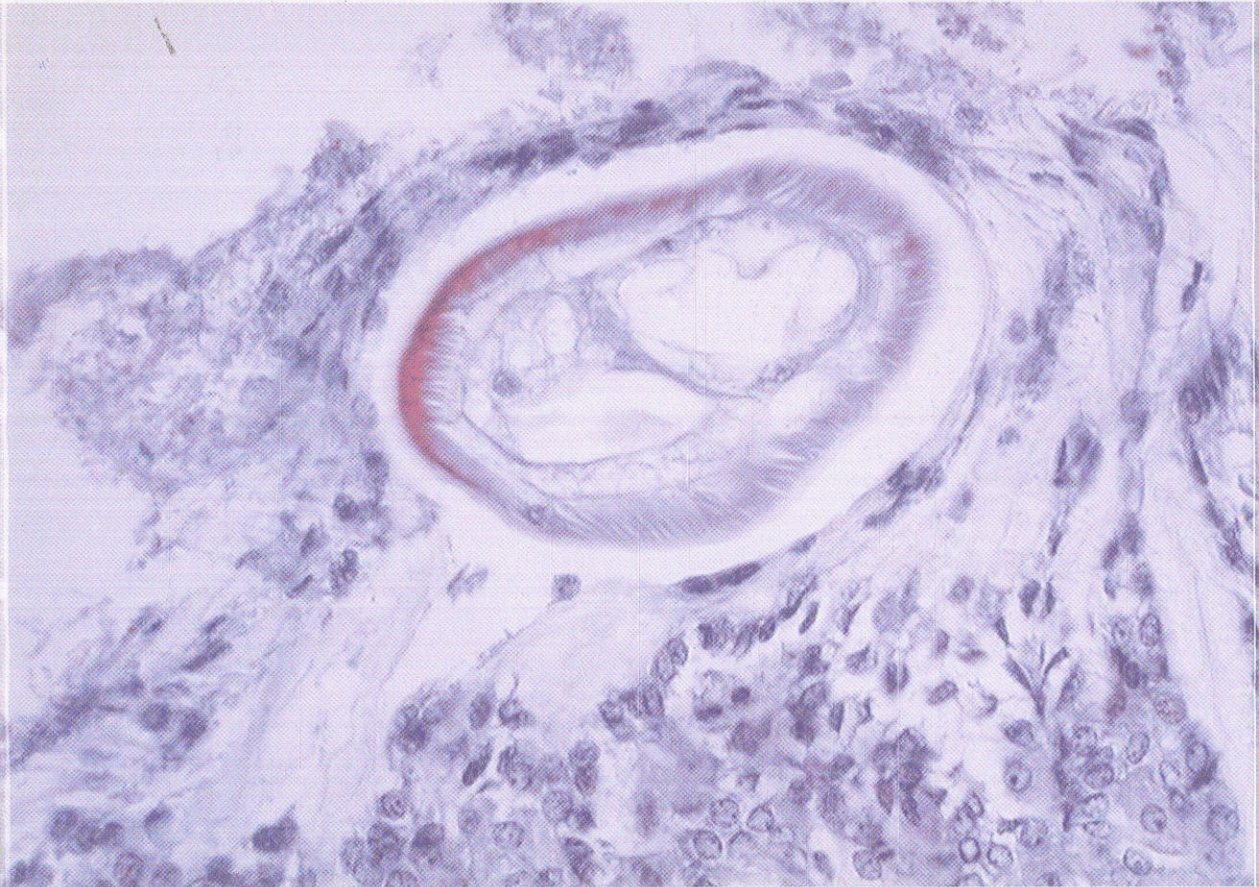


# Gastrointestinal Nematodes of Sheep and Cattle

## Biology and Control

Ian Sutherland and Ian Scott



 WILEY-BLACKWELL

# Contents

<i>Foreword</i>	ix
<i>Preface</i>	xi
<i>Acknowledgements</i>	xiii
<b>1 Nematode parasites</b>	<b>1</b>
The nematodes	1
The important nematode genera and species parasitising ruminant livestock	2
Abomasal genera	3
Small intestinal genera	4
Large intestinal genera	6
Nematode evolution	6
The transition to parasitism	8
Nematode biology	9
Nematode genetics	14
Nematode physiology	15
The dauer larva	17
Anhydrobiosis	17
The nematode life cycle	18
Niches occupied by parasitic nematodes within the vertebrate host	23
The lifespan of parasitic nematodes	26
<b>2 Pathophysiology of nematode infections</b>	<b>33</b>
Are parasites always harmful?	33
Defining 'harm'	34
The abomasum	36
The small intestine	42
The large intestine	43

	The impact of parasites on overall gut function	43
	Effects beyond the gut	47
<b>3</b>	<b>Epidemiology of gastrointestinal nematodes in grazing ruminants</b>	<b>61</b>
	Ecology of GINs – pasture	61
	Egg to L3 development	62
	Effect of host	63
	Survival of L3	63
	Translation of infective larvae	64
	Grazing behaviour and the avoidance of parasites	65
	Patterns of infection	66
	Overdispersion of parasites	67
	Epidemiology of ‘parasitism’	67
	An increase in the infective mass	68
	Alteration in the susceptibility of stock	69
	Arrested development and hypobiosis	70
	Introduction of susceptible stock onto an infected area	70
	Insufficient age-related immunity	71
	The introduction of infected stock to a clean environment	71
	Epidemiology of cattle parasites	72
	Population biology in the parasitic phase	72
	Sheep parasites	73
	Cattle parasites	75
<b>4</b>	<b>The principles of gastrointestinal nematode control</b>	<b>83</b>
	Control of parasites with anthelmintic drenches	83
	Drench programmes	84
	Strategic drenching programmes	85
	Principles of worm control in cattle	88
	Control of GIN by grazing management	88
	Alternate/mixed grazing with different host species or stock classes	89
	Resistance to treatment	91
<b>5</b>	<b>Anthelmintics</b>	<b>95</b>
	What are anthelmintics?	96
	How effective does an anthelmintic have to be?	96
	Which species does an anthelmintic against GIN need to remove?	97
	Description, efficacy, profile and mode of action of anthelmintic families	98
	Combination of anthelmintic treatments	107
	Modifying the delivery of anthelmintics	107
	Parenteral administration	108
	Controlled release of anthelmintics	108
	Injectable formulations	109

<b>6 Anthelmintic resistance</b>	<b>117</b>
Evolution of anthelmintic resistance	118
Worldwide occurrence of anthelmintic resistance	118
Resistance to one or more active families by one or more species	119
Impact of resistance on productivity	120
Mechanisms of resistance	120
Inheritance of resistance	123
Detection of resistance	124
<b>7 Drenching and resistance</b>	<b>133</b>
Frequency of treatment	134
Under-dosing	134
Persistent anthelmintics	135
Why use persistent drenches?	137
The provision of safe pasture and resistance	137
Persistence and efficacy	138
Therapeutic efficacy and resistance – ‘head selection’	139
Prophylactic efficacy and resistance – ‘tail selection’	140
Heads or tails?	141
Persistent activity, immunity and resistance	142
Persistent activity, density dependence and resistance	143
Drench rotation	143
Controlling resistance by drench rotation	143
Drench rotation within seasons	145
Modelling drench rotation	145
Combination anthelmintics	146
Removing resistant worm burdens	146
Efficacy of single actives vs. combinations	146
The odds are against multiple mutations	147
Resistance is already present to one or more constituent active	148
<b>8 Worm control and resistance management</b>	<b>153</b>
What is refugia?	155
Why do we need refugia?	155
How to produce and utilise refugia	157
Importation of resistant parasites	159
A twin approach to worm control and resistance management – utilising refugia and combination drenches	160
<b>9 ‘Non-chemical’ control options</b>	<b>163</b>
Anthelmintic plants	163
Plant material	165
Plant extracts	166
PSM as anthelmintics	167
Forage legumes	168
Practical applicability on-farm	169

Other anthelmintic plants	170
Micro-predacious fungi	170
Homoeopathy	171
<b>10 Nutrition and parasitism</b>	<b>177</b>
Metabolic cost of parasitism	177
Metabolic cost of infection	178
Metabolic costs of immunity	180
Parasites and nutrition: a nutrient utilisation framework	183
Supplementation for increased resilience to parasites	184
Supplementation for increased resistance to parasites	185
Reproducing animals	185
Undernutrition and parasitism	186
Micronutrients and parasitism	187
Improving nutrient availability	188
Forage plants and parasitism	188
Supplementation and immunity: increasing or enabling?	189
<b>11 Animal genetics and parasitism</b>	<b>195</b>
Inter-species variability	195
Inter-breed variability	196
Intra-breed variability	198
Resistance vs. productivity	199
Resilience	200
Pasture contamination, resistance and resilience	201
Markers for resistance and resilience	201
Phenotypic markers	202
Genotypic markers	203
Genetics, worm control and resistance management	204
<b>12 The immune response to parasites</b>	<b>211</b>
Evolution of the host–parasite relationship	212
Immunity and GIN population dynamics	213
The immune phenotype	214
Immunological unresponsiveness	214
Components of host responses to GI parasites	215
Adaptive immune responses to GINs	218
The anti-GIN immune response in cattle to <i>O. ostertagi</i>	221
Impact of immunity on parasites	222
Immunopathology	223
Periparturient rise	223
<i>Utilising immune responses to control GIN</i>	223
Natural antigens	224
Hidden antigens	225
What next for immunoparasitology research?	226
<b>Postscript</b>	<b>235</b>
<i>Index</i>	237