Type: Private practice	65(84)	2(3)	10(13)	19(24)	60(76)	18(23)	6(8)	33(43)	17(22)	1(1)

B. Other methods to detect or monitor resistance

Respondents answering the small ruminant specific question were asked if they used tests/methods other than the FECRT, such as the egg hatch test, larval migration, larval development assay, worm counts, molecular based tests, etc. to detect or monitor antiparasitic drug resistance. Options given were 1) yes, or 2) no.

Seventy-six percent of all respondents, and 83% of the respondents employed in private practice reported that they did not use methods other than the FECRT to detect or monitor antiparasitic drug resistance in small ruminants.

Table IX.16. Use of other methods to detect or monitor resistance in small ruminants (presented as number (n) and percentage (%) of respondents)

Respondent category	Yes n (%)	No n (%)
Across all the respondents (148)	36(24)	112(76)
Employment: Private practice (n=95)	16(17)	79(83)

C. Management recommendations for a parasite control program

Respondents were asked to select *up to three* management practices that they most often implemented or recommended for a parasite control program. Options included: 1) maintain a portion of the parasite population that is not exposed to the antiparasitic drug (refugia); 2) implement quarantine procedures; 3) pasture management (multi-species grazing, controlling forage height, rotational grazing, etc.); 4) select for parasite-resistant animals; 5) alternative techniques, such as copper wire particles or fungi; 6) age-specific treatment recommendations, such as minimizing treatment of adult animals; 7) use of two or more antiparasitic drugs at the same time; 8) strategic deworming (treating when the majority of parasites are in the animal and not in the environment); 9) no management practices implemented or recommended; and 10) other (free-text specified).

Choices #4 and 5 were only listed as options to respondents answering the cattle and small ruminant specific questions.

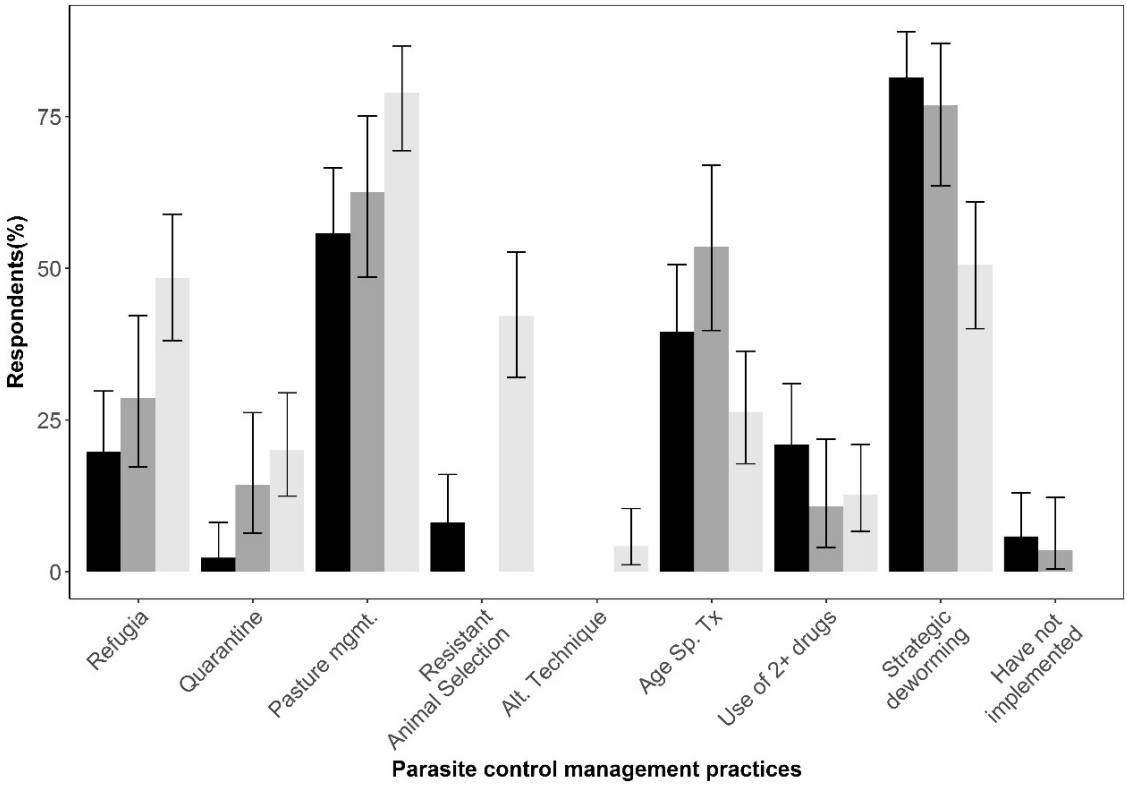
Results are shown using a denominator of respondents, rather than the number of responses for ease of interpretation. The results account for the fact that respondents could choose one, two, or three answers to the question. Respondents were not asked to order their responses if they selected more than one answer.

Most respondents answering the cattle and horse specific question selected strategic deworming (71% [95/133] and 72% [54/75], respectively) and pasture management, such as multi-species grazing, controlling forage height, and rotational grazing (56% [74/133] and 63% [47/75], respectively). Seventy-six percent (113/149) of all respondents answering the small ruminant specific question reported using pasture management. No respondents answering the cattle specific question selected alternative techniques, such as copper wire particles or fungi, as one of their top three management practices. Refugia was selected by 54% (81/149) of all respondents answering the small ruminant specific question compared to 24% (32/133) of all respondents answering the cattle specific question and 29% (22/75) of all respondents answering the horse specific question. Results among respondents identifying their employment type as private practice are also provided in Table IX.17 and Figure IX.1.

Table IX.17. Management recommendations for a parasite control program (presented as number (n) and percentage (%) of respondents answering species specific questions)

Respondent category	**Refug. n (%)**	**Quaran n (%)**	**Pastur n (%)**	**Res.An n (%)**	**Alt. tec n (%)**	**Age-sp n (%)**	**2+ tx n (%)**	**Strat.d n (%)**	**None n (%)**
All-Cattle (n=133)	32(24)	6(5)	74(56)	9(7)	0(0)	53(40)	28(21)	95(71)	12(9)
All-Horses (n=75)	22(29)	13(17)	47(63)	N/A	N/A	43(57)	8(11)	54(72)	2(3)
All-Small Ruminants (n=149)	81(54)	34(23)	113(76)	59(40)	15(10)	36(24)	15(10)	64(43)	0(0)
Employment- private practice	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Within Private practice: Cattle (n=86)	17(20)	2(2)	48(56)	7(8)	0(0)	34(40)	18(21)	70(81)	5(6)
Within Private practice: Horses (n=56)	16(29)	8(14)	35(63)	N/A	N/A	30(54)	6(11)	43(77)	2(4)
Within Private practice: Small Ruminants (n=95)	46(48)	19(20)	75(79)	40(42)	4(4)	25(26)	12(13)	48(51)	0(0)

Figure IX.1. Management practices that private practitioner respondents most often implemented or recommended for a parasite control program. Respondents selected up to three choices. Results are presented as the percentage of respondents answering cattle specific question (black bars); horse specific question (dark gray bars); and small ruminant specific question (light gray bars); 95% confidence intervals are represented by error bars.



Discussion:

When asked which parasite control practices they recommend to their clients, over 50% all respondents, particularly those answering the small ruminant specific question, selected pasture management practices as one of their top three choices. This suggests that respondents prioritized certain non-drug strategies to manage parasites in these grazing species. Using non-drug strategies, such as pasture management, to effectively control parasites requires knowledge of parasite life cycles; which parasite species are present on a farm and their natural hosts; how age and stage of production impact animal susceptibility to parasitic infection; forage types; and environmental conditions.

Just under 30% of all respondents answering cattle or horse specific questions selected the use of refugia as part of a parasite control program compared to 54% of all respondents answering the small ruminant specific question. Refugia are the proportion of the total parasite population that is not exposed to antiparasitic drug treatment; essentially, those parasites that are in “refuge” from the drug. This includes egg and larval stages in the environment (pasture refugia), parasites in other animals in the herd not treated at the same time (host-based refugia), and life stages of the parasite that are unaffected by drug treatment due to physiologic or pharmacokinetic factors (McArthur and Reinemeyer, 2014; Nielsen et al., 2014a). The use of refugia preserves susceptible parasites to mate with resistant

ones (those that survive treatment), thus diluting resistance genes and slowing the rate of resistance development.

The fact that a higher percentage of respondents answering the small ruminant specific question selected refugia compared to respondents answering the cattle or horse specific questions may be due to the availability of data from both models and field studies which have demonstrated the effectiveness of refugia to slow or even reverse antiparasitic resistance in sheep (Leathwick et al., 2015; Leathwick et al., 2012). Additional research on refugia in horses and cattle may be needed before its use will be widely adopted. For cattle, the research focus has been on developing practical methods for preserving refugia that do not result in perceived or actual production losses (McArthur and Reinemeyer, 2014). For horses, further research is needed to assess the benefit of using refugia and targeted selective treatment to slow resistance and to investigate the potential for re-emergence of more pathogenic parasite species. Although it's recommended to minimize use of antiparasitic drugs when few parasite eggs and larvae are on the pasture (i.e., low pasture refugia) and target treatments to those horses shedding the greatest numbers of strongyle eggs in their feces (i.e., targeted selective treatment), the risks and benefits are not fully known (Kaplan, 2012; Kaplan and Nielsen, 2010; Nielsen et al., 2014a). A theoretical concern about targeted selective treatment is that horses shedding a low to moderate number of strongyle eggs would receive little to no regular antiparasitic drug treatment and some of these horses could potentially harbor and spread currently rare but highly pathogenic *Strongylus vulgaris* (Nielsen, 2009).

D. Changes in management practices in response to resistance

Respondents were asked if they have changed the management practices they implement or recommend for parasite control in [cattle, horses, or small ruminants] in response to antiparasitic drug resistance. Response options included: 1) No, because I have not experienced any resistance; 2) No, because changes have not been necessary; 3) Yes, in response to information about resistance; 4) Yes, in response to resistance that I have experienced; or 5) Other (please specify).

Table IX.18. Management changes in response to resistance (presented as number (n) and percentage (%) of respondents

Respondent category	No, no resist n (%)	No, not nec n (%)	Yes, bc resist info n (%)	Yes, bc of resist exp. n (%)
All-Cattle (n=130)	26(20)	22(17)	35(27)	38(29)
All-Horses (n=74)	9(12)	6(8)	30(41)	28(38)
All-Small Ruminants (n=149)	6(4)	8(5)	51(34)	78(52)
Employment- private practice	N/A	N/A	N/A	N/A
Within Private practice: Cattle (n=85)	19(22)	16(19)	22(26)	26(31)
Within Private practice: Horses (n=56)	8(14)	6(11)	23(41)	18(32)
Within Private practice: Small Ruminants (n=95)	4(4)	4(4)	33(35)	50(53)

Other free text responses are provided in Appendix B of this report.

X. SECTION 5: MARKETING AND LABELING OF ANTIPARASITIC DRUGS

After respondents completed one or more (up to three) of the species-specific sets of questions, they were directed to the questions on marketing and labeling of antiparasitic drugs. In this section, responses were not separated by experience with a species.

A. Product labeling

The question stated that product labeling is one way to provide information about the indications and use of an antiparasitic drug. Respondents were asked how helpful or unhelpful they would find the following information if added to an antiparasitic drug label: recommendations for how to detect antiparasitic drug resistance, warnings regarding antiparasitic drug resistance if warranted, and management recommendations to minimize the development of antiparasitic drug resistance. Respondents rated each of the three choices as "very unhelpful" (VU), "somewhat unhelpful" (SU), "neither helpful nor unhelpful" (N), "somewhat helpful" (SH), or "very helpful" (VH). Results were combined in the categories of VU and SU, and SH and VH for ease of interpretation and reporting.

Overall, over half of respondents thought that all three categories of information (recommendations for how to detect antiparasitic drug resistance, warnings regarding antiparasitic drug resistance if warranted, and management recommendations to minimize the development of antiparasitic drug resistance), would be somewhat helpful or very helpful if added to the product labeling. Approximately 25% of respondents thought that the information would be very unhelpful or somewhat unhelpful.

Respondents were also given the opportunity to provide a written comment related to this question if desired. These responses are provided in Appendix C.

Table X.1. Respondent ratings of recommendations for detecting resistance (presented as number (n) and percentage (%) of respondents)

Respondent characteristics	VU/SU n (%)	N n (%)	SH/VH n (%)
Overall (n=283)	67(24)	60(21)	156(55)
Credential type: DVM	55(22)	55(22)	139(56)
Credential type: DVM and MS/PhD or MS/PhD in Veterinary Parasitology	10(37)	5(19)	12(44)
Private Practice Employment	41(22)	39(21)	106(57)
Report experience with resistance	43(21)	45(22)	114(56)
Do not report experience with resistance	13(25)	13(25)	26(50)

Table X.2. Respondent ratings of warnings regarding resistance (presented as number (n) and percentage (%) of respondents)

Respondent characteristics	VU/SU n (%)	N n (%)	SH/VH n (%)
Overall (n=282)	72(26)	50(18)	160(57)
Credential type: DVM	59(24)	45(18)	144(58)
Credential type: DVM and MS/ PhD or MS/PhD in Veterinary Parasitology	11(41)	5(19)	11(41)
Private Practice Employment	43(23)	36(19)	107(58)
Report experience with resistance	47(23)	31(15)	123(61)
Do not report experience with resistance	14(27)	15(29)	23(44)

Table X.3. Respondent ratings of management recommendations to minimize resistance (presented as number (n) and percentage (%) of respondents)

Respondent characteristics	VU/SU n (%)	N n (%)	SH/VH n (%)
Overall (n=285)	67(24)	26(9)	192(67)
Credential type: DVM	58(23)	21(8)	172(69)
Credential type: DVM and MS/ PhD or MS/PhD in Veterinary Parasitology	7(26)	5(19)	15(56)
Private Practice Employment	46(24)	16(9)	126(67)
Report experience with resistance	43(21)	16(8)	144(71)
Do not report experience with resistance	13(25)	10(19)	30(57)

B. Freedom of Information Summaries

Respondents were informed that Freedom of Information (FOI) Summaries for approved animal drugs are available electronically on the FDA website https://www.fda.gov/animal-veterinary/products. These documents summarize the safety and effectiveness information submitted to support the approval of animal drugs.

Respondents were asked if they were aware of the availability of FOI Summaries. Overall, 62% of respondents stated that they were unaware of the availability of FOI Summaries. However, 70% (19/27) of respondents with both a DVM and an MS/PhD in veterinary parasitology stated that they were aware of FOI Summaries.

Table X.4. Awareness of FOI Summaries (presented as number (n) and percentage (%) of respondents)

Respondent characteristics	Yes n (%)	No n (%)
Overall (n=290)	109(38)	181(62)
Credential Type: DVM	88(35)	166(65)
Credential Type: DVM and MS/PhD or MS/PhD in Veterinary Parasitology	19(70)	8(30)
Private Practice Employment	62(33)	127(67)

Respondents were also given the opportunity to describe in their own words which parts were most useful. These responses are found in Appendix D of this report.

C. Prescription status of approved combinations

Respondents were asked their opinion regarding whether approved combinations of antiparasitic drugs should be available over-the-counter (OTC) or by prescription (Rx) only in the United States. Response options for each choice (Rx or OTC) included 1) yes, 2) no, or 3) undecided. Additional explanations provided by the respondents in their own words are found in Appendix E.

Table X.5. Opinions about OTC status of approved combinations of antiparasitic drugs (presented as number (n) and percentage (%) of respondents)

Respondent characteristics	OTC Yes n (%)	OTC No n (%)	Undecided n (%)
Overall n=258	31(12)	175(68)	52(20)
Credential Type: DVM	22(10)	160(70)	46(20)
Credential Type: DVM and MS/PhD or MS/ PhD in Veterinary Parasitology	8(35)	11(48)	4(17)
Private Practice Employment	15(9)	123(72)	33(19)
Report experience with resistance	20(11)	130(69)	39(21)
Do not report experience with resistance	8(19)	28(65)	7(16)

Table X.6. Opinions of Rx status of approved combinations of antiparasitic drugs (presented as number (n) and percentage (%) of respondents)

Respondent characteristics	Rx Yes n (%)	Rx No n (%)	Undecided n (%)
Overall n=274	215(78)	16(6)	43(16)
Credential Type: DVM	195(80)	14(6)	36(15)
Credential Type: DVM and MS/PhD or MS/ PhD in Veterinary Parasitology	15(75)	1(5)	4(20)
Private Practice Employment	148(80)	12(6)	25(14)
Report experience with resistance	151(77)	11(6)	33(17)
Do not report experience with resistance	38(78)	4(8)	7(14)

Discussion:

Currently in the US, most antiparasitic drugs for cattle, small ruminants, and horses are available over-the-counter. This contrasts with many European countries in which antiparasitic drugs are available only by prescription (Becher et al., 2018; Nielsen et al., 2006; Salle and Cabaret, 2015). In 2017, the European Medicines Agency (EMA) recommended that antiparasitic drugs targeting nematodes in food-producing animals be approved as prescription drugs to avoid inappropriate use (EMA, 2017). It is uncertain how EMA recommendations and legislation in individual countries requiring diagnosis and prescription of anthelmintics by veterinarians will impact parasite control strategies in practice. A survey of horse owners in a variety of European countries and the United States suggested that owners in Denmark, where antiparasitic drugs are available by prescription-only following a parasitological diagnosis, used fecal analyses to guide anthelmintic treatment decisions more frequently and treated horses with anthelmintics less frequently than owners in the other countries surveyed. By contrast, despite Austria and Germany having prescription-only restrictions that are similar to those in Denmark for a few decades, parasite control strategies in these countries were not notably different from those used the United States (Becher et al., 2018).

D. Wrap up questions

At the end of the survey, respondents were given an opportunity to state (in free-text) their opinion regarding the roles/responsibilities, if any, of the following groups in managing the use of antiparasitic drugs to minimize the development of antiparasitic drug resistance: veterinarians, regulatory agencies, academia/science, producers/animal owners, pharmaceutical companies, and producer groups/affiliated organizations.

A summary of the responses is provided below:

1. Veterinarians

    a. Educate and advise owners on use of antiparasitics, including sustainable use, product selection, management options, determining which animals to treat, minimizing use of dewormers/judicious use, risk of resistance, techniques to detect and manage resistance
    b. Perform fecal testing and FECRT for owners
    c. Become the source of information about antiparasitic drug use and resistance for clients
    d. Prescribe antiparasitics
    e. Diagnosis of parasitism and prescribe drug based on fecal results
    f. Stay up to date on current state of resistance and resistance management
    g. Monitor effectiveness of drugs in herds
    h. Development of individualized parasite management plans
    i. Lead the efforts to change from rotational deworming to strategic deworming
    j. Report suspected resistance to the drug manufacturers

2. Regulatory agencies

    a. Facilitate the development of new antiparasitics and combinations while ensuring scientific integrity of the development process

b. Approval of drugs
c. Limit or stop allowing OTC sales of antiparasitics; restrict to Rx
d. Research
e. Ensure drugs are safe and effective, including preventing unsafe residues
f. Protect food safety, animal health and the environment
g. Streamline the approval processes, especially for new compounds and combinations; do a much better job of requiring efficacy data from generic products, follow-up on effectiveness and safety, and ensuring the quality of products on the market
h. Facilitate and streamline approval of drugs for small ruminants
i. When approving drugs--ensure field population of worms used in trials
j. Ensure labeling is accurate and provide labeling guidelines
k. Stay within their expertise--regulatory science
l. Communicate information to the veterinary medical community, including information on resistance
m. Stay current on proper parasite treatment and management recommendations
n. Let veterinarians do their jobs
o. Work with academia and industry to understand current practices and research
p. Provide guidelines for veterinarians and producers
q. Control availability of products that have resistance issues
r. Monitor resistance trends in geographic areas (state and/or regions within state)
s. Follow through on cease and desist orders for non-licensed professionals making recommendations
t. Create awareness regarding the need for the sustainable use of antiparasitics
u. Help educate users about resistance status and related issues
v. Collating and disseminating knowledge; stricter control of new drug classes
w. Develop recommendations for the safe and effective use of antiparasitics
x. Making sure drug company studies are done appropriately, and that label claims are accurate
y. Provide flexibility to veterinarians when prescribing drugs in cases of resistance
z. Allow development of combinations while considering scientific issues in the development of these products
aa. Monitor and surveillance of resistance

3. Academia/science

a. Provide independent data on actual prevalence of antiparasitic resistance through studies and surveys; train veterinarians and animal scientists and extensionists in sustainable control of parasites
b. Teach parasite resistance in vet school, help veterinary students get experience on farms developing parasite control practices to prepare them for practice
c. Education of veterinarians and producers; promoting sound deworming practices
d. Research new products (including combinations), new ways to use current products, and management schemes and other alternatives to control parasites without drugs
e. Discover the mode of action of anthelmintics and subsequent mechanism of

resistance
f. Practical and relevant research that can be applied to field conditions
g. Report research findings efficiently to end users
h. Evaluating and determining the best practices to minimize development/spread of resistance
i. Verify claims (efficacy, safety...) made by industry
j. Continue to research management strategies to prevent resistance, find other families of wormers
k. Continue research and education of veterinarians and producers regarding antiparasitic drug resistance; continue
l. Research other inhibiting plants in addition to *S. lespidiza*, etc.
m. Research the ways that our current drugs can be used more effectively- better administration methods, timing, combination, withholding feed, etc.
n. Researching new ways to minimize damage to the animals being treated, novel ways to encourage immunity to parasites, research new dewormers/ management practices that decrease the damage done by parasitism

4. Producers/animal owners

a. Assume major responsibility for proper and sustainable use of antiparasitics
b. Listen to recommendations from veterinarians and follow the label directions; rely on their veterinarian first rather than the feed store or random internet sources
c. Work with veterinarians to develop deworming plans specific to their herd and based on fecal testing and regular consultation; be willing to pay for consultation
d. Avoid overuse or use of inappropriate medications; use management more than anthelmintics
e. Pursue continuing education, keep records, and stay up to date on recommended parasite control practices
f. Gain an understanding of the importance of resistance and how best to deal with it for their own facilities
g. Provide feedback on management recommendations and performance of their herd to their veterinarian, scientists, and pharma
h. Be aware of the effects of their decisions on other farms and the environment
i. Employ management strategies such as isolating new animals and testing before mixing into herd; cull/breed for resistance; and pasture management
j. Become stewards of effective pharmaceuticals within their own herds

5. Pharmaceutical companies

a. Research and development of new antiparasitic products, including new chemical entities and combinations
b. Ensure scientific integrity in development of new products, including combination antiparasitics, and other products that help to minimize resistance
c. Pursue approval of drugs for small ruminants, and determine effective dosing for species such as goats

d. Adopt a model where antiparasitic drugs are only available through veterinarians, especially new drugs with different mechanisms of action; do not market to owners
e. Encourage valid VCPR
f. Provide transparent information regarding product effectiveness especially post approval and in studies where drug effectiveness between products is compared; research parasite resistance situation in all species; let consumers know about resistance if it is found; advertise based on current studies with warning about resistance
g. Publish post-approval studies in peer-reviewed journals
h. Perform studies post-approval to see if their product works and is still working
i. Stop marketing long acting antiparasitics for production gains
j. Retract products when documented resistance is significant
k. Take marketing out of decisions to release products if there is a danger to an entire class (ex. Long-Range)
l. Sell products based on good science and not testimonials
m. Educate veterinarians and producers on sustainable use of drugs and best practices to decrease development of resistance; stop marketing drugs for production claims or promoting overuse of anthelmintics
n. Provide FOI info to practitioners
o. Research food product withdrawal times for minor species
p. Improve warnings on the labels about resistance and appropriate dosing, and promote strategic deworming
q. Support equine parasitology research - external and internal. Publish results in peer-reviewed journals
r. Perform research including field trials, hold workshops, support local agriculture markets and events
s. Provide prepackaged combinations of parasiticides (available in New Zealand)
t. Develop drugs that are affordable for producers
u. Raise the prices on the dewormers to that they are not cheaper than fecal egg counts

6. Producer groups/affiliated organizations

a. Education of producers about sustainable use of anthelmintics within different farming systems; disseminate science-based information; encourage veterinary consultation to develop deworming plans specific to their herd; provide information about current state of resistance in their species; promote strategies to reduce the use of antiparasitic drugs (genetic resistance; managing pastures, targeted deworming, FEC, FECRT)
b. Try to influence the attitudes (early adapters) of members of their groups by targeted education
c. Work with academia on research; collaborate in development of more effective treatment or management of parasites
d. Stop advocating off label usage of existing drugs
e. Provide education to producers and veterinarians through organizing meetings, webpages, open forums, Advocate for solutions to the resistance issues
f. Should educate producers and work with academia
g. Reinforce the importance of veterinary monitoring of individuals/herds, to an effective medical management plan

h. Help to monitor the needs of producers
i. Promote effective strategies that balance animal health, economics, and environmental concerns
j. Encourage more producer education, support expanding labeling to include goats and sheep
k. be aware of the current parasite management recommendations, seek expert advice, and promote education opportunities for veterinarians and owners
l. Listen to veterinarians, regulatory agencies, academia and pharmaceutical companies to make the best decision possible to maintain health and minimize resistance development
m. Support the work of veterinarians and pharmaceutical companies
n. Make resistance research a priority
o. Publish literature and consensus statements
p. If possible, making FEC available at reduced cost to producer
q. Provide funding for research, especially resistance research

Respondents were also given the opportunity to provide any other information that was not covered in the survey relative to antiparasitic drug resistance and/or antiparasitic drugs. These comments are provided in their entirety in Appendix F.

XI. APPENDICES

A. Examples of drugs used concurrently, as documented by respondents answering species-specific questions

Note that answers are provided exactly as they were provided by the respondent.

"**Please list the drugs you use together in cattle"**

- avermectin or milbemycin plus benzimidazole in cattle under 2 years of age
- Ivomectin [sic] and clorsulon
- Depending on need to treat flukes
- avermectin type pou-on [sic] and a white drench dewormer
- Ivermectin, fenbendazole
- ivermectin fenbendazole
- Macrocyclic lactone + fenbendazole
- Ivomec,cylence [sic],panacure [sic]
- Safegard [sic] and cydectin
- Valbezan [sic] and Dectomax
- yes if the first choice does not cover external parasites
- Especially at arrival at the feedyard. We assume that grass cattle have seen multiple doses of macrocyclic lactones
- Avermectins Benzimadazoles [sic]
- If resistant Haemonchus and cooperia are present then I recommend Cydectin injectable, Valbazine [sic] and levamisole
- Ivermectin and benzemidizole [sic] at weaning in bulls being kept for breeding
- Doramectin, albendazole
- Macrocyclic lactones and benzimidazoles
- Avermectin + white dewormer
- an endectocide and levamisole

- dectomax and valbazen
- ivomec panacur
- White wormers and avermectin class
- only in calves with ecto and internal parasites or cattle in areas with liver fluke
- ivermectin fenbendazole
- injectable Ivomec & Safeguard
- In goats with high potential for development of resistance, I recommend it.
- Fenbendazole & ivermectin, moxidectin & levamisole, fenbendazole & levamisole
- Not routinely, but have used fenbendazole with ivermectin before
- Not in cattle, but I have used this strategy in small ruminants.
- inj ivermectins and bendazoles [sic]
- Any Ivomectin [sic] and safeguard or other "white" wormer
- fenbendazole, moxidectin
- ML plus a benzimidazole or levamisole
- panacur ivermectin topically
- in cases of severe clinical signs, not routine deworming
- In highly stressed weaned beef calves I use a benzamidazole [sic] and macrocyclic lactone simultaneously.

“**Please list the drugs you use together in horses”**

- 1) Regularly use ivermectin/moxidectin + praziquantel. 2) Only in a couple of extreme resistance cases I have tried to use multiple drug classes together (i.e. ivermectin+pyrantel, moxidectin+levamisole, etc.)
- ivermectin/moxidectin praziquantel
- Ivermectin / Fenbendazole Strongid / Fenbedazole [sic]
- Praziquantel combinations (azoles)
- Pyrantel pamoate/oxibendazole moxidectin/praziquantel ivermectin/praziquantel
- Avermectin, praziquantel
- ivermectin/praziquantil [sic], moxidectin/praziquantil [sic] l; as needed or at least once a year
- Macrocyclic lactones with praziquantel Oxibendazole with pyrantel
- Pyrantel and oxfenbendazole
- Occasionally I recommend an ivermectin/praziquantel product or moxidectin/praziquantel.
- Anthelcide and ivermectin
- fenbendazole and ivermectin or moxidectin in foals or weanlings not others
- pyrantel pamoate + oxibendazole
- ivermectin/fenbendazole moxidectin/prazi [sic]
- fenbendazole and ivermectin
- Ivermectin/Fenbendazole combination
- Praziquantel and other anthelmintic
- i had a case of ascarids in a racehorse that did not clear on levamisole or fenbendazole or pyrantel or pipzine [sic] on its own. i tube wormed with febendazole [sic] & levamisole and pipzine [sic] 80gms and this got rid of the eggs. N=1 only
- Pyrantel and oxibendazole
- For resistant parasite, I will combine 2 older drugs (usually Fenbendszole [sic] and ivermectin) and retest (FEC), before using Moxidectin.
- Ivermectin and proziquantal [sic] for tapeworms

- Ivermectin and a Benzimidazole

“**Please list the drugs you use together in small ruminants”**

- Valbazen, Prohibit and Cydectin are a combination often necessary in goats in the South.
- Only rarely in cases of unknown history and severe illness. Ivermectin or moxidectin with fenbendazole
- BZ and ML
- Rarely
- Depends on what has been used previously.
- May use praziquantel in conjunction with fenbendazole or moxidectin for control of tapeworms in youngstock
- Sometimes
- Depends on the situation
- fenbendazole with levamisole or ivermectin with albendazole
- Only if indicated by an In vitro Larval Development Assay (Ray Kaplan at UGA)
- a benzimidazol [sic] with a macrocyclic lactone or levaminsole [sic]
- Ivermectin and fenbendazole
- Cydectin levamisole and fenbendazole for new animals
- Cydectin and corid
- Fenbendazole and Cydectin
- ivermectin and pyrantel
- benzimadazoles [sic] + levamisole
- I haven't yet, but know others do.
- Only if previous history of resistance exists or there are multiple parasites demonstrated on FEC that require different treatments; typically utilized ivermectin with fenbendazole on a case by case basis if warranted
- mix either of the classes, depending on the effectiveness of each.
- levamisole/albendazole
- Have not had to do that yet in my area, but am aware of the technique.
- Fenbendazole and Moxidectin
- Fenbendazole and moxidectin
- levamsole [sic] and moxidectin
- ivermecin [sic] and levamisole only if other single methods are not working
- I'll use fenbendazole and an avermectin (usually ivermectin or doramectin) together occsaionally, [sic] but then I'm also treating for multiple parasites (including meningeal worm) quite frequently.
- Fenbendazole and cydectin
- sometimes, when animals have severe anemia
- Ivermectin and fenbendazole
- cydectin and levamisole if the animal is severely anemic
- Try not to unless FEC warrant.
- moxidectin, fenbendazole
- moxidectin, levamisole
- If multi-drug resistance than as a salvage treatment: MCL + BZ; specific ones depends
- I am aware of this option, but have not recommended yet.
- If an individual is extremely anemic and may die, I recommend treating with 2 families of drugs and then culling after appropriate whithholding [sic]

- If truly resistant and valuable goats or alpaca, may use fenbendazole plus macrocyclic lacton [sic]. Have just used higher dose of fenbendazole at right time of year esp. considering breeding season.
- fenbendazole and ivermectin pyrantel/morantel and ivermectin
- If coccidia is an issue than I will combine the use of amprolium or a coccidiostat with antihelminthics [sic] based on the case.
- Only in the case documented all-class dewormer resistance (i.e. fenbendazole, ivermectin, moxidectin, & levamisole resistance in a single animal)
- Not unless no other choice. An avermectin plus a benzimidazole would be the recommendation.
- especially if we cannot get the fecal egg count down to manageable numbers
- have previously recommend multi-modal treatment. Now primarily use levamisole for H contortus control, and use Ivermectin for ectoparasite control. will use fenbendazole in the event tape worms are identified.
- AN Ivermectin / benzimidazole; AN Ivermectin/ levamisole.; AN Ivermectin/ 2nd Avermectin
- Depends on the history at the property. If morantel or levamisole has not been used for several years will be recommended plus albendazole or moxidectin
- levamisole and macorcyclic [sic] lactones
- On occasion in extreme outbreaks, usually recommend Fendbendazole [sic] and Levamisole
- Only on specific occasions - fendbenazole [sic] with either moxidectin or ivermectin.
- Ivermectin and Praziquantel
- Albendazole /Levamisole
- But I would if I were seeing the levels of resistance I hear about in other areas. Haven't yet.
- fendbendazole [sic] and ivermectin
- I have used combination therapy with tetrahydropyrimidine (levamisole) in common with either bezimadazole [sic] or macrcyclic [sic] lactone in severly [sic] debilitated individual animals
- At times we use fenbendazole and moxidectin concurrently with some success.
- levamisole, ivermectin
- Yes, if in a highly resistant situation when other diagnostics and management practices have been implemented. Choice depends on individual or group/herd situation.
- Fenbendazole and moxidectin
- Usually a benzimidazole with either levamisole or a macrocytic lactone/avermectin
- A mix of 2 different classes
- ivermectin pyrantel
- Ivermectin and fenbendazole for some new animals to the herd depending on history
- fenbendazole + levamisole - ONLY to save the life of the animal
- ivermectin copper wire particles
- Only in cases of multi-group drug resistance, an ML and a benzimidazole
- Fenbendazone [sic] /Albendazole, Ivermectin drench
- Macrocyclic lactone with Levamisole, seems to work very well for haemonchus resistance in small ruminants based on fecals pre and post anthelmentic [sic].

B. Optional responses related to changes in management practices in response to resistance

Note that answers are provided exactly as they were provided by the respondent.

Cattle specific question

- Use of longer acting paracitacides [sic]
- Based on pasture growth cycles and climate
- Fed cattle no applic [sic]
- Please note that my responses are based on recommendations made on principle, my involvement in veterinary medicine currently being limited to the classroom
- Stocker from southern US. EPG count pre & post treatment in south to determine resistance then use a 3 way combination before the cattle come to WI.
- will check fecals on ill animals in herd to evaluate parasite control if have diarrhea or unthrifty
- I use none of the above
- perform a fecal count first to determine if treatment is necessary
- Tarhetted [sic] selective treatments (TST) and targetted [sic] treatments (TT)

Horse specific question

- No equines
- depending on environment specific treatmen [sic] may be needed ie Habronema, Oxyuris
- Would like to establish refugia, but owners don't like seeing any worm eggs on fecals!

Small Ruminant specific question

- All of first five and number 7 are all used
- none recommended because I am retired
- Again, I use more than 3 of these strategies depending on the client and the situation.
- Treatment only if indicated by routine quarterly fecal analysis
- I TRY to exhaust ALL of these; not usually possible. I realize "piggybacking" meds might make it worse, but life or death motivates me at this time, especially with nothing new for small ruminants on the immediate horizon.
- All of the above may fit in some situations not others one size does not fil sic] all situations
- FAMACHA scoring
- I use most of these in different sceneros [sic]
- sanitation of feeding areas

C. Product labeling comments

Respondents provided additional/optional comments in response to survey question regarding the potential inclusion of the following information on antiparasitic drug labeling: recommendations for how to detect antiparasitic drug resistance, warnings regarding antiparasitic drug resistance if warranted, and

management recommendations to minimize the development of antiparasitic drug resistance.

Note that answers are provided exactly as they were provided by the respondent.

- The best would be to take them off of the shelf at the hardware store so that veterinarians could be more actively involved. Labeling means nothing to owners- they are more likely to get the dose off of an internet forum than off the bottle!
- For all 3 options above, the label should say "Consult your veterinarian
- I am not sure label instructions would help. Owners struggle to understand some of the concepts. It would help if antiparasitic drugs actually had small ruminant labels and make sure that a proper dosage is included. Most drugs used only have a cattle label.
- Most anthelmintics are administered by producers. Few producers read labels. Even fewer producers know anything about worm species. They tend to choose an anthelmintic based upon (1) price, (2) perceived efficacy, (3) marketing info provided by animal health supply distributors, (4) coffee shop talk, (5) what they find the most progressive producers in the area are using, which usually originates with (6) the local veterinarian.
- I consider myself highly educated in all three areas and would not need product labeling but I think would be very helpful to those less aware of the problems but only if they actually READ the label. Sadly those who need the information the most are the least likely to read labels.
- I place no stock in indications on generic anti parasitic drugs. No proof they are effective. The FDA should require the same level of efficacy for generics as for original formulations.
- must be written so producers can understand
- Add info to consult vet to develop comprehensive parasite control program, of which anthelmentics [sic] are just one part.
- Labels are not user friendly, and too often not read
- Take dewormers off the counter, so that users are required to have a conversation with a trained professional before use.
- I do not think that the majority of people would bother to read the full label. They would go straight to dose and route of administration.
- Also helpful would be new labels for goats because frequently label doses don't do ****.
- cattle in my aea [sic] have minimal internal parasite problems - treat primarily for lice & grubs. equine parasite loads are also less than many areas so resistance to gi parasite resistance is hard to evaluate.
- Every medical case is different, there is no reason to waste time and money stating what is obvious to the profession. Just because a drug is indicated, it is well understood that it won't necessarily perform in all cases.
- I think my job as the DVM is to keep up with that info and help the client make better decisions. Labels are confusing enough already.
- Added to OTC products so clients MIGHT read them!!!
- I teach vet students and consult with clinicias [sic]; as it is most don't read the labels or read them very closely
- Avoid drug companies selling or promoting sales.
- Stick with safety and efficacy. We don't need to be managed.
- Management recommendations are to [sic] complicated to put on label.
- If too much info on label no one reads it
- most of my producers wouldn't read it or comprehend it anyway

D. Comments on Freedom of Information Summaries

If respondents stated they were aware of the availability of FOI Summaries, they were given the opportunity to states which parts they found most useful.

Note that answers are provided exactly as they were provided by the respondent

- Effectiveness
- haven't used much
- Species approval information, which must be taken with a grain of salt, since most companies know where to go to find susceptible strains of parasites species.
- I am aware of them but I am ashamed to say I never personally looked at them. However the experts I depend on for my information do check them regularly and pass along the info
- Where do you find that information? Shouldn't that be sent to all AABP and AVC members from the FDA?
- I am aware of them, but I have never actually read one
- Haven't used
- Summary
- Mode of action, licensing trial data, safety data
- I usually read it all
- Safety studies, effectiveness studies
- Most of the FOI summaries were printed before the resistance was found
- Reactions
- Efficacy and safety -- I read these pretty closely
- Rarely look and don't think helpful for this issue-constantly changing
- Efficacy studies
- Money given on government programs
- haven't used them
- Usually look at safety; efficacy is often limited to specific circumstances.
- Efficacy trials
- None
- I'm aware they are available but haven't used them

E. Comments on prescription status of approved combinations in the United States

Respondents were given the opportunity to provide additional explanation in response to the question about whether approved combinations of antiparasitic drugs should be available over the counter or by prescription only in the United States.

Note that answers are provided exactly as they were provided by the respondent.

- This recommendation is not based on my desire to sell product, I will happily write the prescription. Goats and Sheep are inherently cheap animals. As such their owners are cheap. They don't perceive the animal to be worth a veterinary consult and therefore, they will do everything in their power to treat animals beyond their means until A) it is either too late or B) the animal is dead. By allowing access to dewormers unchecked, this behavior is allowed to continue. If the veterinarian had an opportunity to enter the conversation (when the phone gets picked up because options aren't readily available prior

to that) the animal population would be healthier, the clients more successful and the resistance problems would likely be reduced because we would identify the problem and stop the ridiculous tactics of continual deworming, deworm rotations etc.

- The veterinarian needs to be involved. We can't let producers be the sole decision makers where they buy whatever the feed store salesman says. Anthelmintics are precious and need to be used more judiciously
- Due to risk development of resistance, combining products without the consultation of a DVM to regulate which drugs, which doses & how to evaluate effectiveness would be detrimental
- Promote a more judicious use of our last reserves
- part of the problem of parasite resistance is the easy access of over the counter wormers. and therefore uneducated animal owners using them incorrectly. However the cats out of the bag on that problem.
- Go Denmark
- I have seen too many instances where antiparasitic drugs are used improperly and with little understanding.
- I don't really think most pharmas would spend the money to get a combo drug approved. They would just sell the individual components, as they do now. The cattle industry has already accepted that regimen.
- Overuse of combinations will only hasten the development of additional double resistant strains of parasites if they are used indiscriminately which will undoubtedly happen if they are available over the counter.
- Many ranchers and some veterinarians seem to prefer cheap to effective. Don't know the answer to this problem. It has always been that way for my 42 years in practice.
- Less resistance with control
- Only if research is done to demonstrate effectiveness/resistance rates with these combinations. In general I think all anti parasitic drugs should be prescription-only
- The severity of the situation related to development of parasite resistance in this country requires that veterinarians be involved in the use of antiparasitic drugs to help maintain some level of effectiveness of these medications for future use. This also requires better continuing education of veterinarians on the current recommendations for parasite control.
- If veterinarians are going to be held responsible for parasite/bacterial resistance to medications then there should be none of these sold over the counter and out of our control. Especially if there are no recommendations or warnings about resistance on the label. It is a food safety hazard too for those that raise animals to eat at home and otherwise. There is no guarantee that withdraw times were followed or even known by the farmer who bought the medication over the counter.
- The resistance to dewormering [sic] medications can be slowed or prevented all together through good management practices. We need these drugs to be prescription, so that users have to have conversations with a veterinarian on how to use them effectively. Many producers/hobby farmers continue to use the recommendations of their family members or untrained personnel like ag teachers and feed store employees that offer recommendations that are not up to date.
- There are too many differences in need across this large continent to make "one size fits all" recommendations useful. Better to FECRT animals and use only what is needed for that premise.

- In order to give access to more animals that don't have routine access to veterinary care, OTC may be an option. If the label warnings can educate a client sufficiently about the chance of developing resistance and the drug company successfully meets all the requirements for OTC, then it's the clients and their animals who will ultimately lose out if they misuse it.
- Highly recommend they be used under veterinary supervision only, to help decrease over-use and development of resistance
- I'm a little hesitant on 'the experts' using combos, too.
- There is a lack of oversight of many products today and Dr. Google can't change what people may or may not do, but it is the practicing veterinarian that bears witness early to the problems encountered.
- Prescriptions would allow us to have greater control in sustainable deworming practices, but likely to generate uproar from independently minded clients.
- Client over use & misuse of antiparasitic drugs has, in my opinion, contributed greatly to the parasite resistance problem
- If there is increasing evidence of emerging resistance in cattle, Prescription-only may cause these drugs to be used more effectively.
- If available to all = much more resistance. Generic ivermectin being used for fly control every 30-45 days on some farms!!
- If there is any hope to retain effectiveness of benzimidazoles (may be too late for macrocyclic lactones) then need restricted use
- Over use of combination therapy could be detrimental.
- The requriement [sic] of prescriptions helps to ensure that producers are exposed to some information on prudent use to limit mass inappropriate usage.
- ALL DEWORMERS SHOULD BE Rx ONLY. ALL ANTIBIOTICS (INCLUDING PENICILLIN) SHOULD BE Rx ONLY. LET THE PROFESSIONALS MANAGE THIS, AND NOT THE MINIONS.
- Old style products could be over the counter, new or novel products should be distributed and used with more care.
- I would prefer prescription, so they would get correct directions/advice, a lot of people I have encountered will not use anything if they can't buy it from the feed store and don't/won't seek veterinary advice. They may use products that are useless or even harmful.
- I am concerned about the over-use of antiparasitic drugs and it seems inevitable that resistance will become more prevalent. If veterinarians are prescribing these drugs based on fecal egg counts or clinical findings, the drugs will be used more appropriately and hopefully maintain refugia longer.
- OTC drugs got us into this mess in the first place.
- Resistance is only going to worsen if these drugs remain in the hands of the uneducated. Even vets struggle to understand resistance so if we cannot get things consistent, how will we be successful with a population who do not fully understand the risks. We risk a future with few if any good parasiticides.
- The most frustrating clients are those that call after they have already used all the dewormers they can get OTC. I would rather have a chance to educate them before they exhaust all the available options.
- I feel like if heartworm preventative dewormers for dogs was OTC we would have experienced resistance far sooner than we are today thus I would think that a prescription-only anthelmentic [sic] would be used more appropriately or judiciously. Resistance would occur, but hopefully at a slower rate with veterinary input on its use and dosage

- Anthelmintics have been badly abused already through over the counter availability. Approved combination drugs would get us out of the questionable legality of using home made combinations.
- Would be helpful in controlling use; however, owners are resourceful and seem to be able to get whatever drugs they want, approved or not.
- Combinations should be saved for particular instances (such as for new animals; rescuing an animal infected with resistant parasites). If over the counter, it would be abused and quickly hasten resistance on a farm.
- We know this is furthering parasite resistance, but it is difficult to avoid in individual cases. It should be veterinarian directed, not producer directed (I'd like to think vets are more aware of the risks in these practices and will dose accordingly).
- Managing parasite resistance is complex and well above the education/training/ability of most lay people. Improper use of current OTC products is rampant and contributes largely to the current resistance problems. DVMs/VMDs have the education and resources to properly use antiparasitic drugs in a way that will slow resistance.
- If we are seeing resistance these products should have veterinary oversight. Lay people are not qualified to document resistance, do not do diagnostics, cannot evaluate effectiveness
- strategic deworming strategies and resistance recognition should be done by professional personnel who have taken veterinary parasitology.
- I want antiparasitic drugs to be easily accessed for the good of the horse, but I worry about misuse, especially overusage.
- Owners have taken on a large responsibility for preventive care and so they should have access to effective products because often they do not purchase deworming Meds from a veterinarian and aren't likely to do so even if these combos are only prescription only. Our objective is to optimize health of the horses, not hinder this goal.
- since owners can by [sic] dewormers over the counter, most of them do not consult veterinarians about deworming and thus they know nothing about resistance. if dewormers were prescription only, veterinarians might be able to implement measures like regular fecal egg counts to determine which horses need to be treated and which do not. dewormers are otc and they are very inexpensive compared to sending a fecal egg count to a lab, so it is almost impossible to get them to stop deworming whenever they feel like it. no wonder we have resistance!

F. Summary of other comments provided in wrap up question

The following comments were received in response to the question, “Is there any additional information you would like to convey that has not yet been covered in this questionnaire relative to antiparasitic drug resistance and/or antiparasitic drugs?

Note that answers are provided exactly as they were provided by the respondent.

- We need to move beyond the times where antiparasitic agents are administered at the convenience of producers and en mass with the promise of production efficiency. Data regarding deworming in cattle is especially sparse, but drug companies are able to document weight gains, etc, and this is how they market products. We need to preserve the usefulness of antiparasitic agents and that means taking them off of the feed store shelves and into the

hands of veterinarians. Practitioners lack the will to conduct fecal exams and producers don't want the additional cost. Unfortunately, this will not work out as a long term plan. We need to invest in better rapid testing for parasites, especially in cattle. And, we need to further define when it is appropriate to treat infected animals.

- There seems to be a need to get new info out to clients on major changes in protocols w [sic] make in the professional community. Horse owners are still using daily dewormers or deworming every 6wks. Sheep & goat owners are still deworming their whole flock, goat owners are not double dosing. Availability of product over the counter has many producers treating for worms and coccidia without proper diagnosis
- Would be nice if there were a source of Haemonchus that had no resistance to any antiparasitic drug so they could be used to replace resistant Haemonchus.
- Antiparasitic drug resistance was a big issue that we discussed a lot in Veterinary school. Out in private practice, almost no one cares about parasite resistance. I've talked to clients, tried to educate them, but they don't want to pay for fecal floats or change their routine. So I'm not sure how to convince them they need to change. Also, older practitioners seem completely either unaware or unperturbed by resistance issues, and are therefore not addressing those issues with clients.
- IME, the alpaca owning population is overall much better educated than the sheep and goat owning population regarding the risks and prevention of antiparasitic resistance. I have met very few sheep and goat producers who run fecals or are even necessarily aware of the concept of antiparasitic resistance, while it seems that the majority of alpaca owners are very conscientious regarding best practices for parasite management. Forgot to mention that, for the question regarding antiparasitic resistance that I have personally witnessed, effectively ALL alpaca gastrointestinal parasites are resistant to ivermectin, because SQ ivermectin is used on a monthly basis to prevent development of meningeal worm in populations where White Tailed Deer are prevalent. I have heard some DVMs suggest that this practice should be stopped because it contributes to the development of antiparasitic drug resistance; however, I feel that the risk of alpaca contracting meningeal worm is too great in these areas, and that alpaca GI parasites are all resistant already at this point in time (2015), so there is no benefit to the cessation of this practice.
- Camelids - alpacas and llamas - are a growing part of the small ruminant population that need to be considered along with sheep and goats.
- You can extrapolate the problems in small ruminants to all species. Need to consider species, regions, production parameters, and include real veterinarians (those who practice) in your decision-making processes (policy, approvals, etc).
- Small ruminant producers are treating their own animals and only contact veterinarians when it is not working or an animal dies. Very frustrating. We offer many FAMACHA classes across the state and several producers have attended, but not as many as there are producers out there. We have internal parasite problems for 7-8 months (or more).
- Yes, to be clear I think all antiparasitic drugs should be available prescription-only. I have made significant efforts to educate horse owners for the last 5 years about resistance problems- and some of them follow my recommendations but many of them don't. As long as owners/producers are able to obtain these drugs themselves, there will be incorrect use and overuse of them. If the FDA is not willing to make the currently available drugs

prescription-only, then please at least do so for any new drugs that (hopefully) become available in the future.

- Thanks for looking into this topic. I do a LOT of educational programming in this area. Producers are always amazed to hear it is illegal to use medications off label without veterinary recommendation and oversight. I strongly recommend selecting for resistant animals.
- Combination products are needed (most other countries have them) Even when resistance is documented (Wisconsin study Larry Smith) cattle can be managed efficiently. There are more cattle grazed on that operation today than 5 years ago. Education of producers is the key.
- There is a paucity of data related to this subject in most species; resistance in small ruminants gets noticed because it involves Haemonchus and obvious clinical signs of anemia and death. Particularly in cattle, there is very little data available as to current best practices related to parasite control. More funding needs to be available to study important questions related to these issues to provide needed information to stakeholders before it is too late.
- No
- The trend in information dissemination promotes the concept that anthelmintic resistance is present all across the whole United States. There are vast areas with dry climate that do not have parasite resistance now. Producers in those areas read the lay publications and lists that encourage aggressive treatment. Use of multiple anthelmintics at one time in these situations is unnecessary, not cost effective and might actually increase resistance over time. Not all environment is parasite friendly and we should be telling clients how to improve the environment to prevent parasitism.
- Everyone needs to work together and stay on the same page in the same geographic location
- Multifactorial issue. US should look to other countries that have been dealing with this for much, much longer. Don't try to reinvent the wheel. FDA needs to have Parasitologists review, work on and advise on programs, methods of evaluating efficacy and dosing. If FDA thinks it should be spearheading resistance work, then they need to do so through the professional and academic societies where the expertise really is. Are there any parasitologists working at FDA? Has FDA talked to any of the regulatory bodies in countries experience [sic] severe resistance problems?
- We're all in this together. The above groups, I feel, are already working together to minimize in future resistance of parasites. At this moment I feel small ruminants are the most at risk.
- Understudied or under reported. Not enough information to vets and producers
- The introduction of LongRange has become one of the scariest products introduce [sic] in the cattle industry with regard to resistance.
- Timeliness is important. Waiting to make challenging decisions is a reason parasite resistance issues are here today.
- The network for Small Ruminant production in the NE of USA has been deteriorating to the point that veterinarians might not be needed. This is a scary thought. Veterinarians need to be supported to be able to help this unfortunate situation of resistance. SR farmers will do most procedures without consulting with a vet unless there is a BIG problem in the farm. At this point, sometimes, even a vet can help. Most local farmers will not be able to afford a FECRT, and certainly a Drenrite [sic] assay. I am thankful I live in the NE where the resistance is less prominent but it is reaching us as I have seen animals affected by it. The main problem is the farmers themselves listening to the drug companies. New farmers (local farmers, new generation of farmers

or sustainable agriculture farmers) are more supportive of the FAMACHA and strategic deworming. Old farmers, those that have been able to survive the demise of agriculture, are much more difficult to educate as they consider themselves experts. Support the vets, pay for the talks they give. We don'td make enough money to keep working with SR. thanks for your time, I find the subject very interesting.

- Good survey, much better than most. Small ruminant owners tend to have a word of mouth and do all kinds of weird treatment regimens.
- I think that this is an issue that the FDA CVM needs to be aware of, but stay out of. There are many other pressing issues that need to be addressed (public perceptions of antibiotics in our food, efficacy of generics) before resistance to antiparasiticides in cattle. If ANYTHING, I would hope that the FDA CVM rescinds some formulations of generic products (generic ivermectin pour-on) based on poor product performance. I know that I am seeing poor efficacy with these products, yet is [sic] I come back and use the original, name-brand product, IT WORKS. I really wish your survey would have dove deeper into this problem of generics. Very disappointed. This is the iceberg that you are going to run your ship into
- regulatory agencies should not allow food to enter the us that was produced with products not approved in the us resistance is a problem in spite of the RESISTANCE DENIERS
- Bottom line economic summaries of animals without heavy parasite burdens vs those that have heavy worm burdens, costs of drugs vs costs of pasture rotation etc.
- Only that we move quickly with new regulations, I feel like a criminal whenever I use two anthelmintics at the same time
- I am finding as a private practice equine vet that it is very difficult to get clients to think differently about their deworming programs than they always have. It is a difficult thing to change but I am continuing to "fight the good fight" and try to educate owners about responsible deworming practices and why we need to change the way we think about deworming horses. My biggest selling point for fecal egg counts has been that it can greatly reduce the amount of dewormer the horse has to get on an annual basis which is seen as a benefit to the owner either because of cost or because they want to have a more "natural" horse that receives less medication.
- It is here, it is real, it is moving from small ruminants into cattle. Has been in horses in some areas for a long time, too. We know a lot about how to control parasites that are resistant, and could know even more ... but there are not patents and no big profits for corporations in/for these solutions, so no money available to document and promote them A sorry commentary on our culture.
- FEC tests and FECRT are ideal but in reality, very few producers can actually afford to have full herd individual tests performed. I'm not really sure what the answer is for that as we all have to earn money somehow, but maybe if pharm companies or affiliated organizations offered a subsidy to producers to help with the cost of routine FECs that might help with compliance
- I find the most resistance in show animals. I can make recommendations until I am blue in the face, but producers will still call their neighbor down the road who recommend deworming once a month double strength.
- I have been harping on clients/ drug reps/ barn owners/ trainers etc for years about how parasite resistance is a HUGE problem not being heard. I tell folks that goats and sheep and even camelids are dropping like flies from Haemonchosis and no one cares since sm. ruminants/ camelids do not line anybody's pockets significantly, and we don't allow cattle to live long enough

to be a significant die-off statistic, but WAIT til the horses start dropping dead and there is nothing new on the horizon to combat the problem we have created by past indiscriminate medicinal use and where will we be?? I hope to NOT LET IT get to that point.

- The parasitic resistance to equine and cattle anthelmintics is significant.
- No
- My patient population of horses is on desert dry lots - no pasture. We do not give any antiparasitics to our horses that have a neg fecal O&P which is about 95% of our horses and we check O&Ps annually. We have been doing this for 6 years with no increase in parasite load in our population.
- Make FECRTs affordable for producers
- I am aware and concerned about this problem. However - look at how well LongRange has been accepted....this is a drug that, by its very nature, could lead to increased parasitic resistance, but those that use it see its benefits and advocate for its use. If this is the way drugs are heading, we are only speeding up the inevitable.
- we need new drugs or combos
- The questions make the outcome measures predictable. Lawyers would call this survey "leading the witness". Suggest a [sic] Objective questions be asked next time.
- In equine, the largest problem I have seen is resistance of Strongylus vulgaris to benzimidazoles. Semiannual macrocyclic lactone with daily pyrantel has been the most effective treatment strategy for Strongylus vulgaris that I have seen in practice. Horses have many occult infections of Strongylus vulgaris with false negatives on fecal examination. I have seen this on multiple horses with colic that I have done serial fecals with negative results. I have peformed [sic] necropsies on many of these horse secondary to euthanasia due to colic finding a heavy load of Strongylus vulgaris both in the adult stage and encysted stage. Horses on semiannual macrocyclic lactones with daily pyrantel rarely if ever colic and I have never performed a necropsy on one of these horses (usually secondary to trauma) and found encysted or adult Strongylus vulgaris.
- the lay public can buy dewormers for anywhere from $4 to $15 per tube. fecal egg counts cost $20-40 each, when you include the shipping to the lab. there is no way the public are going to agree to do fecal egg counts and deworm based on them when just giving a dewormer is considerably cheaper. the public in general does not care enough about resistance to spend more money to prevent it. large farms might agree to this type of plan, but private individuals with a few horses will not. this is not an issue that education will resolve. you must look at the economics from the client's perspective.

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