Stocktake of Global Research on Gastrointestinal Nematodes

Executive summary

Beef + Lamb New Zealand (B+LNZ) surveyed individuals in New Zealand and globally who were involved in livestock parasite management in 2023. The purpose of this was to compare key livestock gastrointestinal nematode (GIN) issues across countries, identify useful sources of information for farmers, and to find out new ideas and alignment for research collaboration and tool development along with international funding opportunities. The individuals were from organisations identified by B+LNZ for their expertise in GIN management, and ranged from researchers in the field, to industry bodies and animal health company representatives.

Sixteen respondents answered the survey – 15 with a focus on sheep and cattle (beef and dairy) across eight countries, and one with a focus on horses. There was a range of different farming systems across countries but for sheep and beef, extensive farming was the most common.

Haemonchus species, *Teladorsagia circumcincta* and *Trichostrongylus* species were listed as the most problematic for livestock across most countries surveyed, with *Ostertagia ostertagi* and *Cooperia* species commonly reported for cattle. A range of drenches were available across countries, with most countries having at least four families available.

All respondents said that worm egg counts/faecal egg counts were the most used diagnostic test in their country (including for horses). Most countries listed veterinarians and other qualified advisers as the main source of advice to farmers on internal parasites, and a range of other sources were given.

Respondents listed active research areas as vaccine development, improved diagnosis of GIN species and GIN resistance markers to drenches, improved and novel treatments including decision support tools and targeted selective treatment, and identification of resistant or resilient individual hosts. This survey provided a broad picture of research and innovation underway overseas and highlights several possibilities for collaboration.

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Introduction

B+LNZ is aiming to achieve sustainable management of livestock GIN. Given the global challenges associated with GIN management in livestock, B+LNZ is exploring global partnerships to develop mutually beneficial programmes and work together to seek funding. B+LNZ has identified several organisations overseas with expertise in livestock parasite management who are open to exploring opportunities for collaboration. It was decided a survey would be useful to identify points for further discussion. This survey supplements published literature and surveys of drench resistance, which also inform this discussion.

Methods

A selected group of GIN experts and representatives were asked to complete a survey using Cognito Forms online survey platform (Cognito LLC) in November 2023. The recipients were those that the B+LNZ Research team had held online conversations with in 2023 about the state of global livestock parasite management. The aim was to identify information, resources, research initiatives, funding sources and possible collaborators for the B+LNZ Livestock Parasite Management Research Programme, as well as to provide farmers access to relevant tools and resources from overseas.

Survey recipients were asked their name, job title, institution and country, then a series of questions covering livestock drench resistance, diagnostic tools in use and under development, and extension activities and sources of information for farmers/producers, as follows:

1. What is the most common farm system in your country?
2. What livestock host species is most adversely impacted by GIN in your country?
3. What livestock hosts have the most problems with drench resistance?
4. What species of GIN are most problematic for your country?
5. What classes of actives are available in your country to manage GIN?
6. Do you have information on the drench resistance status of impacted livestock in your country?
7. What are the most used diagnostic tools used for GIN in your country?
8. Where do livestock farmers/producers predominantly get their GIN management information from?
9. What are your active areas of research projects related to parasite management?
10. What are your active areas of extension/adoption/research related to parasite management?

11. Can you please provide links to relevant publications publicly available resources in the parasite management research extension and adoption space / resources for farmers, rural professionals and researchers that your organisation has
12. Is there any new technology you know of that is being tried on farm in your country with links to public information where possible
13. Can you detail the funding sources available/suitable for international partnerships
14. Is there anything else you would like to add that we have missed?

Results and analysis

Sixteen respondents (including B+LNZ) answered the survey – 15 with a focus on sheep and beef across eight countries, and one with a focus on horses. Sheep and beef respondents were based in Australia, Belgium, Brazil, Argentina, Canada, China, New Zealand and the UK. The horse respondent was based in the US.

Important parasites and hosts in each country

Most common farm system in each country

This question was answered in different ways, with some respondents listing species farmed while others listed the detailed farming system.

There was a range of farming systems in the countries surveyed, from pasture-based/extensive through to intensive beef and dairy.

Pasture-based/extensive farming systems are reported as most common in Canada, the UK, New Zealand, Australia and China. There is regional variation in lambing indoors in the UK. There was reported widespread transition to semi- and full-confinement in Canada and Australia reported beef feedlots as a common farm system with a smaller number of sheep feedlots. Belgium reported intensive dairy and beef suckler cows. Brazil reported semi-intensive systems for sheep, and extensive/semi-extensive for sheep and cattle. Literature supports traditional family-based, extensive sheep farming as the most common sheep farming system in Brazil and extensive systems as the most common for cattle [i]. Argentina reported cow-calf grazing and feedlot stock.

This shows that New Zealand's extensive, pasture-based sheep and beef farming models are not unique, from a global perspective and that there is value in relating work done overseas to a New Zealand context.

Livestock host species most adversely impacted by GIN

Five respondents said sheep were the main species impacted by GIN. All other respondents noted that sheep plus other species (9) were the most adversely

impacted by gastrointestinal nematodes. Other species impacted were cattle/bovine (9), goats/caprine (2), horses (2), poultry (1) and pigs (1). One respondent noted that cattle only was the most adversely affected by GIN. This demonstrates that sheep or sheep and cattle are adversely affected across all countries surveyed, suggesting there could be several opportunities for collaboration on work relating to sheep and cattle.

Livestock hosts that have the most problems with drench resistance

Sheep were also reported as the most problematic livestock in terms of drench resistance across all countries, with two also listing goats, and NZ, Brazil, Argentina and the UK also listing cattle. The lack of mention of goats by respondents likely reflects their areas of expertise being sheep and cattle. It is likely not a true reflection of the incidence of drench resistance in goats, given that literature shows this as being widespread globally[ii].

Respondents listed varying levels of knowledge of the extent of drench resistance across countries. This aligns with a survey conducted by the World Organisation for Animal Health on its members across the world that showed that the degree of anthelmintic resistance varies across the world but its true prevalence is unknown due to cost, time, a lack of surveillance programmes and consistent measurement, and other factors[iii].

Species of GIN that are most problematic

Table 1 shows GIN that were reported as problematic for livestock species for each country. *Anoplocephala perfoliate* and *Parascaris* spp. were listed for horses in the US. This does not show which species are linked to resistance specifically, but does give an idea of the spread of issues across GIN species.

Table 1. Livestock gastrointestinal nematodes reported as most problematic in countries responding to a 2023 survey of parasitology experts and advisers.

Country	***Haemonchus* / *H. contortus***	***Teladorsagia circumcincta***	***Trichostrongylus* spp. including *T. colubriformis*, *T. axei*, and T. *vitrinus***	**Nematodiris / *N. battus***	***O.ostertagi***	***Cooperia* spp.**
Australia						
Belgium						
Brazil						
Argentina						
Canada						
China						
NZ						
UK						

Coloured boxes indicate this is the GIN that is the most problematic in the named country.

Tools used to manage livestock GIN

Availability of drench classes for livestock

A range of actives were reported as available for livestock in each responding country (Table 2). Horses are not represented in the table, but drenches were listed as benzimidazoles, pyrimidines, macrocyclic lactones, and praziquantel.

Table 2. Livestock anthelminthics reported as available in countries responding to a 2023 survey of parasitology experts and advisers.

Country	Amino-acetonitrile derivatives (AAD / AD) including monepantel / Zolvix	Benzimidazoles (BZ / white)	Levamisole (LV / clear)	Macrocyclic lactones (ML) including Ivermectin (drench and injectable)	Salicylanilides (SA) – closantel	Spirinodole (SI) – including derquantel (SI)/abamectin (ML) drench
Australia						
Belgium						
Brazil						
Argentina						
Canada						
NZ						
UK						

Coloured boxes indicate the drench families available in the named countries.

Most common diagnostic tools

All respondents said that worm egg counts/faecal egg counts were the most commonly used in their country (including for horses). Other tools listed were:

- Serum pepsinogen assay for cattle
- ELISAs for *O. ostertegi*
- Clinical evaluation
- Faecal Egg Count Reduction Tests
- Larval culture

Again, some of these additional tools are most likely used in other countries (eg FECRT, bulk milk tank sampling and clinical evaluation) but respondents answered this question with their most common tool rather than listing all tools available. See here for diagnostic tools used in European COMBAR labs https://www.combar-ca.eu/sites/default/files/Deliverable_1.1_Report_07_03_2022.pdf)

Extension activities and sources of information

Common sources of GIN management information used by livestock farmers/producers

Most countries listed veterinarians and other qualified advisers as the main source of advice to farmers on internal parasites. A range of other sources were also given:

- internet
- rural re-sellers and product salespeople
- advisors/extension service/consultants
- farmer meetings
- media
- local stores
- TV
- Booklets/flyers etc
- friends and neighbours
- academia/researchers, and
- industry associations.

Active areas of extension and sources for further information

A range of online, published and face-to-face extension initiatives are shown in Table 3.

Table 3. **Active areas of farmer extension in countries responding to a 2023 survey of parasitology experts and advisers.**

Country	Active areas of extension
Australia	• Integrated parasite management online platforms • Workshops • Written resources (e.g. Flystrike resources, Paraboss)
Belgium	• Demonstration activities, communication approaches
Brazil	• Courses, diagnostic, Herd health management and parasite control strategies
Argentina	• Workshops
Canada	• Various extension efforts by region, from publications to online tools.
China	• High-throughput egg counting technique and host genomic selection
New Zealand	• Wormwise programme – workshops, website, social media, media articles • Different communication methods – podcasts, wall calendars, animations, factsheets • Regional livestock parasite management groups • Modelling case studies of the impact of drench resistance • Providing information with regard to best use of products known to be effective
UK	• Occasional market research into farmer attitudes and current practices • Extensive farmer engagement / knowledge exchange on use of anthelmintic use including rotational grazing and targeted selective treatment (TST) • Farmer information events and sheets - factsheets, webinars, animation series, newsletters to members (11,000 farmer and vet members) all available at https://moredun.org.uk/resources.

Research, innovation, and funding

Table 4 shows active areas of GIN research, new technologies and funding sources for each country.

Table 4. Active areas of research, new technologies and funding sources for countries responding to a 2023 survey of parasitology experts and advisers.

Country and organisation	Active areas of research	New technologies being tried on farm	Funding sources for international collaboration	Links for further information
Australia *(Meat Livestock Australia, Australian Wool Innovation)*	• scour worm vaccines • flystrike management • parasite diagnostics	No	• Meat and Livestock Australia co-funds investments with international partners • AWI co-funding using levy funds and matched government contributions • https://www.arc.gov.au/funding-research/funding-schemes/linkage-program grants	www.wool.com/flystrikeresources www.wool.com/flystrikelatest www.paraboss.com.au
Belgium *(Kreavet)*	• detection of anthelmintic resistance • improving diagnosis • decision support • dissemination and communication	Decision support systems	• EU partnership animal health and welfare • EIC accelerator	https://kreavet.com/publications/ www.combar-ca.eu www.lihra.eu www.wormsparc.eu
Brazil *(Universidade Federal do Paraná)*	• New therapy/remedies • Diagnostic of drug resistance, health programs	• Vaccines • plant-based products • FAMACHA	• Governmental agencies • private Pharma	https://www.redalyc.org/pdf/4457/445744148049.pdf https://www.sciencedirect.com/science/article/pii/S0304401709003471

		• multi-drug resistance modulators verapamil and cyclosporin A		https://www.sciencedirect.com/science/article/pii/S0304401711003864 https://www.sciencedirect.com/science/article/pii/S0304401712003706 https://www.sciencedirect.com/science/article/pii/S2405939017300527 https://www.scielo.br/j/pvb/a/SpzwwXBCr3bvrnjpD5PpBbT/?lang=en https://doi.org/10.1017/S003118202200018X https://doi.org/10.1016/j.parint.2022.102588 https://ojs.uel.br/revistas/uel/index.php/semagrarias/article/view/40872
Argentina *(Laboratorio de Farmacología)*	• Pharmaco-parasitological approaches to optimise the control of GIN in animal production. Pharmacokinetic/pharmacodynamic relationship of different anthelmintics in beef cattle, under real field conditions - PK and PD studies, efficacy studies, comparison of different routes of administration and different anthelmintic combinations.	No	• Bill and Melinda Gates Foundation • European Cooperation in Science and Technology (COST)	https://www.motivar.com.ar/2023/05/control-parasitario-es-la-combinacion-de-antihelminticos-una-herramienta-valida-2 https://www.sciencedirect.com/science/article/pii/S1471492218301144?via%3Dihub https://www.sciencedirect.com/science/article/pii/S0020751923000504 https://pubmed.ncbi.nlm.nih.gov/31778612/

Canada	• Developing Nanopore DNA sequencing for routine diagnostics. • Improving diagnostics and making diagnostics accessible to stakeholders. • Investigating immune response of sheep to GIN in grazing systems. • Leveraging OMICS and systems biology to understand genes and metabolic pathways associated with genetic resistance to GIN infections. • Resistance surveys by region. • Utilizing the CarLA saliva test to lower the risk of gastrointestinal parasitism in some regions.	Under development	Central and local government grant on international S&T cooperation	https://vet.ucalgary.ca/research/sheep-parasite-control/home https://www.ontariosheep.org/uploads/userfiles/files/Parasite%20Handbook_April_2019%20updated_reduced.pdf#:~:text=In%20Canada%2C%20the%20most%20common%20and%20the%20most,are%20Teladorsagia%20circumcincta%2C%20Trichostrongylus%20spp.%20and%20Haemonchus%20contortus https://cdn.dal.ca/content/dam/dalhousie/pdf/faculty/agriculture/oacc/en/tcog/TCOG_2012_Parasites_in_Sheep.pdf https://ablamb.ca/images/documents/factsheets/Guide-To-Parasites-In-Sheep.pdf https://www.gov.mb.ca/agriculture/livestock/sheep/pubs/control-of-gi-parasites-in-sheep-and-goats.pdf https://www.cansheep.ca/resources
China *(Xinjiang Academy of Animal Science)*	• genetic selection of GIN resistant individuals	No		
New Zealand *(Elanco, AgResearch, B+LNZ)*	• Production management • Research to lower farmer reliance on the use of drenches	TST using SmartWorm® app		www.farmanimal.elanco.com/nz http://www.smartworm.nz/ B+LNZ Wormwise programme | Beef + Lamb New Zealand (beeflambnz.com)

	• Diagnostics for timely species differentiation (PCR) in sheep and cattle • WGS of *Trichostrongylus* species • Resistant markers to ML in *Trichostrongylus* species			
UK *(Moredun Research Institute, Elanco, CIEL)*	• Vaccine development. • Vaccine development for *Teladorsagia circumcincta* and Trichostrongylus species. Includes WGS to chromosome level, transcriptomic and proteomic analyses of parasitic stages, antigen identification, vaccine formulation and delivery and vaccine testing at pen and field scales. • Interests in sustainable control through environmental management	• Targeted selective treatment based on individual growth rate compared to the individual's potential - http://bit.ly/30thevx • FEC check app (https://app.moredun.org.uk/fec); TST (https://sefari.scot/research/making-worms-squirm-sustainable-worm-control-in-lambs-through-precision-livestock-farming) • FECPAKG2 utilized widely across UK, environmental DNA capture has been studied for liver fluke (https://parasitesandvectors.biomedcentral.	Horizon Europe https://www.ukri.org/opportunity/bbsrc-new-zealand-partnering-award/	https://moredun.org.uk/resources e.g.: https://moredun.org.uk/resources/factsheets/reducing-reliance-on-wormers-using-lam-performance-to-optimise-treatments https://moredun.org.uk/resources/videos/war-of-the-worms https://moredun.org.uk/resources/videos/test-dont-guess wwww.farmanimalhealth.co.uk https://moredun.org.uk/research/diseases/parasite-control https://www.scops.org.uk/ https://www.cattleparasites.org.uk/ https://ahdb.org.uk/knowledge-library/parasite-control-guide https://onlinelibrary.wiley.com/doi/full/10.1111/gfs.12429

		com/articles/10.1186/s13071-018-2928-z) - potential application to GINS? • https://app.moredun.org.uk/fec is being widely used now as an app and we are seeing more and more UK farmers adopting vaccination for *Haemomnchus contortus*		

Conclusions

This survey collected information in a relatively straightforward way. While there were gaps in the information provided, it still gives a good picture of major areas of research and innovation. The results of the survey have identified numerous synergies between countries and presents several opportunities for future collaboration.

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[i] Silveira et al https://doi.org/10.1080/27685241.2021.1956220

[ii] Baudinette et al. 2021. Anthelmintic resistance of gastrointestinal nematodes in goats: a systematic review and meta-analysis. https://doi.org/10.1016/j.vetpar.2022.109809 PMID: 36395622.

[iii] World Organisation for Animal Health (founded as the OIE). 2021. Responsible and prudent use of anthelmintic chemicals to help control anthelmintic resistance in grazing livestock species. OIE, Paris. ISBN: 978-92-95121-15-7 https://www.woah.org/app/uploads/2021/12/oie-anthelmintics-prudent-and-responsible-use-final-v4-web-opt.pdf