320 (2026) 106847

Contents lists available at ScienceDirect

The Veterinary Journal

journal homepage: www.elsevier.com/locate/tvjl

Antimicrobial practices for *Mycoplasma* infections in cattle: A survey of veterinary practitioners in light of current scientific evidence and national guidelines

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ARTICLE INFO

Keywords:
Cattle
Mycoplasmas
Antimicrobial use
Veterinarian
Questionnaire

ABSTRACT

Mycoplasmas are major pathogens in cattle, causing respiratory disease, mastitis and arthritis, and leading to significant economic losses. These pathogens' microbial characteristics complicate diagnosis, treatment, and the performance of certain laboratory assays such as antimicrobial susceptibility testing (AST). Based on a dedicated survey, this study is the first international investigation of diagnostic and treatment strategies used by cattle veterinarians to manage mycoplasma infections. It also assesses how closely these practices align with current scientific evidence and regulatory recommendations. The survey was led by the MyMIC consortium, whose primary objective is to standardize AST methods for livestock mycoplasmas. The survey collected 270 responses from cattle veterinarians across 40 countries worldwide. PCR was the most commonly used diagnostic method, while culture and AST were performed less frequently. Macrolides, florfenicol and tetracyclines were the preferred antimicrobials, in line with current guidelines. However, some prescription practices deviated from recommendations, including the use of ineffective antimicrobial classes (e.g., beta-lactams and trimethoprim/sulfonamides) or of critically important antimicrobial classes as well as inappropriate dosing or duration regimens. These findings emphasize the need for coordinated actions at multiple levels: promoting the use of AST by veterinarians, disseminating updated diagnostic and treatment recommendations, and developing standardized guidelines and procedures for AST in livestock mycoplasmas. The MyMIC consortium has established an inventory of veterinary strategies for antimicrobial use and diagnosis, including resistance surveillance, thereby contributing to improved antimicrobial stewardship and to the health of livestock systems affected by mycoplasmoses. Continued support of this initiative is strongly recommended.

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https://doi.org/10.1016/j.tvjl.2026.106847
Accepted 24 August 2026
Available online 25 August 2026

1. Introduction

Mycoplasmas are bacteria responsible for many diseases in livestock. Several *Mycoplasma* species are implicated in diseases in cattle such as *Mycoplasma mycoides* subsp. *mycoides*, *Mycoplasma bovis, Mycoplasma dispar* and *Mycoplasma californicum.* Some others species such as *Mycoplasma bovirhinis*, *Mycoplasma arginini, Mycoplasma alkalescens*, and *Mycoplasma bovigenitalium* are considered part of the resident microbiome, with limited or no direct pathogenic role. Hemoplasmas (e.g. *Mycoplasma wenyonii* or *'Candidatus* Mycoplasma haemobos') are also part of this genus but are less known in cattle.

M. bovis is one of the most predominant pathogenic *Mycoplasma* species worldwide and can affect cattle of all ages (neonatal, preweaned, postweaned, and adult) across different production categories, including dairy, beef, and rearing cattle (Dudek et al., 2020). This pathogen is associated with BRD, mastitis, arthritis, and otitis media, with the first two being the most common. Many studies have shown high prevalence and widespread occurrence of this pathogen worldwide (Buczinski et al., 2024; Dudek et al., 2020; Haapala et al., 2021; Jaÿ et al., 2021; Jordan et al., 2021; Maunsell et al., 2011; Sultana et al., 2023). In both mastitis and BRD, intermittent bacterial shedding and the chronic nature of infection complicate aetiological diagnosis, yet accurate identification remains essential because these syndromes involve multiple pathogens. When *M. bovis* is suspected, targeted PCR could easily be performed. Other molecular methods, such as multiplex-PCR or PCR-Denaturing Gradient Gel Electrophoresis (DGGE) or whole genome sequencing (PathoSense - available in different European countries), allow the simultaneous detection of co-infecting agents (Jaÿ et al., 2025). These molecular methods are then widely used by field veterinarians. But some other *Mycoplasma* species could be present and evade these specific diagnostic methods, as non-targeted. Culture enables the isolation of a large panel of *Mycoplasma* species from clinical cases, but it is slow and technically demanding, as it requires specialized equipment and media for these peculiar bacteria: not all laboratories have the expertise to perform it routinely. Due to the diversity of *Mycoplasma* species, accurate species-level identification is essential for guiding diagnosis, treatment, and control strategies.

As part of the *Mollicutes* class and due to the lack of cell-wall, bacteria of the genus *Mycoplasma* are intrinsically resistant to antimicrobial classes that target the cell-wall synthesis like beta-lactams, glycopeptides, fosfomycin and polymyxins. They also do not synthesize folic acid, making them naturally resistant to sulfonamides and trimethoprim. Conversely, mycoplasmas are susceptible to antimicrobials that act on proteins like macrolides, tetracyclines, florfenicol, lincosamides and aminoglycosides, or those that act on DNA, like fluoroquinolones (Heuvelink et al., 2016; Lysnyansky and Ayling, 2016). Most of these antimicrobial classes are reported in national guidelines that guide veterinarians in treating mycoplasma infections depending on the clinical presentation. Although effective treatments and control measures have been well documented, a broad variability in resistance to antimicrobial classes effective against mycoplasmas, particularly *M. bovis*, has been reported worldwide in many studies (Bokma et al., 2020; Cai et al., 2019; García-Galán et al., 2020; Gautier-Bouchardon et al., 2014; Heuvelink et al., 2016; Jaÿ et al., 2021; Klein et al., 2017; Klein et al., 2019). Treating mycoplasmoses in cattle remains challenging, especially for the main clinical presentations associated with *M. bovis*, including BRD and mastitis.

In acute BRD cases, an early antimicrobial treatment represents the best opportunity to control disease, and florfenicol, tetracyclines, or macrolides are recognized as effective in the scientific literature (Calcutt et al., 2018). Early diagnosis and isolation of infected animals are also often recommended (Dudek et al., 2020). Beneficial use of metaphylactic, and also prophylactic antimicrobial treatment to prevent BRD in feedlot beef cattle have been demonstrated in several surveys (Godinho et al., 2005; Hendrick et al., 2013; Rérat et al., 2012; Sultana et al., 2023). However, in many countries, these treatment methods have been restricted or banned due to their effect on the development of antimicrobial resistance. The frequent association of mycoplasmas with other pathogens and the chronic nature of respiratory disease could result in treatment failure (Andrés-Lasheras et al., 2024; Caswell and Archambault, 2007) leading to significant economic impacts.

Mycoplasma mastitis remain highly contagious and cause significant loss in milk production (Maunsell et al., 2011). The fact that infected cows often remain subclinical, also contributes to the persistence of intermittent shedders within the herd (Gelgie et al., 2024; Nicholas, 2011; Nicholas et al., 2016). Culling of infected animals is generally the primary measure to take, mainly due to the lack of effective treatment.

The challenge of treatment in the field is reinforced by the lack of methods to assess antimicrobial susceptibility of mycoplasmas. Due to the slow growth and culture media requirements of mycoplasmas, standard methods for antimicrobials susceptibility testing (AST) are not applicable. The effectiveness of antimicrobials is assessed by *in vitro* measurement of the minimum inhibitory concentrations (MIC) and some guidelines for *in vitro* testing of veterinary *Mycoplasma* species have been published a long time ago (Hannan, 2000). However, the *in vivo* efficacy of antimicrobials from *in vitro* MIC values is difficult to extrapolate as no *in vitro* testing standards and no clinical breakpoint concentrations (CBPs) have been determined (Jaÿ et al., 2025).

To fill the gap on AST of mycoplasmas, an international consortium of 22 research institutes from 18 countries established in 2023, called MyMIC, and supported by the Joint Programming Initiative on Antimicrobial Resistance (JPIAMR) organisation has been created (Jaÿ et al., 2025). The aim of this network is to standardize AST and propose clinical interpretation in livestock mycoplasmas. To achieve these objectives, one part of the project was to evaluate field practices of veterinarians concerning diagnosis and treatment of *Mycoplasma* infections in livestock. A survey, by mean of a specific questionnaire, was then performed to collect data from veterinarians worldwide on their use of antimicrobials, and their practices of diagnostic methods and AST in case of *Mycoplasma* infections in cattle, swine and poultry. The aim of this study is to present the results of this survey for cattle veterinarians on diagnostic approaches and antimicrobial use, and to compare them with practices recommended by scientific evidence and national guidelines.

2. Material and methods

2.1. Survey

The survey was developed to collect data on veterinarians' treatment practices worldwide in case of *Mycoplasma* infections in cattle, swine and poultry. Details for the whole questionnaire construction and diffusion have been previously published for swine (Hollard et al., 2026). For questions related to frequency of certain practices, a five-point scale (never, rarely, occasionally, often, always) was employed. The intermediate scale levels were defined as follow: "Rarely" meant the frequency was less than 1 in 10 cases; "Occasionally" referred to a frequency between 1 in 10 and 1 in 2; "Often" meant the frequency was greater than 1 in 2. Some questions in the survey used percentage-based intervals, but the boundaries of these intervals were not explicitly defined. This may have led to variations in how respondents interpreted the categories, although the aim was not to obtain precise quantitative values. Some may have responded based on a specific condition, but since we didn't explicitly ask them to differentiate between conditions like mastitis or BRD, we could only interpret the responses globally, without distinguishing between disease types.

2.2. Data handling and statistical analysis

Data were collected anonymously, but veterinarians were free to leave their email address at the end of the questionnaire if they wanted to be informed of the outcome of the survey. The collected data were exported in a Microsoft® Excel file and calculations of percentage and graphics were performed in RStudio (R Core Team., 2024) for each species separately. Data for cattle are presented in this study. The comparison of implementation of metaphylactic treatment in European countries vs. others was done using a Pearson's Chi-squared test. Due to low expected counts in several cells of the original 5-category contingency table (never, rarely, occasionally, often and always), data were analysed in grouped categories (rarely or never, occasionally, frequently).

Table 1 summarizes veterinarians' dosing practices (dose and duration) for treating *Mycoplasma* infection in cattle, compared with the Summary of Product Characteristics (SmPC) applicable in their countries. Each response was provided as a free-text field, allowing veterinarians to describe dosage regimens in their own words. Each free-text response was then interpreted in relation to the SmPC of the antimicrobial class chosen by veterinarians as preferred option treatment for each cattle category. When the free-text field referred to a dosage component (e.g. a dose or a duration), and the respondent selected multiple antimicrobial classes for different production categories without specifying distinct dosages per class, the same dosage was compared individually to the SmPCs corresponding to each molecule cited in those categories. The number of boxes in the table is therefore greater than the number of respondents to the dosage question. SmPCs were found in different drugs databases depending on the country (European Medicines Agency, 2025c; AntiMicrobial Consumption and Resistance in Animals, 2025; Australian Pesticides and Veterinary Medicine Authority APVMA, 2025; Government of Canada, 2010; Veterinary Medicine Directorate, 2025; South African Health Products Regulatory Authority SAHPRA, 2022; Ministerio de Sanidad, 2025).

Table 2 provides the antimicrobial classes recommended for *Mycoplasma* infection in cattle, according to the type of disease, based on national guidelines from various countries issued by veterinary associations with or without support from government, Health or Food authorities. References are available in the legend of Table 2.

3. Results

3.1. Demographic features of cattle veterinarians who answered the study

Among the 469 respondents to the survey from 40 countries, 270 were from veterinarians working with cattle. The responses, represented in Fig. 1, came from France (n = 101), Canada (n = 30), United Kingdom (n = 22), Sweden (n = 13), Switzerland (n = 13), Austria (n = 11), Germany (n = 11), Pakistan (n = 11), Belgium (n = 8), Finland (n = 7), South Africa (n = 7), The Netherlands (n = 5), Australia (n = 4), Hungary (n = 4), and Italy (n = 3). Fewer responses came from Argentina, the Czech Republic, Israel, Kenya, Mauritania and Turkey (n = 2 for each country) and from Burkina Faso, New-Zealand,

Table 1
Number of veterinarian's responses regarding dose and duration treatment per production category and antimicrobial class (n = 431).

Production category			Dairy cattle (n = 130)						Cattle rearing (n = 165)						Beef cattle (n = 136)						
Antimicrobials			Florfenicol	Tetracyclines	Macrolides	Lincosamides	Fluoroquinolones	Other molecules	Florfenicol	Tetracyclines	Macrolides	Lincosamides	Fluoroquinolones	Other molecules	Florfenicol	Tetracyclines	Macrolides	Lincosamides	Fluoroquinolones	Other molecules	
	dose	duration	15	30	61	4	13	7	38	28	72	10	12	5	27	21	70	6	10	2	n
Strategies compliant to SmPC indication	=	=	4	11	24	3	7	5	13	8	33	4	3	4	9	6	29	2	3	2	170
	=	?	2	2			1		1	1		1	1		1	1	1	1	1		14
	?	=	1	7	3	1			3	1	13				1	2	12	3			47
extended duration	=	↗	4	6	14		1	2	15	12	13	2	4	1	9	9	15		2		109
	?	↗	2	2	18				3	3	11	3			6	1	11		1		61
	↗	↗					1		2				1								4
	↘	↗		1						1						1					3
	=	↘					1						1						1		3
	↗	=	1		1		1			1	1		1				1		1		8
	↘	=	1										1						1		3
	↗	?		1	1		1		1	1	1				1	1	1				9

↗, increased dose or duration; ↘, decreased dose or duration; = , dose or duration corresponding to the SmPC. The three first lines show answers compliant with the SmPC, the four following show a longer duration than SmPC indications. Grey boxes indicate doses and durations not compliant with the SmPC, that could be detrimental for antimicrobial resistance. When veterinarians reported a single dosage without specifying the antimicrobial class, but selected different antimicrobial classes for each cattle production category, the reported dosage was applied to each chosen class within each category. Consequently, the number of entries in the table exceeds the number of respondents to the dosage question.

Table 2
National Guidelines provided by National Veterinary Associations or Ministries for Mycoplasma infections in cattle.

Guidelines provided by	*National Veterinary Associations supported by the Government*						*Health or Food Ministries*				
Country	Canada		Australia		Switzerland		Finland			Spain	Italy
Category	Dairy cattle	Beef cattle	Dairy cattle	Cattle rearing & beef cattle	Cattle rearing	Beef cattle	Dairy cattle	Cattle rearing	Beef cattle	Cattle	Dairy cattle
BRD (associated with Mycoplasma bovis*)*	**Florfenicol*** **Oxytetracycline dihy.** Oxytetracycline hyd. Tilmicosin* Tulathromycin*	**Florfenicol** Tilmicosin Tulathromycin *Danofloxacin* *Enrofloxacin*	**Oxytetracycline** **Tulathromycin**	**Florfenicol** **Tilmicosin** **Tulathromycin**	**Florfenicol** Tetracyclines *Fluoroquinolones*	ND	**Oxytetracycline**	Macrolides		Florfenicol **Tetracyclines** Tylosin Tilmicosin Tulathromycin Lincosamides *Marbofloxacin* *Enrofloxacin*	**Tetracyclines** Macrolides Lincosamides *Quinolones*
Otitis media	**Florfenicol*** **Oxytetracycline dihy.** Tilmicosin* Tulathromycin* *Enrofloxacin*	**Florfenicol** Oxytetracycline hyd. Tilmicosin Tulathromycin *Enrofloxacin*	ND	**Florfenicol** **Tilmicosin** **Tulathromycin**	Florfenicol **Tetracyclines** *Macrolides* *Fluoroquinolones*	ND	**Oxytetracycline**	Macrolides		ND	ND
Arthritis	ND		**Oxytetracycline** **Tulathromycin**	**Florfenicol** **Tilmicosin** **Tulathromycin**	**Tetracyclines** Enrofloxacin		**Oxytetracycline**			ND	**Tetracyclines** Macrolides Lincosamides *Quinolones*

Guidelines provided by	National Veterinary Associations				
Country	Belgium	Germany**	Netherlands	Sweden	USA
Category	Dairy cattle, Cattle rearing & Beef cattle		Cattle rearing & Beef cattle	Cattle	Cattle
BRD (associated with Mycoplasma bovis)	**Florfenicol** Doxycycline Oxytetracycline Tilmicosin Tulathromycin Tylosin Lincomycin + Spectinomycin *Danofloxacin* *Difloxacin* *Enrofloxacin* *Marbofloxacin*	Tetracyclines Macrolides Lincosamides Pleuromutilins Fluoroquinolones	**Florfenicol** **Oxytetracycline** Tylosin Tulathromycin *Enrofloxacin* *Marbofloxacin*	Florfenicol Oxytetracycline Gamithromycin Tulathromycin	**Florfenicol** **Gamithromycin** **Tulathromycin** **Danofloxacin** **Pradofloxacin** *Enrofloxacin*
Otitis media	**Florfenicol** Doxycycline Oxytetracycline Tilmicosin Tulathromycin Tylosin *Danofloxacin* *Difloxacin* *Marbofloxacin*		**Florfenicol** **Tilmicosin** Tulathromycin **Tylosin** *Enrofloxacin*	ND	ND
Arthritis	#		**Oxytetracycline**	ND	ND

(*continued on next page*)

Table 2 (*continued*)

Guidelines provided by	National Veterinary Associations				
Country	Belgium	Germany**	Netherlands	Sweden	USA
Category	Dairy cattle, Cattle rearing & Beef cattle		Cattle rearing & Beef cattle	Cattle	Cattle
	<u>Lincomycin + Spectinomycin</u> *Enrofloxacin*		**Tilmicosin** **Tylosin** <u>Tulathromycin</u> *Enrofloxacin*		

ND, No data. Antimicrobials which are shown in **bold** are those recommended as first-choice treatments, those in underline are recommended as second-choice treatments, and those shown in *italics* are recommended as third-choice treatments. These guidelines were found in: (AntiMicrobial Consumption and Resistance in Animals, 2025; Arrigoni et al., 2023; Australian Veterinary Association AVA, Animal Medicines Australia AMA, Dairy Australia, 2022; Australian Veterinary Association AVA, Animal Medicines Australia AMA, Meat and Livestock Australia MLA, 2024; The Swedish Veterinary Association, 2013; Australian Veterinary Association AVA (2024); Bundestieraerztekammer BTK, 2015; Canadian Veterinary Medical Association (CVMA) and Agriculture and Agri-Food Canada, 2008; D'Hoe et al., 2017; Elintarviketurvallisuusvirasto (Evira) and Faculty of Veterinary Medicine (FVM) of Helsinski, 2016; Maunsell et al., 2011; Ministero della Salute, Republic of Italy, 2023; Ministerio de Sanidad, 2025; Faculté Vetsuisse (OFAV), Société des Vétérinaires Suisses (SVS), Office fédéral de la sécurité alimentaire et des affaires vétérinaires (OSAV), 2022).

*The Canadian guidelines precise that Tilmicosin and Tulathromycin must not be used in lactating dairy cattle and only in dairy cattle under 20 months of age.

**The German guidelines provide a general list of antimicrobials for treatment of mycoplasma infections.

#The Belgian guidelines precise that no antimicrobial is authorized for the arthritis indication, the veterinarians should then determine the pathogen's entry point (pneumonia / infected wound / umbilical infection) and treat according to the indication for these conditions.

Nigeria, Norway, Poland, Romania, Saudi Arabia and Thailand (n = 1 for each country).

Veterinarians involved in cattle treatment that contributed to the survey mostly had between 6 and 15 years of experience as practitioners (n = 96), followed by those over 25 years (n = 72), between 16 and 25 years (n = 69), and less than 5 years (n = 33). Most veterinarians worked in mixed practice (n = 153) or were specialized in cattle (n = 118), while less were specialized in poultry (n = 9) and pigs (n = 7) or worked in other veterinary fields like small ruminants, or in research or academia (n = 12). Concerning the size of the veterinary practices (i.e., number of veterinarians employed), the majority of the respondents worked in rather small practices: 90 veterinarians answered between 1 and 3, 89 worked with 4–6 other veterinarians, 48 with over 10 veterinarians and finally 43 with 7–9 veterinarians.

The cattle production categories in which the survey veterinarians worked with were dairy cattle (n = 219), beef cattle (n = 188) and cattle rearing (n = 149). To a lesser extent, these veterinarians also worked with pig nursery, weaning piglets, fattening pigs and breeding sows (n = 23, 22, 29 and 25 respectively) and with layers, breeders and broilers chickens and meat turkeys (n = 25, 17, 27 and 9 respectively). Only responses concerning cattle are presented in this study.

3.2. *Mycoplasma species frequently found in cattle*

Almost all respondents working with cattle (n = 270) came across *Mycoplasma* infection at least once in their practice (n = 244) and very few didn't (n = 26) whatever the country. *Mycoplasma* infections were mostly encountered in cattle rearing (n = 152), in dairy cattle (n = 138) and then in beef cattle (n = 114). Only a few veterinarians reported encountering mycoplasmas in just one production category (n = 19 for dairy cattle, n = 18 for beef cattle and n = 33 for cattle rearing).

The *Mycoplasma* species most commonly associated with clinical signs in cattle cited by veterinarians was *M. bovis* regardless of the production category as it represented 78.8% of answers (n = 130) in cattle rearing, 80.0% (n = 124) in dairy cattle and up to 81.3% (n = 100) in beef cattle. In a few cases, veterinarians were unsure of the *Mycoplasma* species they were dealing with (n = 18, 23 and 18 for the three different categories, respectively). Other *Mycoplasma* species were mentioned only in a few cases and were always cited in association with *M. bovis*. *M. dispar* was reported by five veterinarians in dairy cattle, five in cattle rearing and one in beef cattle. *M. bovirhinis* was cited once in each of the three cattle production categories. In dairy cattle, *M. californicum* and *Mycoplasma putrefaciens*, a species usually isolated in goats, were each reported once. Finally, *M. wenyonii*, which is a hemoplasma, was mentioned three times.

Fig. 2 presents the proportion of animals affected in case of clinical disease due to *Mycoplasma* infection. More than half of the veterinarians (n = 117, 52.7%) indicated that less than 10% of the animals were affected.

3.3. *Diagnostic method and AST performance frequency*

In cases of a suspected mycoplasma infection based on clinical signs, diagnostics tests were used with different frequency: always 11.9% (n = 27), often 27.9% (n = 63), occasionally 27.0% (n = 61), rarely 23.0% (n = 52), never 10.2% (n = 23).

As shown in Fig. 3, the diagnostic method performed most often was PCR (n = 172, 42.5%). Responses classified as 'Other' (n = 4, 1%) for this question are provided in the figure caption. These few results should be interpreted with caution, as they mostly refer to complementary examinations rather than primary diagnostic methods.

Fig. 4 presents the number of veterinarians that performed AST for mycoplasmas. Only 22.9% of veterinarians asked for ASTs in more than half of the cases of confirmed mycoplasma infections (often, n = 35 or always, n = 17). Among veterinarians who use culture 30% (n = 21/70) performed AST often or always, compared to 15.5% (n = 31/200)

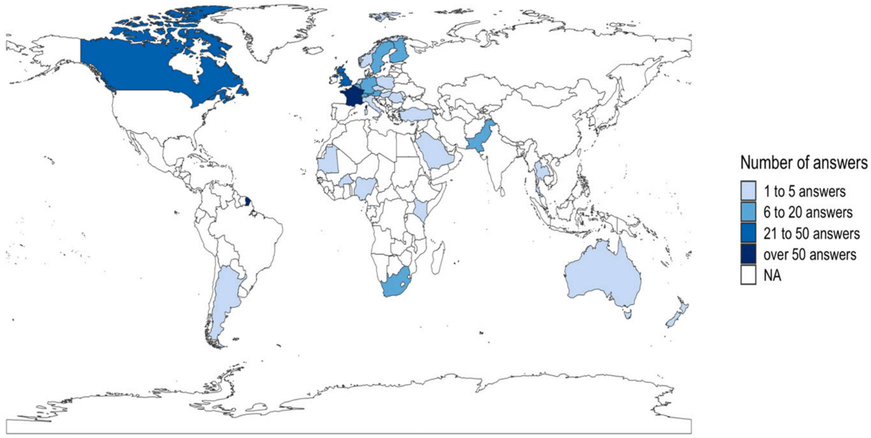

Fig. 1. Geographical Distribution of Survey Participants (n = 270). Shades of blue represent the variations of number of answers per country to the question “In which country do you work as a veterinary practitioner?”.

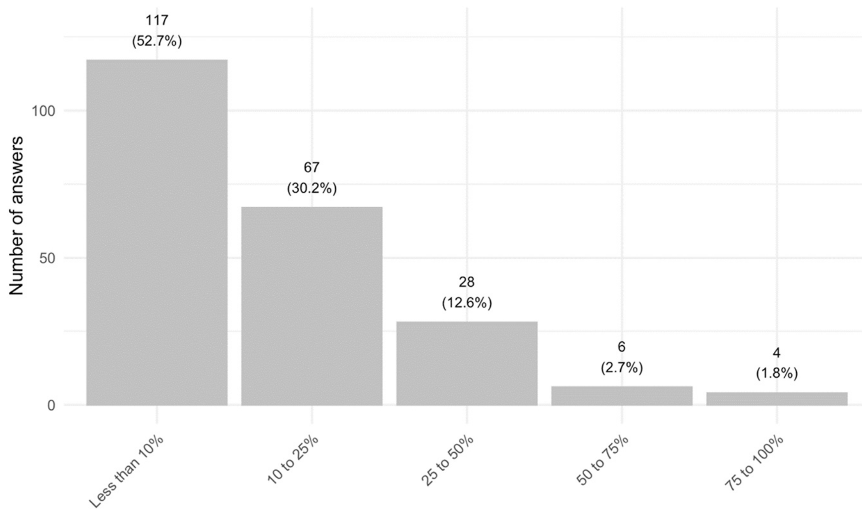

Fig. 2. Proportion of animals affected in case of clinical disease due to mycoplasma infections (n = 221). This graph represents the number of answers (y-axis) given to the question “What is the proportion of animals affected when you encounter a clinical infection with Mycoplasma?”. Percentages are indicated in brackets for each number.

among those who did not.

Differences were observed between countries, though the limited number of responses calls for cautious interpretation. The countries where AST was reported as done often or always in more than half of the answers were United Kingdom (n = 13/21), Germany (n = 5/9), Belgium (n = 4/7), Italy (n = 2/3), Romania (n = 1/1) and Turkey (n = 1/1).

3.4. *Conditions of treatment in case of cattle mycoplasma infection*

When managing mycoplasma infections, the veterinarians believed that treatment was necessary: always 40.1% (n = 91), often 40.5% (n = 92), occasionally 13.2% (n = 30), rarely or never 3.1% (n = 7).

The primary reason veterinarians cited for administering treatment in cases of infection was in priority the severity of clinical signs (n = 193, 45.8%), and then the results of the laboratory testing (n = 82, 19.5%), the risk of rapid spread of the disease (n = 57, 13.5%), the percentage of diseased animals (n = 55, 13.1%), the request from farmers or industries (n = 25, 5.9%). To complete their responses, some veterinarians mentioned never initiating treatment in case of *M. bovis* mastitis (n = 3) and one mentioned that clinically ill animals were usually treated before mycoplasma diagnosis. The implementation of vaccination instead of treatment was also a reason cited by one veterinarian working with beef cattle and cattle rearing.

The primary reason why veterinarians chose not to treat animals for mycoplasmoses was the expected lack of efficacy (n = 115, 41.2%). The other motivations reported were: treatment costs (n = 54, 19%), logistical challenges related to withdrawal times (n = 41, 14.4%), legal restrictions (n = 22, 7.7%), and concerns about the impact of treatment on trade or the industry agreements (n = 12, 4.2%). Among the veterinarians who reported other reasons for not initiating treatment, 12 mentioned that the clinical signs impacted their decision (either absent or too severe, euthanasia being mentioned then) and 5 mentioned that culling of affected animals was carried out instead of implementing treatment, especially for dairy cattle. Vaccination and the farmer’s refusal were also cited once. In contrast, when having to precise the reasons why they decided not to treat, 18 veterinarians insisted on the fact that they always treat *Mycoplasma*-diseased animals.

3.5. *Preferred option treatment applied to mycoplasma infections in cattle*

To make their choice for treatment, the veterinarians primarily referred to national treatment guidelines (n = 108, 27.7%), farm history (n = 92, 23.6%), and overview of antimicrobial susceptibility of the

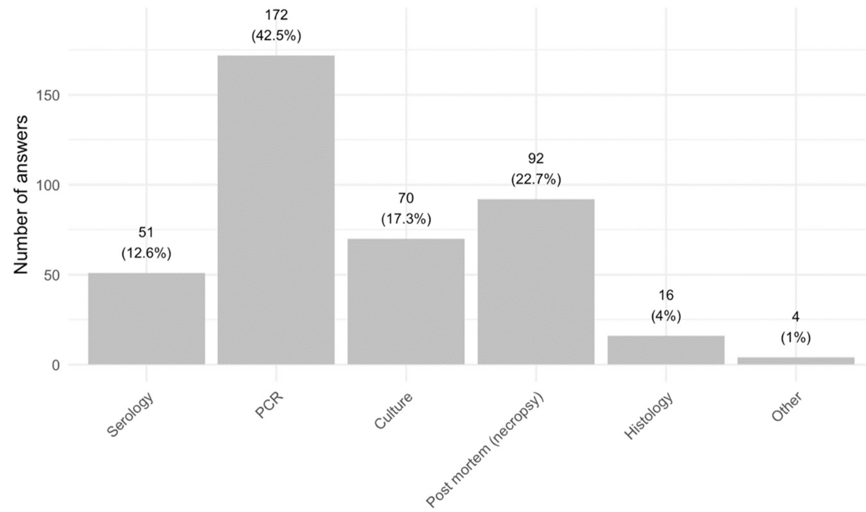

Fig. 3. Additional diagnosis performed by veterinarians in case of suspected mycoplasma infections (n = 405). This graph represents the number of answers (y-axis) given to the multiple-choice question "If yes, what additional diagnosis?". Serology, PCR and culture are targeted methods, whereas the others (necropsy, histology and the other answers reported) are conclusive about the disease but are not able to confirm the aetiological pathogen. The other answers reported were: "Immunohistochemistry on the pulmonary lesions; Blood smear and PCR if M. wenyonii is suspected; Nasal swab; Transtracheal lavage." Percentages are indicated in brackets for each number.

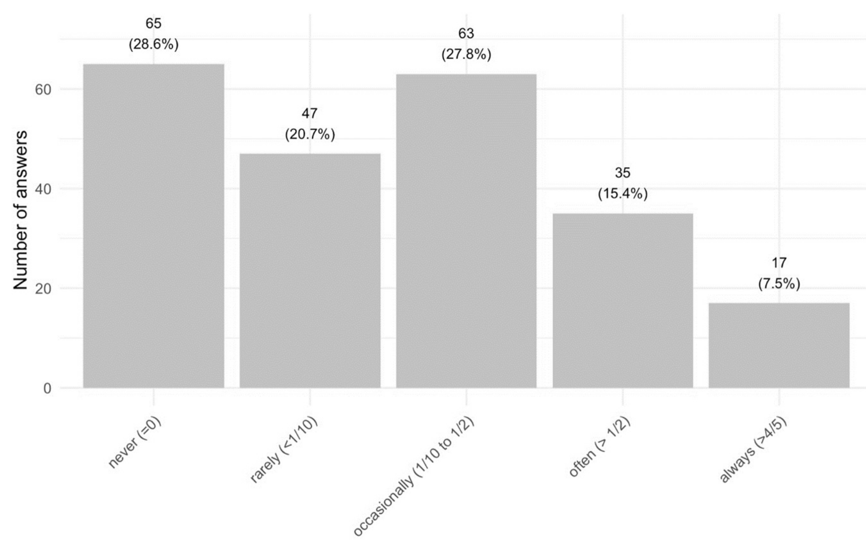

Fig. 4. Number of veterinarians that perform or have a third party perform antimicrobial susceptibility test in case of suspected mycoplasma infection (n = 227). This graph represents the number of answers given to the single-choice question "Do you perform (or let a third party perform) antimicrobial susceptibility tests?". Percentages are indicated in brackets for each number.

etiological agent (n = 82, 21%). Other motivations were the economic feasibility of the treatment (n = 59, 15.1%) and the AST results (n = 47, 12.1%).

The preferred option treatment for each production category is presented in Fig. 5. Macrolides were the first choice for the three cattle production categories. Florfenicol and tetracyclines were respectively the second and third most selected antimicrobials except for dairy cattle, for which tetracyclines were the second most selected and florfenicol the third. Then, fluoroquinolones were reported as the 4th most commonly used antimicrobial class. Finally, 9.6% (n = 16) of veterinarians preferred not to treat dairy cattle in case of mycoplasma infections, due to the lack of effective or authorized treatment, especially for mastitis (n = 6/13). Other categories were far lesser reported.

Among the 269 cattle veterinarians, 221 responded to the open question regarding the dosage. They were asked to specify the criteria used for the prescribed dosage for each antimicrobial class and each cattle production category. Therefore, 167 responses were provided for dairy cattle, 190 for cattle rearing and 163 for beef cattle. For a few respondents, no treatment was indicated (n = 25). Among the 495 answers collected for this question, 431 (87.1%) were interpretable as they included a mention of either a dose or a duration that could be compared to the corresponding SmPC. The results – including the detailed numbers of responses per antimicrobial class and category - are presented in Table 1. According to these results, the veterinarians declared to follow the SmPC indications in 231 responses (53.6%), but the information about the duration and the dose of treatment was not provided in 14 and 47 cases respectively. The main deviation from the SmPC indications was the extended duration of treatment (177 cases; 41.1%).

3.6. Second-choice treatment in case of failure

In case of failure, 213 veterinarians reported their second-line

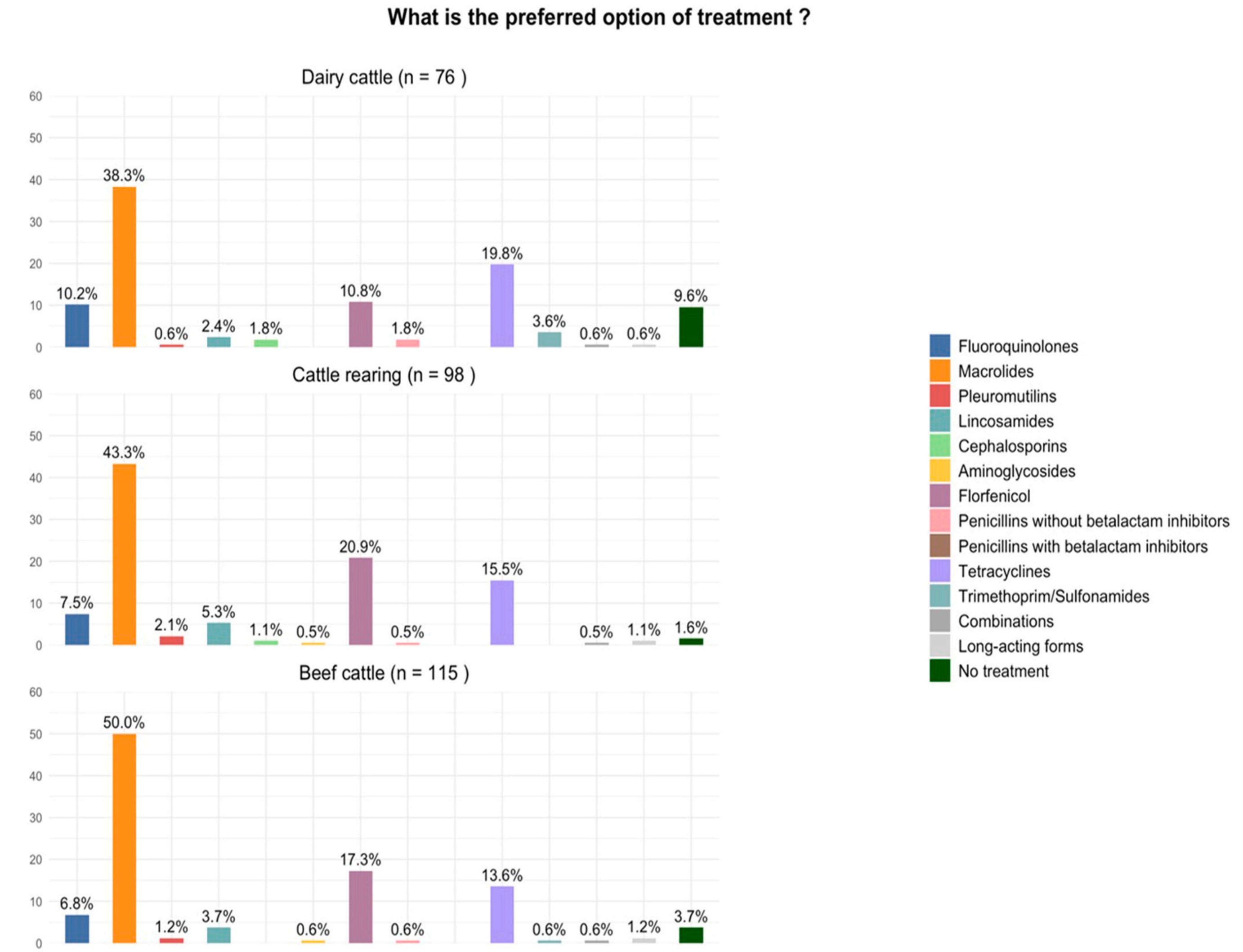

Fig. 5. Preferred option treatment for each cattle production category. Each graph shows the percentage of answers for one antimicrobial family to the question "What is the preferred option of treatment?". Numbers of answers vary per production category according to the number of veterinarians treating these categories. Veterinarians could only select one antimicrobial family per category. Some veterinarians clarified that they used macrolides long-acting formulations (n = 1, n = 4 and n = 9 for dairy cattle, cattle rearing and beef cattle, respectively).

treatment. Fluoroquinolones were the most used antimicrobials (n = 59), followed by macrolides (n = 39) and florfenicol (n = 36) as shown in Fig. 6. Some veterinarians also reported that no treatment was done in second intention (n = 20), primarily because of the expected lack of efficacy of a second treatment (n = 18) and then for economic reasons (n = 2).

3.7. *Use of metaphylactic treatment*

To the question "Do you perform metaphylactic treatment for *Mycoplasma* infections?", the veterinarians could only answer once, from a general point of view. No major differences were observed according to the main categories treated by the respondents (data not shown). More than half of respondents answered that they never (n = 89, 39.4%) or rarely (n = 52, 23%) performed metaphylactic treatment, some performed it occasionally (n = 42, 18.6%) or often (n = 34, 15%) and a very few performed it always (n = 9, 4%). The comparison of implementation of metaphylactic treatment in Europe vs. other countries was done using a Pearson's Chi-squared test. No significant difference (χ^2 = 3.81, df = 2, p-value = 0.149) was found between European (n = 174) and non-European (n = 53) countries in the usage of metaphylactic treatment.

The reasons proposed for the use of metaphylactic treatment were similar to those of therapeutic treatment. For metaphylaxis, the respondents chose first the percentage of diseased animals (n = 86, 33.2%), then the severity of clinical signs (n = 65, 25%), the risk for a rapid spread of the disease (n = 62, 23.9%), the results of laboratory diagnostic (n = 21, 8.1%) and the request from farmer or industry (n = 20, 7.7%). The most common application routes of metaphylactic treatment for each antimicrobial class are shown in Supplementary Figure 2. Parenteral routes were the most commonly employed when a metaphylactic treatment was applied. Among them, the intravenous injection was rarely reported, except for fluoroquinolone and trimethoprim/sulphonamides treatments, for which around 30% was reported. *Per os* administrations account for less than 10% of the responses, except for pleuromutilins and tetracyclines (14.3% and 29.1% respectively).

3.8. *National guidelines for cattle mycoplasma infections*

In order to compare veterinarians' practices with recommendations, national guidelines have been compiled in Table 2. While most countries provide such guidelines for treatment, only a few - such as the Republic of Ireland, New Zealand, and Finland - have implemented specific indications for eradication or control programs without antimicrobial use

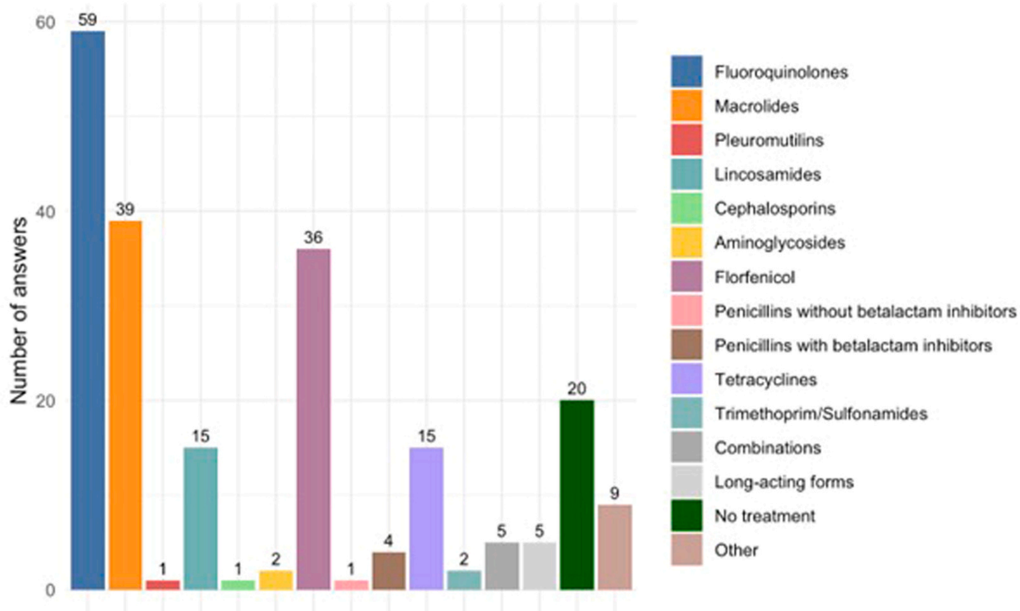

Fig. 6. Second choice of treatment applied by veterinarians in case of failure of treatment all categories combined (n = 214). this graph represents the number of answers given to the single-choice questions "in case of failure of treatment, what is the second choice of treatment available?".

(Dudek et al., 2020). The majority of the guidelines listed in Table 2 focus exclusively on *M. bovis* with its diverse clinical aspects. The guidelines for mastitis have not been included in the table, as the main recommendations given are not to treat in Italy, Canada and Switzerland (Arrigoni et al., 2023; Canadian Veterinary Medical Association CVMA and Agriculture and Agri-Food Canada, 2008;European Parliament (2023); Faculté Vetsuisse OFAV, Société des Vétérinaires Suisses SVS, Office fédéral de la sécurité alimentaire et des affaires vétérinaires OSAV, 2022), culling is even advised in Finland, USA and Australia (US Food and Drug Administration and Medicine Center for Veterinary, 2024; Australian Veterinary Association AVA, Animal Medicines Australia AMA, Dairy Australia, 2022; Elintarviketurvallisuusvirasto Evira and Faculty of Veterinary Medicine FVM of Helsinski, 2016; Maunsell et al., 2011).

4. Discussion

This is the first study evaluating veterinary practices with regard to mycoplasmoses in cattle worldwide. With 469 answers collected in 40 countries, and 270 from cattle veterinarians, this study represents a high participation of livestock veterinarians providing a robust insight in veterinary practices concerning mycoplasma infections worldwide and particularly in Europe. The large number of responses from cattle veterinarians (n = 270) and the diversity of their practice profiles provide the first representation of both the most used diagnostic methods and the antimicrobials used for treating mycoplasma infections in cattle. However, the high number of responses from cattle veterinarians from France (37.4%) and Canada (11.1%) may reflect stronger local engagement or an initial distribution bias and constitutes a geographical coverage bias that may affect generalisability of the results. Even though some veterinarians dealt with other animal species (n = 28), most of the respondents treated only cattle (n = 118) or worked in mixed practices (n = 153), the answers can then be considered as representative of cattle practitioner specialists. Some answers could be considered as unclear, but they represent the unrefined data as we chose to stick to the questionnaire and not to extrapolate when not possible. For example, the majority of the questions referred to "mycoplasma infections" and it was not possible to know which diseases were most thought of by the vets (e.g., mastitis versus BRD) nor which production category was considered when answering. The few veterinarians who encountered mycoplasmas in only one production category were too scarce to analyse them alone. Our analysis is therefore global, primarily considering *M. bovis* as the main species encountered, and does not distinguish between BRD, mastitis, arthritis or otitis unless specified.

The results of the survey point out some inconsistencies the diagnostic practices in case of mycoplasma infection in cattle. Firstly, the fact that most veterinarians report encountering *M. bovis* as the main mycoplasma species is likely related to good diagnostic practices, as 67.1% of them routinely use lab diagnosis. However, the first diagnostic method used by veterinarians was PCR in 42.5% of cases, while culture, mentioned in 17.3% of cases, is useful when AST is intended to be run (Dudek et al., 2020). The fact that culture is a laborious diagnostic method, requiring several days to weeks to obtain results and that it can only be performed in specialized laboratories may orient veterinarians to faster and more available diagnostic methods such as PCR. This method has increasingly replaced culture for mycoplasma detection due to its higher sensitivity and specificity, as well as its ability to provide results within a single day (Wisselink et al., 2019). Additionally, PCR can still be performed even when antimicrobial treatment has already been initiated, which is not the case for culture (Andrés-Lasheras et al., 2020). Another advantage of PCR is its versatility, particularly when using multiplex panels that can simultaneously detect *M. bovis* along with other pathogens, such as BRSV or bacteria that may be involved in diseases like BRD or arthritis (Caswell and Archambault, 2007; Maunsell and Donovan, 2009). This comprehensive approach proves diagnostic accuracy in the field.

Given the low number of culture-based identifications reported in the survey, ASTs are rarely implemented, with 48.7% of veterinarians not performing AST routinely and up to 77% performing it infrequently or not at all. This can be explained by several factors. First, to perform AST culture is required and as discussed previously, this diagnostic method has several disadvantages making it rarely used by veterinarians. Additionally, the lack of standardized culture conditions and interpretation criteria (such as ECOFFs and CBPs) for bovine mycoplasmas in laboratories limits access to AST of certified quality (Jaÿ et al., 2025), which may also influence veterinarians' diagnostic decisions. We also observed that AST was requested more frequently in Germany, Belgium and Italy, when considering all animal species (poultry, swine and cattle). These results may be surprising as for example Belgium does not offer routine AST for mycoplasma species (J. B., personal communication). As answers were self-declarations, it was impossible to verify whether veterinarians answered only for mycoplasmoses or for all the pathogens they treat. A confusion bias may have been present for this question. Nevertheless, these results highlight the lack of systematic performing AST on mycoplasma species in the practitioners' diagnostic routine, either depending on the veterinarians' choice or on the availability of the methods in their country.

According to scientific literature and National Guidelines provided in Table 2, the antimicrobials classes considered effective against mycoplasmas are represented by macrolides, tetracyclines, amphenicols, lincosamides, fluoroquinolones and some aminoglycosides (Heuvelink et al., 2016; Lysnyansky and Ayling, 2016). Tetracyclines and florfenicol are consistently cited as a first-line treatment in BRD, while macrolides and fluoroquinolones are recommended as second and third-line treatment respectively. In cases of mycoplasma mastitis, recommendations are consistent in advising against treatment and instead suggest culling the affected animals. The antimicrobials classes most prescribed by veterinarians in our survey as first-line treatment in case of mycoplasma clinical disease in cattle were macrolides, amphenicols, and tetracyclines. According to the 2023 Annual Surveillance report on European sales and use of antimicrobials for veterinary medicine published by the European Medicines Agency (EMA) (European Medicines Agency, 2025a), penicillins and polymyxins were the most antimicrobial class sold for food-producing animals with respectively 31.4% and 21.6% of sales. These antibiotics are ineffective against mycoplasmas and their use by veterinarians was very limited or even non-existent for mycoplasmoses in our study. Regrettably, antimicrobial use data were only partially analysed in the two most recent EMA reports, as data collection coverage exceede3d 90% in only 7 or 8 of the 26 countries (European Medicines Agency, 2025a, b). No comparison could then be done between our data and the general use in the different countries. A focus should be done on recently acquired resistances in *M. bovis*. Many studies have been published worldwide: acquired resistances have been observed for all antimicrobial families, at different levels and frequencies of occurrence in the different countries' studies (Bokma et al., 2020; Cai et al., 2019; García-Galán et al., 2020; Gautier-Bouchardon et al., 2014; Heuvelink et al., 2016; Klein et al., 2017; Klein et al., 2019). A comparison between national usage of antimicrobials and the available studies on acquired resistance in each country would make it possible to assess the veterinarians' ability to adapt their prescribing practices to recent scientific data. These analyses would also be useful to update national guidelines accordingly. However, for that purpose, efforts should be done by governments and veterinarians to increase the report of data on antimicrobial use in their countries (European Medicines Agency, 2025b). Eventually, many veterinarians didn't use antimicrobial treatment for dairy cattle mastitis due to the expected lack of treatment efficacy in case of mycoplasma aetiology (n = 6/13). All these results highlight the consistency between veterinary practitioners' behaviour and scientific recommendations and national guidelines on the prudent use of antimicrobials, underscoring their skill in selecting appropriate antimicrobial therapies based on the microbiological characteristics of mycoplasmas and supported by targeted prescribing practices. However, those results should be interpreted with caution and may not completely reflect the field reality as the data were collected based on voluntary recruitment and self-reporting.

Regarding the management of metaphylaxis, 62.4% of respondents reported not implementing metaphylactic treatment, and up to 81% indicated that they did not use it routinely. These percentages likely reflect the impact of Regulation (EU) 2019/6(2023), which has redefined such therapeutic practices by imposing stricter criteria and limiting the use of metaphylaxis. This strategy may also be related to the low proportion of affected animals in mycoplasma infections reported in the survey, because the main motivation described by veterinarians for implementing a metaphylactic treatment was the percentage of diseased animals. These results are inconsistent with some studies describing the beneficial use of metaphylactic antimicrobial treatment to prevent BRD in feedlot beef cattle (Godinho et al., 2005; Hendrick et al., 2013; Sultana et al., 2023). On the contrary other studies underscore the role of metaphylactic antimicrobial use in the selection and dissemination of resistant bacterial strains, particularly in the context of BRD (Amat et al., 2019; Becker et al., 2020). A possible explanation for this disagreement could be the chronic nature of mycoplasmosis in the complex of BRD, while metaphylaxis is mainly used when an acute outbreak of BRD occurs, probably linked to other bacterial infection, as *Mannheimia haemolytica* or *Histophilus somni*. Therefore, the results of the survey concerning metaphylaxis management seems to reflect a more prudent approach to antimicrobial stewardship when cases of BRD occurs. This could be subject to debate, given the rapid spread of mycoplasma infection within a herd and the delay between infection and the appearance of clinical signs. In such cases, avoiding metaphylactic treatment may be unwise, as it could facilitate broader transmission and necessitate treatment of a larger number of animals, particularly in case of asymptomatic carriers.

Some prescription practices that may have an impact on the development of antimicrobial resistance in mycoplasmas and other pathogens in cattle had been highlighted in this survey. Firstly, the frequent use of fluoroquinolones, classified as critically important antimicrobials by the WOAH (World Organisation for Animal Health WOAH, 2025), may represent the primary risk practice identified in this survey. Fluoroquinolones' administration is conditioned upon the results of pathogen identification and AST in Europe (The European Commission, 2024). Their use is also strictly regulated in Canada and the USA as prescription before use is required in both countries and extra-label use is forbidden in the USA (US Food and Drug Administration and Medicine Center for Veterinary, 2024; Agence de la santé publique, Government of Canada, 2017). In our survey, fluoroquinolones ranked as the fourth most preferred treatment in the three cattle production categories (Fig. 5) and became the first therapeutic choice in case of treatment failure (Fig. 6). These findings are particularly concerning when correlated with the unsatisfactory results of the study on veterinarians' AST practices. Data collected in scientific literature regarding the acquired resistance of *M. bovis* show that the majority of the strains are still susceptible to fluoroquinolones in Europe (Bokma et al., 2020; Gautier-Bouchardon et al., 2014; Klein et al., 2019), except in Italy and Spain (García-Galán et al., 2020; Klein et al., 2019)), in Asia (Kawai et al., 2014; Kong et al., 2016) and in North America (Lysnyansky and Ayling, 2016). The frequent use of fluoroquinolones by veterinarians in our survey could be explained by their awareness of the preserved susceptibility of mycoplasmas to this class but this might be a threat to antimicrobial susceptibility. The choice of treatment with fluoroquinolones could also be guided by its pharmacological properties, as it has a mycoplasmacidal effect whereas most other antimicrobials only have a mycoplasmastatic effect (Lysnyansky and Ayling, 2016), and by disease expression as it has a good joint distribution (Maunsell et al., 2011). The suspicion of bone infection was therefore cited by one veterinarian to justify the use of fluoroquinolones as preferred option treatment. In any case, these combined results highlight the inappropriate use of fluoroquinolones, which increases the potential risk of selecting resistant mycoplasma strains and other bacterial agents, including zoonotic ones, to this class of antimicrobials. These findings point out the need to raise awareness among veterinarians regarding the prudent use of critically important antimicrobials and the importance of implementing AST for cattle mycoplasmoses. In comparison, in pig diseases, fluoroquinolones were less used as second intention antimicrobials, while AST seemed to be performed more frequently (Hollard et al., 2026). Promoting harmonized AST procedures would improve access to these diagnostics, both for laboratories and veterinarians. Monitoring the antimicrobial resistance profiles in the field is also essential to guide treatment strategies and reduce the use of critically important antimicrobials. Many respondents were from France where surveillance of AMR is conducted annually by the Vigimyc network (Jaÿ et al., 2021): paradoxically this special awareness of the remaining susceptibility of *M. bovis* to fluoroquinolones might also explain the important use of these antimicrobials in our survey. However, the interpretation of *in vitro* resistance data remains challenging due to the absence of harmonized culture methods and clinical interpretative criteria. This gap highlights the importance of the MyMIC network's work on harmonizing mycoplasma AST procedures (Jaÿ et al., 2025).

Inadequate dosage prescriptions had also been reported by some veterinarians in this survey. While overdosing was reported occasionally (Table 1, n = 21), the prolongation of treatment duration was the most frequent inappropriate practice as it was mentioned in 177 cases in this survey. Lower doses (Table 1, n = 6) and shorter treatment durations (n = 3) than those recommended by the SmPC were reported in several antimicrobial classes and in different cattle category production. Such deviations from the SmPC may impact treatment efficacy and contribute to the selection of antimicrobial resistance particularly in the cases of concentration-dependant antimicrobials like florfenicol or fluoroquinolones. However, this interpretation should be done with caution, as the way Table 1 was constructed may introduce potential sources of bias. The application of a single unspecified dosage to multiple antimicrobial classes across production categories may artificially inflate the number of observations, weakening the accuracy of dosage–class associations, and potentially distorting conformity assessments with SmPC guidelines. Shorter treatment durations may lead to a relapse of the infection and an increase in chronically infected animals, finally resulting in greater antimicrobial use and a higher risk of resistance selection. Conversely, longer treatment durations may cause unnecessary overuse of antibiotics, which also increases the risk of resistance development and leads to additional costs for farmers, including more frequent treatments and extended withdrawal periods (Riviere et al., 1998). Moreover, the ACVIM consensus statement on antimicrobial use in veterinary medicine (Weese et al., 2015) recalls that antimicrobials should be stopped once there is clinical and microbiological evidence that the infection has been eliminated. Such bacteriological healing is impossible to reach in cases of mycoplasma infection as the pathogen persistence in the herd is frequent, primarily due to rapid spread and the intermittent shedding of infected animals for weeks to months (Dudek et al., 2020). These difficulties, particularly in case of mycoplasma mastitis may induce longer treatment durations. This extended persistence may also be associated with the ability of mycoplasmas to localize in anatomical niches, such as joints, within the host animal or to trigger chronical lesions in lungs where antimicrobials are not effective.

Very few veterinarians cited the use of antimicrobials known to be ineffective against mycoplasmas, such as beta-lactams, trimethoprim, and sulfonamides. When mentioned, their use was mainly justified by the need to target co-infecting pathogens rather than mycoplasmas. This was also observed for pig veterinarians but in a higher proportion (Hollard et al., 2026). In BRD cases, *M. bovis* is commonly associated with other pathogens, with co-infections involving viruses and bacteria detected in 37.2% and 36.0% of samples respectively in a recent Quebec study (Buczinski et al., 2024). However, *M. bovis* was also the sole pathogen isolated in 34% of fatal pneumonia cases (Caswell and Archambault, 2007) and shows high prevalence in both Europe and North America (Nicholas, 2011; Sultana et al., 2023). It should therefore be considered as a major BRD pathogen, requiring treatment strategies that target both *M. bovis* and potential co-infecting agents. Furthermore, since other antimicrobial agents are known to be effective against both mycoplasmas and common co-infecting pathogens, these alternatives may represent more suitable therapeutic options than beta-lactams. Re-evaluating the treatment strategy is also particularly important in cases involving caseo-necrotic lung lesions or when there is no response to initial therapy, especially in BRD cases associated with arthritis or otitis media (Maunsell and Donovan, 2009; Nicholas, 2011). Moreover, while antimicrobial resistance in mycoplasmas has been well documented, antimicrobial resistance has also been reported in other BRD-associated pathogens, such as *Pasteurella multocida* and *Mannheimia haemolytica* (Alhamami et al., 2021; Sultana et al., 2023) further underscoring the need for an informed and comprehensive antimicrobial selection.

These results further highlight that the use of antimicrobials in cattle with mycoplasma infections should be supported by appropriate diagnostic testing and AST, as enabled by the work carried out by the MyMIC network in harmonizing AST methods (Jaÿ et al., 2025). Surveillance networks such as VIGIMYC (Jaÿ et al., 2021) are also of great importance, as they provide updated data on the various mycoplasma strains circulating in the field and their level of antimicrobial resistance. It also points to the importance of coordinated actions at different levels: prevention among farmers and veterinarians for carrying out identification and AST, development of guidelines and harmonized procedures concerning AST for mycoplasmas and accessibility for veterinarians to specialized laboratories able to perform it.

5. Conclusion

This survey provides a comprehensive overview of veterinary diagnostic and treatment practices for bovine mycoplasmoses. Macrolides, florfenicol, and tetracyclines were most frequently used as first-line treatments, and the practices of more than two thirds of respondents were consistent with international scientific recommendations and national antimicrobial guidelines. However, the occasional use of critically important antimicrobials - particularly as second-line treatments - and rare deviations from the SmPC in terms of dosage and duration may increase the risk of selection of resistant mycoplasma strains in cattle, leading to treatment failure. The infrequent use of culture and AST impair the antimicrobial stewardship. The accessibility of diagnostic tests and laboratories capable of culturing mycoplasma and performing AST and the development of harmonized methods for AST, along with the updating of national treatment recommendations based on scientific literature on acquired resistance, are key challenges highlighted by the MyMIC network in this study, with the aim of improving the management and treatment of mycoplasmoses in livestock.

Funding

This study belongs to the MyMIC projet "Standardization of diagnostics and antimicrobial susceptibility testing and clinical interpretation in animal mycoplasmas". The project received financial support by the French National Research Agency (ANR) in the framework of JPIAMR 2022 calls about Diagnostics and Surveillance Networks (https://www.jpiamr.eu/calls/) (grant number ANR-22-AMRG-0001–01).

CRediT authorship contribution statement

Claire A.M. Becker: Writing – review & editing, Writing – original draft, Formal analysis, Conceptualization. **Jade Bokma:** Writing – review & editing. **Jeanine Wiegel:** Writing – review & editing, Resources, Conceptualization. **Anneke Feberwee:** Writing – review & editing. **Antonio Barberio:** Writing – review & editing. **Susan Saudoyez:** Writing – original draft, Formal analysis, Data curation. **Manon Holstege:** Writing – review & editing. **Emma Hurri:** Writing – review & editing. **Salvatore Catania:** Writing – review & editing. **Lucía Manso-Silván:** Writing – review & editing. **Florence Tardy:** Writing – review & editing, Project administration, Funding acquisition. **Anne V. Gautier-Bouchardon:** Writing – review & editing, Project administration, Funding acquisition. **Ijaz Ahmad:** Writing – review & editing. **Katarzyna Dudek:** Writing – review & editing.

Declaration of Generative AI and AI-assisted technologies in the writing process

Authors declare that no AI Tools were used for manuscript preparation.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Florence Tardy reports financial support, article publishing charges, and travel were provided by French National Research Agency. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

The authors want to thank FVE and their members for distributing the questionnaire to field practitioners. Also, members of MyMIC, personal contacts and European colleges aiding in the distribution are thanked for their efforts. This work was done in collaboration with two other veterinary students from VetAgro Sup, Héloïse Marquet and Romain Hollard, who are thanked for their contribution to data collection and interpretation.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.tvjl.2026.106847.

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