

A qualitative investigation of the attitudes and practices of farmers and veterinarians in Wales regarding anthelmintic resistance in cattle

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Summary

Despite the importance of stakeholder practices in the potential development of anthelmintic resistance (AR) in livestock, there is a lack of qualitative research examining the attitudes and behaviours of anthelmintic end users and their professional advisors. Given the increasing importance of developing anthelmintic resistance patterns in cattle, and the need to avoid AR in cattle developing to the same extent as it has in sheep, the objective of this qualitative study was therefore to assess the factors affecting anthelmintic product choice and usage, and awareness and attitudes towards AR in cattle in north Wales. Twelve semi-structured face-to-face interviews were conducted with nine cattle farmers and three veterinarians. Farmer knowledge and engagement with the issue of AR in cattle in this study was low. A lack of perceived threat was apparent, with only a demonstrable problem at farm level the likely incentive to change future worming protocols and practice. Cost had a very prominent influence on anthelmintic product choice, but importance was also given to product recommendations from social farming networks and other non-veterinary advisory sources. A more proactive approach should be taken to raise farmers' and veterinarians' awareness of increasing levels of AR in cattle and improve anthelmintic governance.

Indagine qualitative sugli atteggiamenti e sulle pratiche degli agricoltori e dei veterinari riguardo alla resistenza antielmintica nei bovini in Galles

Parole chiave

Resistenza antielmintica,
Comportamenti e
opinioni,
Allevamento,
Interviste
semi-strutturate,
Scienze sociali,
Galles.

Riassunto

Nonostante l'importanza della resistenza antielmintica (RA) nel bestiame, mancano in questo settore le ricerche approfondite che esaminano i comportamenti degli utenti finali e dei loro consulenti professionisti. Date la crescente importanza dello sviluppo di modelli di resistenza antielmintica nei bovini e la necessità di evitare che la RA si sviluppi nei bovini nella stessa misura che ha avuto negli ovini, obiettivo di questo studio è stato valutare i fattori che influenzano la scelta e l'uso del prodotto antielmintico, e la consapevolezza e i comportamenti degli operatori nei confronti della RA nel Galles del nord. Sono state condotte interviste frontali con nove allevatori e tre veterinari. Scarsi sono risultati la conoscenza e l'importanza della materia in esame; manca la percezione della minaccia, avvertita solo con portata individuale. Il costo influisce in maniera determinante sulla scelta dei prodotti antielmintici, ma sono risultate importanti anche le raccomandazioni sui prodotti provenienti da varie associazioni sparse sul territorio e da altre fonti di consulenza non veterinarie. In conclusione, gli autori auspicano una maggiore sensibilizzazione e formazione di allevatori e veterinari sul questo problema emergente al fine di migliorare le profilassi antielmintiche.

Introduction

The frequent usage of relatively low-cost, broad-spectrum anthelmintic drugs, coupled with inappropriate parasite management strategies, has increased selection pressure for resistant populations in ruminants over the past 40 years, especially in sheep (Guerden *et al.* 2015, Martínez-Valladares *et al.* 2015). Potentially perceived as a minor and relatively new problem by industry stakeholders (George *et al.* 2017), the issue of anthelmintic resistance (AR) in cattle has been growing in scientific research significance, especially over the past decade. In countries with important cattle industries such as the United Kingdom (UK), New Zealand, Brazil, Argentina and the United States of America, the definite trend is towards increasing AR detections in cattle nematodes, and resistance to the three main anthelmintic classes has been confirmed in all major nematodes of cattle (De Graef *et al.* 2013, Leathwick and Milller 2013, Gasbarre 2014, Suarez and Cristel 2014, Ramos *et al.* 2016, Cristel *et al.* 2017). Indeed, a recent systematic review of the issue of AR in cattle has demonstrated that the problem is global (Baik *et al.* 2018). Hosking and colleagues (Hosking *et al.* 1996) reported the issue featuring in the literature back to 1986, but warnings about the importance of the emerging problem may have gone largely unheeded in the field. It is imperative to dramatically slow AR development, and conserve the efficacy of the anthelmintic treatments for cattle currently widely available, as has become a priority within the sheep industry (Taylor 2012, Learmount *et al.* 2016).

An understanding of the decision-making processes of the farmers who use anthelmintics is important to guide future strategy formulation for encouraging sustainable worming practices (Charlier *et al.* 2016). VandeVelde and colleagues (VandeVelde *et al.* 2018a) and Morgan and colleagues (Morgan *et al.* 2019) emphasize the need for interdisciplinary research between veterinary parasitology and other academic disciplines, and call for a better understanding of farmer behaviours and motivations concerning anthelmintic treatments and helminth control. There has been a general lack of published social science research focusing on the attitudes and awareness of stakeholders regarding AR in cattle. This deficit has begun to be addressed within the last five years in Belgium and the UK, although there is still much to be investigated. Vande Velde and colleagues have conducted questionnaire (Vande Velde *et al.* 2015) and semi-structured interview studies (Vande Velde *et al.* 2018b) with Belgian dairy farmers on their use of anthelmintics. Easton and colleagues (Easton *et al.* 2016 a, b, Easton *et al.* 2018) have reported on questionnaire studies in the UK with a wide range of industry stakeholders involved in prescribing and administering anthelmintics in cattle, and Bellet

(Bellet 2018) used semi-structured interviews to qualitatively investigate dairy farmers' attitudes and practices in England.

Semi-structured interviews with farmers, veterinarians and other stakeholders are increasingly being used to investigate animal health across a wide range of issues (e.g. Vaarst *et al.* 2002, Adam *et al.* 2017, Robinson 2017 a, b, Clémence *et al.* 2018, Lomas and Robinson 2018). Qualitative research methods such as interviewing allow for the interpretation of data unable to be expressed numerically, such as individual attitudes and reported behaviours with their underlying rationale (Saunders *et al.* 2016), and provide insights into the cultural framings that people use to make sense of their experiences (Miller and Glassner 2016).

In a similar vein, this paper reports on qualitative research involving interviews with cattle farmers and livestock veterinarians in north Wales that were designed to elucidate their awareness and attitudes regarding AR in terms of the perceived current and future risks, and how this affects pharmaceutical treatment protocols and engagement with professional advice and herd health planning. Wales has a cattle population of approximately 1.1 million cattle (Welsh Government 2018), some 11% of the overall UK cattle population of 9.9 million (DEFRA 2018). Farms in north Wales are predominantly family farms, with a mix of dairy and beef cattle and sheep.

Materials and methods

The research ethics committee of Harper Adams University granted ethical approval for this research project (Approval no. 1113-201612-STAFF). Purposive, non-probabilistic sampling was chosen to increase the likelihood of providing information-rich and relevant data (Curtis *et al.* 2000, Patton 2015). A veterinary practice in north Wales acted as a research gatekeeper by providing potential participants with 70 or more cattle in their herd in either a dairy or a beef commercial enterprise that utilised outdoor grazing for at least part of the year. Other farmers were sourced through 'snowball sampling' (Noy 2008) where participants suggested further contacts, allowing others to be found who could otherwise be inaccessible or difficult to identify (Saunders *et al.* 2016).

Twelve semi-structured face-to-face interviews (including two pilot interviews) were conducted in north Wales between December 2016 and March 2017. The interviewees consisted of four dairy farmers, two beef suckler farmers, three who had both dairy and beef enterprises and three livestock veterinarians. The main objective of interviewing the veterinarians was to triangulate the data from the farmer interviews using an alternative data source

with knowledge and experience of farmer attitudes and practices (Flick 2014).

All the interviews were arranged in advance by telephone, and then took place face-to-face at a location chosen by the participants. Participants were assured that their identities would remain anonymous throughout the data collection, analysis and write-up process, along with their right to withdraw from the study at any time. Written informed consent was obtained prior to the commencement of each interview. All interviews were recorded using a digital recorder, before being transcribed verbatim using NVivo software (Version 11, QSR International Ltd). The data analysis used a grounded theory approach, using both preconceived themes and those emerging during data collection and analysis in an iterative process involving reading and re-reading the interview transcripts and involving both authors (Glaser and Strauss 2008, Saunders *et al.* 2016). NVivo software was also used to code the data during the analysis.

Results

The herd sizes of the farms represented in the interview sample ranged from 70 to 650 cattle, with a mean herd size of 335 across the nine farms. The interviews lasted up to 80 minutes for the farmers and up to 51 minutes for the veterinarians. The following sections describe the key findings of the interviews.

Decision-making regarding anthelmintic treatment product and protocol

All nine farmers' worming protocols utilised a combination of anthelmintic treatments and pasture management to lower the impact of parasitism in their cattle. There were various combinations of husbandry strategies such as rotational grazing, grazing silage aftermath, using pastures that had been grazed by sheep in the previous season, co-grazing with sheep, and lowering stocking densities of cattle on pasture. The most commonly chosen anthelmintic class and formulation were the pour-on macrolactone (ML) products, heavily influenced by ease of administration:

«I like a pour-on rather than a drench [...] Ease of use really, ease of application [...] It's a lot of work if you've got to go and drench so many cattle.» (Int F3, dairy-beef farmer)

«We tend to use the pour-on for cattle because when you get them in a race, you can easily dose them [...] Years ago we used to use the bolus. To be honest with you, the

pour-on is a lot easier safety-wise – you don't get hurt.» (Int F9, beef farmer)

Charlier and colleagues (Charlier *et al.* 2016) cite economic factors as a major influence on decision-making with respect to anthelmintics, therefore it was expected that farmers would regard economic factors to be of importance in the current study, which was the case with most interviewees, as evidenced by these quotes:

«Farmers have had a really rough two years and you've got to pick the cheapest thing. Whether that's the right thing or not remains to be seen.» (Int F3, dairy-beef farmer)

«It basically came down to whatever was on offer [...] if it's coming to the end of the line and they're doing 30% off, [or] the use-by date's up in a month and you know you're going to use it by then, yes, we'll buy it.» (Int F6, dairy farmer)

Throughout the interviews, product cost clearly influenced product choice, with perceived efficacy and the farmer's own risk assessment of helminth infection on the farm also influencing treatment choice. Two farmers (F3 and F9) suggested that cost took precedence over anything else. This view was also confirmed by one of the vets interviewed:

«For a lot of farmers, certainly our farmers, cost is the main thing, instead of looking at what they're getting for it.» (Int V3, veterinary surgeon)

Despite this, other farmers supported the value of product efficacy and quality above cost, but the price of the anthelmintic product was still highly influential:

«We'll get the advice first and work out what we're going to use, and then we'll get a price.» (Int F1, dairy farmer)

«With wormers, you tend to get what you pay for, you tend to pay for quality, and if you're quite opportunistic you can go to the local supplier and they'll have offers and that encourages you to buy the best quality stuff.» (Int F2, dairy farmer)

«With the pour-ons, if there's an offer on, then I'll buy that product. But [anthelmintic product] works well for me and it always seems to come out the cheapest. I'd ask the price for that, because I know that'll do the job.» (Int F9, beef farmer)

Eight of the nine farmers calibrated their dosage apparatus before use, with the majority acquiring new apparatus annually. All of the farmers stated that they deliberately overdosed cattle when administering anthelmintics. However, only three farmers (F1, F6 and F7) possessed weigh tapes or

scales to enable accurate estimation of bodyweight, with the majority estimating weights visually.

The farmers were generally confident in the suitability of their cattle worming protocol, with many adopting an 'if it isn't broken, don't fix it' attitude towards their practices. Some did not see any need to ask for advice on worming, preferring to follow long-established traditions:

«I've got a way of doing things that has worked for years and to me, if it's not broken, why fix it? I would be disgruntled if I was asked to change things if I had spent time perfecting it.» (Int F2, dairy farmer)

«I've got a worming policy that seems to work, so if it's not broken then I'm not going to fix it.» (Int F9, beef farmer)

«I bet [that] 75% of farmers' worming policies are what grandad's done [in the past] [...] They do x, y and z every year, and that's it.» (Int F3, dairy-beef farmer)

Diagnosis before treatment, or assessment of product efficacy did not feature highly in the discussions. Only one farmer from the sample of nine had conducted helminth diagnostics in their cattle, and the following quote was the response of one of the veterinarians when asked about faecal egg counting:

Interviewer: «Do you find that cattle farmers utilise faecal egg counts much, in your experience?»

Veterinarian: «I don't think I've done one for cattle. We've done horses and the occasional sheep, but not for cattle [...] it's not something I've ever seen anyone do.» (Int V2, veterinarian)

Awareness and concern regarding AR in cattle

The farmers' opinions regarding AR were strongly influenced by the lack of an apparent problem on their own farm, with most of them downplaying the importance of AR for this reason. Five of the nine farmers interviewed had some limited knowledge of the issue of AR in cattle, but others were completely unaware. Overall, it was deemed to be of low importance for them as individual farmers:

«Well, I'm not aware [of it] because I haven't had to be.» (Int F5, dairy-beef farmer)

«I do try to [rotate anthelmintics] – I suppose they can get immune to the stuff after a while.» (Int F2, dairy farmer)

«I'm conscious of it, but I wouldn't say I'm too concerned about it because it hasn't affected me.» (Int F3, dairy-beef farmer)

Other farmers tended to attribute AR to media or pharmaceutical industry exaggeration or pseudo-science exacerbating the issue beyond its true seriousness, leading farmers to suggest that there would be a wider coverage of AR if there was a significant problem:

«Where are the actual facts coming from? Are they scientific facts? That's the biggest problem we've got.» (Int F1, dairy farmer)

«If there was a widespread problem, we'd be made far more aware of it before now. The fact that it's not very well-advertised and there's no big push on it – if there was a nationwide problem, we'd know about it. The vets and the drug companies would be straight onto it.» (Int F9, beef farmer)

«I think you've got to be careful that the worming companies aren't driving the issue and making it sound worse than it is. Speaking from my own experience, we don't have a major problem.» (Int F8, dairy-beef farmer)

Most interviewees had more awareness of AR in sheep, and two farmers (F5 and F7) had prior experience of AR occurring in their own sheep flocks, but there was a general lack of awareness and it was perceived as a lower risk for cattle. The farmers in this study tended to prioritise matters with a more obvious economic impact on their farming enterprise:

«The last thing you would look at when you buy a heifer or whatever is what the worm burden would be. The biggest worry around here is [bovine] TB.» (Int F1, dairy farmer)

«Worming control's in there, but it's not that high up the list. My main concerns are mastitis, lameness, fertility – they're the biggest three [...] I suppose they're every dairy farmer's biggest three.» (Int F3, dairy-beef farmer)

The veterinarians also agreed that the issue of AR was a low priority amongst their farm clients, and one explained the issue as follows:

«Perhaps we're talking to farmers who don't have a perceived problem and we're saying, "You need to do this and that and have all this extra work", for them to ask, "Why?" Because they're already pushed as it is time-wise, and they don't see it [AR] as a problem.» (Int V1, veterinarian)

Another veterinarian (V3) concurred, attributing the farmers' lack of AR awareness to difficulties in quantifying reduced production parameters such as slower growth, therefore convincing farmers to refine or completely change their worming protocols was challenging.

Attitudes towards the perceived value of advisory sources on anthelmintics

Official guidelines

Farmers and veterinarians alike noted the importance of education in combating AR, but the farmers appeared to have little interest in engaging with educational resources and knowledge transfer meetings on responsible anthelmintic use:

«To be honest, if something came through my door saying that HCC (Hybu Cig Cymru (Meat Promotion Wales) – farmer levy body) are doing a meeting about wormer resistance, I probably wouldn't go. It's not really ever stimulated me enough to do anything. If I haven't got a problem with it, I'm not going to try to do anything about it.» (Int F3, dairy-beef farmer)

«I'd have to speak to someone about where my resistance is going to come from in my herd. I'm not bothered about anyone else's.» (Int F8, dairy-beef farmer)

The farmers compared unfavourably generic official guidelines and online advice to the specificity of veterinarians' advice for their particular farm circumstances. None of the farmers interviewed used official worming guidelines provided by the farmer levy boards.

Advice from other farmers

Several of the farmers took a proactive approach to obtaining animal health advice from their farming peers through attending discussion groups on cattle health and by talking to farming friends in their locale:

«Friends I regard to do a really good job of farming – not just like Bob next door. I've got mates in my discussion group from all over the country. They might not be right, but I'd listen to them first [...] I'd regard their opinions quite highly.» (Int F3, dairy-beef farmer)

«I get that [product] more because I know other people and have had a word of mouth recommendation [...] When you know people who have used the product and they're pleased with the product, that is more of an incentive than anything in [the farming press].» (Int F2, dairy farmer)

«The proof is in the pudding, as it were. If you know a guy who's had a problem with fluke, and he says "Well, I used this [anthelmintic] to get rid of it", why would you not do that yourself?» (Int F9, beef farmer)

Suitably Qualified Persons (SQPs) and pharmaceutical sales representatives

In the UK, an SQP is an animal medicines advisor who has legal authority under The Veterinary Medicines Regulations 2013 to prescribe and/or supply certain categories of veterinary medicines having been trained and professionally qualified to do so. Richens and colleagues (Richens *et al.* 2015) highlight farmers' willingness to use agricultural merchants for their livestock vaccine purchases as they were perceived to be cheaper and often more convenient than visiting veterinary practices. This finding led to the same expectations of opinions regarding anthelmintic purchase, and this was confirmed by the interviews. The pricing policies, sales trends and advice of SQPs working in agricultural stores were very influential factors on product decision-making for these two farmers:

«You can guarantee in April time there will be a litre extra for free, so it's a good incentive really [...] The [SQP] is quite good to be honest. She knows what works and what doesn't; what are good sellers, and what isn't.» (Int F2, dairy farmer)

«A couple of the lads there [at the agricultural merchants] are farmers themselves. They'll say: "Well we've sold a lot of this recently". So they're there for advice.» (Int F9, beef farmer)

However, for others there appeared to be mixed views in terms of the quality of SQP advice, with both farmers and vets showing a degree of scepticism regarding the advice given in such a setting:

«It's the same with worming – this is why they're overused. Sometimes [sales] reps are trying to sell a product so they'll tell you that you need to use it.» (Int F7, beef farmer)

«At the end of the day, they're trying to sell you stuff. You're in their hands a bit [...] That's why we lean towards the vet a bit more than the others.» (Int F1, dairy farmer)

«If I go and pick up a wormer to give at home [...] whether because they may know I'm a vet, they (SQPs) don't usually question me on what I'm wanting it for. I've seen other people in agricultural merchants and they'll ask for a product, and they're not taken aside to have a chat.» (Int V3, veterinarian)

Veterinary advice

Some of the farmers also stated that other advisory sources, such as veterinarians, could offer tailored advice which was more specific to their farm. A recurring theme in the interviews was that the veterinarian's familiarity with their farm conferred

a superior advisory position to others who were legally qualified to give advice on wormers:

«If I want to know something I'd rather ask the vet. They're dealing with these things every day.» (Int F7, beef farmer)

«The vets may be a bit more specific [...] about the issues and problems that people have got. So, I suppose, deep down, I would value the vet's opinion a bit more than someone from the agricultural merchants.» (Int F2, dairy farmer)

Nonetheless, despite the value apparently placed on veterinary advice, there were varying degrees of engagement with veterinarians. Concurrent with the findings of Richens and colleagues (Richens *et al.* 2015), veterinarians tended to be underused by farmers in the current study for animal health advice, undertaking mainly 'fire-brigade work' on farms and being approached for advice only when there was a specific problem:

«He [the veterinarian] came the other day to a calving and he's come out about four times in 16 years. 'Fire-brigade work' (coming out for emergencies only) would be the policy.» (Int F6, dairy farmer).

The veterinarians interviewed tended to agree, noting the limitation of these types of contact for advisory opportunities regarding AR, and frustrated that they were unable to allocate sufficient time to discuss worming protocols in any detail:

«It's not one I've particularly spoken to farmers about. It tends to be the case where they come in, they buy their wormer, and they disappear. We don't tend to talk to them a huge amount about worms.» (Int V2, veterinarian)

«Speaking about this job, it is one of the limitations [...] that we can't actually give them the time they need to discuss things.» (Int V1, veterinarian)

Interestingly, all nine farmers stated that they had herd health plans in place, which had been devised with a veterinarian in all but one case. This provides a valuable opportunity to discuss routine herd health with veterinarians, which should include parasite control, but one farmer attributed unfamiliarity with the veterinarians at their local practice as a deterrent from using them for routine advice:

«I will often ask one of the vets [for advice], but there's a big throughput of vets in my practice [...] You tend to cover the same things with another one again.» (Int F5, dairy-beef farmer).

Furthermore, familiarity and trustworthiness tended to be prominent factors involved in seeking advisory sources regarding anthelmintic treatment:

«I've known the vet and the agricultural merchant all my life. I've trusted them and their advice had always worked in the past.» (Int F8, dairy-beef farmer).

«We do have quite a good friend who's a vet, so I will ask their advice occasionally.» (Int F6, dairy farmer).

Farmers who received routine herd health visits from the vet (F1 and F3) utilised their advice more. Despite positive intentions, the veterinarians found it challenging to implement responsible anthelmintic prescription with farmers:

«It's difficult when they have the same [product] every time to say, "Why don't you try this one instead?" So if they come in and want a wormer, they can have whatever they want.» (Int V2, veterinarian).

«When they've had one way of doing things and it's been working out okay, they would have to have a real problem for them to really want to change.» (Int V1, veterinarian).

Despite this, veterinarians' attempts to exercise authority in terms of conservative anthelmintic prescription were apparent, with one veterinarian (V2) noting that they try to offer a benzimidazole (BZ) anthelmintic where possible, as opposed to utilising the other categories, such as ML. These factors may be affected by the lack of allocated time to discuss anthelmintic control in detail, despite the veterinarians' intention to do so:

«When farmers walk in, nine times out of ten it's at a really busy time so [although] you almost want to have a consult, [but] that never happens [...] We can't actually give them the time they need.» (Int V1, veterinarian)

Future prevention of AR in cattle

In terms of their beliefs regarding the development of AR, the farmers tended to attribute the problem to a reaction of nature, an overuse of anthelmintics, and generally poor farming practice, as evidenced by these quotes:

«Nature has a way – doesn't matter what the disease challenge is, some will always get around it. But it's not helped by the fact that people have abused wormers. I feel some people aren't using them properly.» (Int F7, beef farmer)

«I think it [AR] occurs on single-species farms with heavy stocking rates. That's more of a risk factor.» (Int F5, dairy-beef farmer)

The notion of veterinarians not having the same degree of control over anthelmintics as with antibiotics was one which was highlighted during

the interview process by two of the veterinarians interviewed:

«The antimicrobials are under the POM-V [veterinarian-only prescription category], so they [farmers] can't get them. The only way they'd be able to control anthelmintics is to bring them back into line.» (Int V3, veterinarian)

«I think vets probably need to tighten up their anthelmintic usage a little bit in terms of "No, you can't have that first". The problem is, we haven't got the monopoly in that you have to go through a vet to get them like you do with antibiotics.» (Int V2, veterinarian)

However, some of the farmers interviewed had an optimistic view and believed that a new anthelmintic drug would become available in the event of a future resistance problem:

«I suppose I'd have to change my products wouldn't I? Just go to the next product and it wouldn't be an issue.» (Int F2, dairy farmer)

«The easiest thing to do would be to improve the product. Find a product which is like [ivermectin] – when that came out, that was marvellous! [...] That's the quickest solution [to AR], isn't it?» (Int F8, beef farmer)

Linking AR to antimicrobial resistance, and the issues surrounding limitations of choice of antibiotic, one dairy farmer suggested that there would be a reversal of trends away from newer products towards those previously used in the past, heavily influenced by food retailer pressures:

«You can see the same thing happening with wormers, once there's a resistance they'll go back to the old ones [...] Obviously the supermarkets are putting their input in with antibiotics, and the same thing will happen with wormers.» (Int F1, dairy farmer)

One farmer thought there was an onus for collective responsibility, and for the whole industry to take urgent action on the problem of AR in cattle, but another felt that veterinarians may not be incentivised to actively engage with the issue:

«If it's going to be a serious problem, we should do something about it now while we can. But it's not just farmers' responsibility – it's the whole industry. It's vets, farmers, drug companies, merchants – everyone needs to work together on the problem.» (Int F3, dairy-beef farmer)

«I think that the vets could push this kind of thing (anthelmintic advice) [...] I suppose the only problem with some vets is that there's nothing in it for them, especially if they don't sell [...] wormers.» (Int F2, dairy farmer)

Discussion

The detection of AR in cattle has become much more common worldwide in recent years, prompting legitimate concerns that the resistance that is much more prevalent in the helminths of sheep is also fast developing in cattle (Taylor 2012, Baiak *et al.* 2018). The data generated in this study provided the opportunity to better understand the factors underpinning on-farm decision-making with respect to anthelmintic use in cattle, and contextualise the results obtained, consistent with an approach to situate animal health knowledge and practices within their wider socioeconomic and sociocultural backdrop (Robinson 2017a, Chenais and Fischer 2018) It is also provides an insight into veterinary practitioner thinking on the issue, and illustrates a potential lack of veterinary engagement. We draw out three particular lessons.

First, financial considerations around product retail price appear often to outweigh suitability and efficacy considerations regarding choice of anthelmintic product and protocol, especially when sold by agricultural stores. This was also discussed by Bellet (Bellet 2018) in her interview-based research with farmers in England, and noted by Easton and colleagues (Easton *et al.* 2016b) in the context of veterinarians in the UK not selling anthelmintics as often as SQP channels such as agricultural merchants. Easton and colleagues (Easton *et al.* 2016b) suggest that because SQPs have a statutory requirement for continuing professional development in the subject area, while veterinarians do not, they can be more up-to-date in their knowledge of the subject. In their study, SQPs generally performed as well as veterinarians in an online test of knowledge of helminthology and best practice in livestock and horses. This is not therefore an issue of a lack of the capability of SQPs to offer advice on worming protocols. However, the evidence presented in our study would suggest that price often easily outweighs other factors regarding anthelmintic product choice, whether or not specific advice is offered by SQPs at the time of purchase. The data would suggest that some farmers may go to the retailer with a predetermined mind-set to choose the least expensive or best value-for-money option, regardless of best practice. It appears that, at least on some occasions, retailers may encourage such an attitude through sales promotions and the advocacy of products that are selling in high volumes. Although maximising profit is certainly not the only consideration in livestock farming (Robinson 2017a), it is an important influence, and as Charlier and colleagues (Charlier *et al.* 2015) point out, farmers have the challenge of profit-making in competitive markets, while simultaneously meeting wider societal demands such as the need to slow

the development of drug resistance. For some cattle farmers, the price of the product and sense of acquiring a bargain, may therefore supersede matching worming strategy and product within an overall herd health plan.

Second, it is also clear, and consistent with previous studies in the UK and Belgium (Bellet 2018, Vande Velde *et al.* 2018), that some cattle farmers do not see a need to reconsider their anthelmintic protocols and practice, as they do not see a resistance problem on their farm. Several of the farmers in this study were not aware that AR was a problem in cattle at all, despite being aware of the issue in sheep, and generally adopted an 'it isn't broken, so don't fix it' attitude reinforced by habit and longstanding routines. A novel finding was that several participants thought that the media or pharmaceutical companies were exaggerating the issue. This line of reasoning is consistent with the findings of other studies in the realm of the public understanding of science, where lay framings of animal or human health issues can diverge from those of scientific experts (e.g. Suryanarayanan and Kleinman 2012, Robinson 2017b), and where the media or the pharmaceutical industry can be blamed or villainised as exaggerating or distorting health concerns (Aronowitz 1991, Wagner-Egger *et al.* 2011). It is difficult to address a problem that is not appreciated by the stakeholders most involved, and complicated by conspiracy theories that may be hard to dispel, as has been seen with vaccination controversies in both human and animal health (Leach and Fairhead 2007, BVA 2018).

Third, the study would suggest the need for a more proactive governance approach to responsible anthelmintic usage by farmers, with tighter controls over the prescription of anthelmintics to mitigate against their misuse, and conservation of the available licensed products, as is increasingly the case with antimicrobials. In addition to taking professional advice from SQPs and veterinarians, the farmers in this study reported that they were influenced in their anthelmintic choices and practices by farming peers through social and discussion group networks. This finding contrasts with Vande Velde and colleagues (Vande Velde *et al.* 2018), where other farmers' opinions on parasite control were considered untrustworthy. The trust placed in the opinions of other farmers may be reflective of a generally negative attitude towards paying for veterinary advice. Both the farmers and the veterinarians in our sample confirmed that farmers in their area tended to utilise a veterinarian for emergency veterinary work rather than preventive herd health management and advice. This was despite farmer references to the perceived specificity and value of veterinarians' expertise in the interviews. Encouraging a more

proactive approach to herd health planning and regular veterinarian contact may be beneficial, as it facilitates the creation of a partnership between both stakeholders in promoting more sustainable anthelmintic use, as has been advocated by veterinary organisations such as the British Veterinary Association (BVA 2017). Changing farmers' attitudes towards AR through focussing on parasite control within an effective overall herd health framework is vitally important, and that would suggest veterinarians, through herd health planning, have a vital role to play in the governance of anthelmintic protocols and practice. However, the challenge remains that there is a possible divergence between the onus on veterinarians to advise farmers on helminth control in the wider context of farm health planning, and their lack of direct influence over their product choice through minimal sales and revenue stream (Easton *et al.* 2016b). A similar divergence may arise with other disease conditions. For example, veterinarians in the UK are encouraged to engage in active health planning with cattle farmers on bovine tuberculosis control (e.g. Glossop 2013, Woodroffe 2014). However, veterinarians may lack interest and be disengaged from the topic because of the regulatory rather than therapeutic frameworks within which the disease is situated, and focus their efforts on other health conditions which they are much more interested in. As a result, they may not be valued or used as bTB advisors by farmers to the extent envisaged by state authorities (Godfray *et al.* 2018, Hamilton *et al.* 2019). Instead, they may be part of a perpetuating cycle of not being interested in providing farm-specific advice unless being explicitly paid for it, and therefore not being asked to provide it; a similar situation could prevail with anthelmintic advice. There are also fundamental challenges in getting farmers to engage with herd health planning, as has been found in other studies in the UK (Bell *et al.* 2006, Hall and Wapenaar 2012).

While the study is small in that it involved a sample of 12 people, the findings are nonetheless valuable as a pilot study as they are likely to be indicative of the attitudes and behaviours of not just other Welsh cattle farmers and veterinarians, but also the wider farming and veterinary population in the UK. The sample size is legitimised by the findings from other qualitative interview-based studies that have demonstrated how a sample of 12 interviewees can provide data saturation and produce reliable results from which to derive theory (e.g. Guest *et al.* 2006, McAloon *et al.* 2017). Nonetheless, a limitation of the study was that the veterinarians all worked in the same veterinary practice, and two thirds of the farmers interviewed were their clients, which may introduce a bias into the sample. Future research on the theme would ideally cover a wider sample across

a larger population of farmers and veterinarians in different regions and veterinary practice areas.

Conclusions

This study in north Wales illustrates the complexity of farmer decision-making and opinion formation, and emphasizes the need to understand the situated knowledge and contextualised frameworks within which farmers and veterinarians operate in relation to AR (Charlier *et al.* 2015, Charlier *et al.* 2016, Bellet 2018). There are multiple hurdles to overcome if the issue of AR in cattle is not to become one of the most significant threats to cattle health and welfare in the UK and internationally, and there is a need for concerted (and urgent) action.

While it is easy to blame farmers for their malpractices and lack of knowledge, it is too simplistic to adopt a 'deficit model' approach (Wright and Nerlich 2006), and suggest that all that is needed is to address the gaps in knowledge that farmers have about the issue of AR in cattle. The findings of this study illustrate that there are gaps in farmer knowledge

with respect to the issue, and these must be addressed by raising the profile of the issue of AR in cattle as it has been in sheep, but it could also be argued that not all veterinarians are as engaged with the issue as they could be. Indeed, there is a need to expand the qualitative investigation of this issue to veterinary and other industry stakeholder opinions and practices beyond farmers. Given the apparent complacency that still exists towards AR in cattle, and as McArthur and Reinemeyer (McArthur and Reinemeyer 2014) eloquently argue, there will need to be a paradigm shift in parasite control knowledge, attitudes and behaviours. This must involve the efforts of multiple stakeholders and through multiple approaches if the problem of AR in cattle is to be managed more effectively in the future.

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