

## Vaccines against gastro-intestinal nematodes in cattle: challenges and opportunities

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Side-effects of worm control through intensive use of anthelmintics have prompted research into nematode vaccine development. Optimally, vaccines could provide durable protection against multiple parasites, without associated chemical residue issues. Experimental vaccines against helminth parasites in livestock are at various stages of development. For the bovine gastro-intestinal nematodes, *Ostertagia ostertagi* and *Cooperia oncophora*, worm antigens were identified that consistently give protection in vaccine trials. However, obtaining acceptable protection levels with recombinant antigens has proven difficult. Current research in the EU-funded PARAGONE project is focusing on differences in protein folding and secondary modifications, such as glycosylation, between the native and recombinant proteins as possible reasons for the lack of protection. Immune responses against protective and non-protective versions of the antigens are compared, to obtain insight in the immune mechanisms that need to be triggered, in order to optimize recombinant antigen expression, use of adjuvants and antigen delivery.

To protect young animals until natural immunity has developed, vaccines should lower pasture infection levels by reducing worm egg output in vaccinated animals for a certain period. The level and duration of protection needed will be different in different epidemiological settings and may change with changing climate or farm management. Vaccination should be part of integrated worm control programmes, including pasture management and anthelmintic treatment. The large number of possible scenarios that arise from this could be modelled by helminth transmission models, currently under development, to inform vaccine developers about efficacy requirements. After field validation, these models could ultimately lead to decision support software for integrated worm control. At the end, it will be the farmer's decision to vaccinate and the veterinarian's role to implement vaccination strategies. Socio-psychological research to identify drivers of farmers' and veterinarians' decision making will be crucial to optimize uptake of novel parasite control tools, including antiparasitic vaccines.