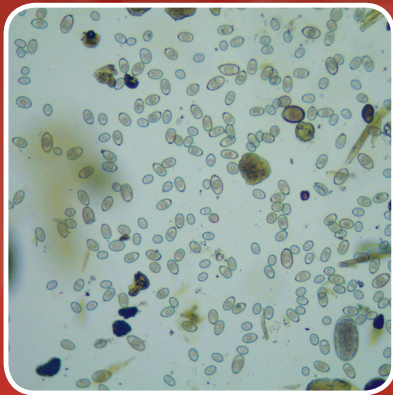
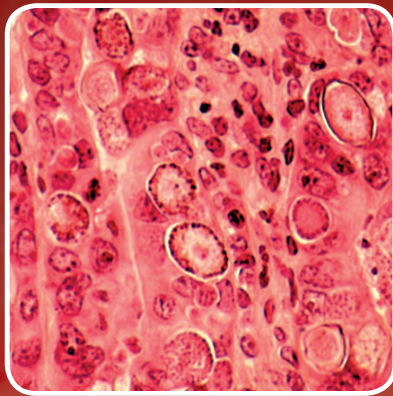


VETERINARY PARASITOLOGY

FOURTH EDITION



MA Taylor
RL Coop
RL Wall

WILEY Blackwell

Veterinary Parasitology

Veterinary Parasitology

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Fourth Edition

WILEY Blackwell

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Introduction

Based on previous editions of *Veterinary Parasitology*, this fourth edition has been further developed into a two-part reference text with enhanced and updated parasite taxonomic classification systems.

Part 1 contains expanded individual parasite descriptions and taxonomic status within three new chapters on Veterinary helminthology (Chapter 1), Veterinary protozoology (Chapter 2) and Veterinary entomology (Chapter 3). As with previous editions of *Veterinary Parasitology*, further updated chapters include Laboratory diagnosis of parasitism (Chapter 4), Antiparasitics (Chapter 5), The epidemiology of parasitic diseases (Chapter 6) and Host resistance to parasitic diseases (Chapter 7). Host species chapters have been retained and updated and are now in Part 2 of the edition. Additional information on non-obligate ectoparasites that may be found on several hosts are grouped in a separate chapter, Facultative parasites and arthropod vectors (Chapter 17). In keeping with the third edition of *Veterinary Parasitology*, extensive indexing and cross-referencing are provided throughout this edition.

There are several slightly different definitions of parasitism and parasites. In the context of this book parasites are considered as organisms which live for a considerable portion of their lives in (**endoparasites**) or on (**ectoparasites**) another different kind of organism, the host. Ectoparasites are also frequently vectors of pathogens that may cause disease. Parasites are dependent on that host and benefit from the association, at the host's expense. They derive nutrition from the host and may also gain other benefits such as a protected habitat in which to grow and reproduce. Parasites are generally harmful to their host, although this is not always easy to demonstrate as an individual parasite may cause no recognisable damage. Disease is frequently a population phenomenon, with small numbers of parasites having no discernible impact but large numbers causing effects ranging from subclinical damage to

debilitating fatal disease. Damage to the host may also result from the host's defence mechanisms reacting to the presence of parasites.

Many parasites are entirely dependent upon a specific host or hosts in order to complete their life cycle and survive and these organisms are known as an **obligate** parasite of that particular host. Where an organism can either survive or complete its life cycle independently from a host, or can have a parasitic existence, then it is called a **facultative** parasite. There are instances where for various reasons parasites become established in hosts other than their definitive host and in which they cannot complete their normal life cycle. These hosts are termed **accidental** hosts and in the case of some zoonotic parasites of veterinary importance, humans are an example.

Every parasite must have at least one host in its life cycle and many species have several hosts. The host in which the parasite is best adapted and in which it develops to an adult or sexually mature stage and reproduces is known as the **definitive, primary or final** host. If there is only a single host in the life cycle, then transmission is said to be direct and the parasite to have a **direct** life cycle. Many parasites have more complex life cycles with additional hosts in which essential development to a new parasite stage occurs. These stages either do not reproduce or if they do then it is by asexual multiplication. These hosts are known as **intermediate or transitional** hosts. Some of these hosts can also be **vectors** (such as ticks, mosquitoes), which carry and spread disease-causing parasites from one host to another. These life cycles with more than one host are known as **indirect or complex** life cycles. There are some parasites that use additional hosts to overcome adverse environmental conditions or to increase the likelihood that the parasite will be transmitted to the definitive host. There is no further development of the parasite in these hosts. They are known as **paratenic or transport** hosts.

Part 1: General parasitology including taxonomy, diagnosis, antiparasitics

1 VETERINARY HELMINTHOLOGY

Kingdom Animalia

Phylum	Class Subclass	Order	Superfamily Family (Subfamily)	Genus	Chapters
Nematoda	Secernentea	Strongylida	Trichostrongyloidea		
			Trichostrongylidae	<i>Trichostrongylus</i>	1, 8, 9, 10, 11, 12, 14, 15, 16
				<i>Marshallagia</i>	1, 8, 14
				<i>Hyostongylus</i>	1, 11
				<i>Mecistocirrus</i>	1, 8, 9, 11
				<i>Graphidium</i>	1, 15
				<i>Obeliscoides</i>	1, 15
				<i>Libyostrongylus</i>	1, 16
				<i>Graphinema</i>	1, 14
				<i>Impalaia</i>	1, 14
			(Ostertaginae)	<i>Ostertagia</i>	1, 8, 9, 14
				<i>Teladorsagia</i>	1, 9, 14
				<i>Spiculopteragia</i>	1, 14
				<i>Apteragia</i>	1, 14
				<i>Camelostrongylus</i>	1, 14
			(Haemonchinae)	<i>Haemonchus</i>	1, 8, 9, 14
			Cooperidae	<i>Cooperia</i>	1, 8, 9, 14
			Ornithostrongylidae	<i>Ornithostrongylus</i>	1, 16
			Amidostomidae	<i>Amidostomum</i>	1, 13
				<i>Epomidiostomum</i>	1, 13
			Molineidae	<i>Nematodirus</i>	1, 8, 9, 14
				<i>Nematodirella</i>	1, 14
				<i>Lamanema</i>	1, 14
				<i>Ollulanus</i>	1, 11, 12
			Helligmonellidae	<i>Nippostrongylus</i>	1, 15
				<i>Nematospiroides</i>	1, 15
			Dictyocaulidae	<i>Dictyocaulus</i>	1, 8, 9, 10, 14
			Strongyloidea		
			Strongylidae	<i>Strongylus</i>	1, 10
				<i>Triodontophorus</i>	1, 10
			(Strongylinae)	<i>Chabertia</i>	1, 8, 9, 14
				<i>Oesophagostomum</i>	1, 8, 9, 11, 14
				<i>Poteriostomum</i>	1, 10
				<i>Craterostomum</i>	1, 10
				<i>Oesophagodontus</i>	1, 10
				<i>Codiostomum</i>	1, 16
			(Cyathostominae)	<i>Cyathostomum</i>	1, 10
				<i>Cylicocyclus</i>	1, 10
				<i>Cylicodontophorus</i>	1, 10
				<i>Cylicostephanus</i>	1, 10

(Continued)

Kingdom Animalia *Continued*

Phylum	Class Subclass	Order	Superfamily Family (Subfamily)	Genus	Chapters			
			Syngamidae	<i>Syngamus</i>	1, 3, 13, 16			
				<i>Cyathostoma</i>	1, 4, 16			
				<i>Mammomonogamus</i>	1, 8, 9, 12			
				<i>Stephanurus</i>	1, 8, 11			
			Deletrocephalidae	<i>Deletrocephalus</i>	1, 16			
				<i>Paradeletrocephalus</i>	1, 16			
			Ancylostomatoidea					
			Ancylostomatidae	<i>Ancylostoma</i>	1, 12			
				<i>Uncinaria</i>	1, 12			
				<i>Bunostomum</i>	1, 8, 9, 14			
				<i>Gaigeria</i>	1, 9			
				<i>Necator</i>	1			
				<i>Globocephalus</i>	1, 11			
				<i>Agriostomum</i>	1, 8			
			Diaphanocephaloidea	<i>Kalicephalus</i>	1, 16			
			Metastrongyloidea					
			Metastrongylidae	<i>Metastrongylus</i>	1, 11			
			Protostrongylidae	<i>Muellerius</i>	1, 8, 14			
				<i>Protostrongylus</i>	1, 8, 14			
				<i>Cystocaulus</i>	1, 8, 14			
				<i>Spiculocaulus</i>	1, 8			
				<i>Neoststrongylus</i>	1, 8			
				<i>Varestrongylus</i>	1, 14			
				<i>Parelaphostrongylus</i>	1, 14			
				<i>Elaphostrongylus</i>	1, 14			
			Filaroididae	<i>Oslerus</i>	1, 12			
				<i>Filaroides</i>	1, 12			
				<i>Aelurostrongylus</i>	1, 12			
			Angiostrongylidae	<i>Angiostrongylus</i>	1, 12, 15			
			Crenosomidae	<i>Crenosoma</i>	1, 12			
			Rhabditida	Rhabditoidea				
			Strongyloidea	<i>Strongyloides</i>	1, 8, 9, 10, 11, 12, 13, 14, 15, 16			
			Panagrolaimidae	<i>Halicephalobus</i>	1, 10			
			Rhabditidae	<i>Rhabditis</i>	1, 10			
			Rhabdiasidae	<i>Rhabdias</i>	1, 16			
			Ascaridida	Ascaridoidea				
			Ascarididae	<i>Ascaris</i>	1, 11, 16			
				<i>Toxocara</i>	1, 8, 12			
				<i>Toxascaris</i>	1, 12			
				<i>Parascaris</i>	1, 10			
				<i>Ascaridia</i>	1, 13,16			
				<i>Heterakis</i>	1, 13, 16			
				<i>Porrocaecum</i>	1, 13			
				<i>Bayliascaris</i>	1, 16			
				<i>Polydelphus</i>	1, 16			
				<i>Ophidascaris</i>	1, 16			
				<i>Angusticaecum</i>	1, 16			
			Anisakidae	<i>Anisakis</i>	1			
				<i>Contracaecum</i>	1, 13			
				<i>Hysterothylacium</i>	1			
				<i>Pseudoterranova</i>	1			
				<i>Sulcascaris</i>	1, 16			

	Diectophymatoidea			
	Diectophymatidae	<i>Diectophyma</i>	1, 11, 12	
		<i>Hystrichis</i>	1, 13	
		<i>Eustrongylides</i>	1, 13	
Oxyurida	Oxyuroidea			
	Oxyuridae	<i>Oxyuris</i>	1, 10	
		<i>Skrjabinema</i>	1, 8, 9, 14	
		<i>Enterobius</i>	1, 15	
		<i>Aspicularis</i>	1, 15	
		<i>Syphacia</i>	1, 15	
		<i>Passalurus</i>	1, 15	
		<i>Dermatoxys</i>	1, 15	
	Cosmocercidae	<i>Probstmayria</i>	1, 10	
	Aspidoderidae	<i>Paraspidodera</i>	1, 15	
	Pharyngodonidae	<i>Tachygonetria</i>	1, 16	
	Spirurida	Spiruroidea		
		Spirocercidae	<i>Spirocerca</i>	1, 12
<i>Ascarops</i>			1, 11	
<i>Physocephalus</i>			1, 11	
<i>Simondsia</i>			1, 11	
Habronematidae		<i>Habronema</i>	1, 10	
		<i>Draschia</i>	1, 10	
		<i>Parabronema</i>	1, 8, 9, 14	
		<i>Histiocephalus</i>	1, 13	
Thelaziidae		<i>Thelazia</i>	1, 8, 10, 12, 14	
		<i>Oxyspirura</i>	1, 13	
Ganthostomatidae		<i>Gnathostoma</i>	1, 11, 12	
Gongylonematidae		<i>Gongylonema</i>	1, 8, 9, 11, 13, 14	
Physalopteridae		<i>Physaloptera</i>	1, 12	
Spiruridae		<i>Spirura</i>	1, 12, 16	
		<i>Odontospirura</i>	1, 16	
Tetrameridae		<i>Tetrameres</i>	1, 13, 16	
Hartertiidae		<i>Hartertia</i>	1, 13	
Pneumospiridae		<i>Metathelazia</i>	1	
		<i>Vogeloides</i>	1	
Subuluroidea				
	Subuluridae	<i>Subulura</i>	1, 13	
Dracunculoidea				
	Dracunculidae	<i>Dracunculus</i>	1	
		<i>Avioserpens</i>	1, 13	
Acuarioidea				
	Acuriidae	<i>Echinuria</i>	1, 13	
		<i>Dispharynx</i>	1, 13,16	
		<i>Cheilospirura</i>	1, 13	
		<i>Streptocara</i>	1, 13	
Filarioidea				
	Filariidae	<i>Parafilaria</i>	1, 8, 10	
		<i>Stephanofilaria</i>	1, 8	
		<i>Brugia</i>	1	
		<i>Loa</i>	1	
		<i>Suifilaria</i>	1, 11	

(Continued)

Kingdom Animalia Continued

			Onchocercidae	<i>Dirofilaria</i>	1, 12
				<i>Acanthocheilonema</i>	1, 12, 14
				<i>Onchocerca</i>	1, 8, 10, 14
				<i>Pelecitus</i>	1, 16
				<i>Chanderella</i>	1, 16
				<i>Setaria</i>	1, 8, 10
				<i>Elaeophora</i>	1, 8, 9, 10, 14
				<i>Splendidofilaria</i>	1
				<i>Wuchereria</i>	1
				<i>Mansonella</i>	1
				<i>Paronchocerca</i>	1, 16
			Adenophorea	Enoplida	Trichuroidea
		Trichuridae	<i>Trichuris</i>	1, 8, 9, 11, 12, 14, 15	
			<i>Trichosomoides</i>	1, 15	
		Capillaridae	<i>Capillaria</i>	1, 8, 9, 12, 13, 14, 15, 16	
			<i>Eucoleus</i>	1, 13	
		Trichinelloidea			
		Trichinellidae	<i>Trichinella</i>	1, 10, 11, 12	
Acanthocephala		Oligacanthorhynchidae	<i>Macracanthorhynchus</i>	1, 10, 11	
			<i>Oncicola</i>	1, 11	
			<i>Prosthenorchis</i>	1, 15	
		Polymorphidae	<i>Polymorphus</i>	1, 13	
			<i>Filicollis</i>	1, 13	
			<i>Moniiformis</i>	1	
Platyhelminthes	Trematoda				
	Digenea	Echinostomatida	Fasciolidae	<i>Fasciola</i>	1, 8, 9, 10, 11, 12, 14
				<i>Fascioloides</i>	1, 8, 9, 14
				<i>Fasciolopsis</i>	1, 11
			Paramphistomatidae	<i>Paramphistomum</i>	1, 8, 9, 14
				<i>Orthocoelium</i>	1, 8, 9, 14
				<i>Cotylophoron</i>	1, 8, 9
				<i>Calicophoron</i>	1, 8, 9
				<i>Gigantocotyle</i>	1
				<i>Bothriophoron</i>	1
				<i>Pseudodiscus</i>	1, 10
			Gastrodiscidae	<i>Gastrodiscus</i>	1, 10, 11
				<i>Homalogaster</i>	1, 8
			Gastrothylicidae	<i>Gastrothylax</i>	1, 8, 9
				<i>Fischoederius</i>	1, 8, 9
				<i>Carmyerius</i>	1, 8
			Echinostomatidae	<i>Echinostoma</i>	1, 12, 13, 16
				<i>Echinoparyphium</i>	1, 13, 16
				<i>Hypoderaeum</i>	1, 13, 16
				<i>Echinochasmus</i>	1, 12
				<i>Euparyphium</i>	1, 12
			Philophthalmidae	<i>Philophthalmus</i>	1, 16
			Cyclocoelidae	<i>Typhlocoelum</i>	1, 13
				<i>Hyptiasmus</i>	1, 13
			Notocotylidae	<i>Notocotylus</i>	1, 13
				<i>Catatropis</i>	1, 13
				<i>Cymbiforma</i>	1, 8, 9
		Plagiorchida	Dicrocoeliidae	<i>Dicrocoelium</i>	1, 8, 9, 14
				<i>Eurytrema</i>	1, 8, 9, 11, 12, 14
				<i>Platynosomum</i>	1, 12

		Paragonimidae	<i>Paragonimus</i>	1, 14	
		Nanophyetidae	<i>Nanophyetus</i>	1, 12	
		Collyriclidae	<i>Collyriclum</i>	1, 13	
		Prosthogonimidae	<i>Prosthogonimus</i>	1, 13	
		Plagiorchiidae	<i>Plagiorchis</i>	1, 13	
	Opisthorchida	Opisthorchiidae	<i>Clonorchis</i>	1, 12	
			<i>Opisthorchis</i>	1, 10, 11	
			<i>Metorchis</i>	1, 12	
			<i>Parametorchis</i>	1, 12	
			<i>Pseudamphistomum</i>	1, 12	
		Brachylaemidae	<i>Brachylaemus</i>	1, 13, 16	
			<i>Skrjabinotrema</i>	1, 9	
			<i>Postharmostomum</i>	1, 11	
		Heterophyidae	<i>Heterophyes</i>	1, 12	
			<i>Metagonimus</i>	1, 12	
			<i>Apophallus</i>	1, 6	
			<i>Cryptocotyle</i>	1, 6	
			<i>Haplorchis</i>	1, 6	
	Strigeidida	Schistosomatidae	<i>Schistosoma</i>	1, 8, 9, 10, 11, 12, 14	
			<i>Bilharziella</i>	1, 13	
			<i>Trichobilharzia</i>	1	
			<i>Orientobilharzia</i>	1, 8, 9	
			<i>Ornithobilharzia</i>	1	
			<i>Heterobilharzia</i>	1	
			<i>Austroilharzia</i>	1	
		Diplostomatidae	<i>Alaria</i>	1, 12	
			<i>Diplostomum</i>	1	
		Strigeidae	<i>Apatemon</i>	1, 13	
			<i>Parastrigea</i>	1, 13	
			<i>Cotylurus</i>	1, 13	
Cestoda	Cyclophyllidea	Taeniidae	<i>Taenia</i>	1, 8, 9, 11, 12, 14, 15	
			<i>Echinococcus</i>	1, 8, 9, 10, 11, 12, 14	
		Anoplocephalidae	<i>Anoplocephala</i>	1, 10	
			<i>Paranoplocephala</i>	1, 10	
			<i>Moniezia</i>	1, 8, 9, 14	
			<i>Cittotaenia</i>	1, 9	
			<i>Thysanosoma</i>	1, 8, 9	
			<i>Thysaniezia</i>	1, 8, 9, 14	
			<i>Stilesia</i>	1, 8, 9, 14	
			<i>Avitellina</i>	1, 8, 9, 14	
		Dilepididae	<i>Dipylidium</i>	1, 12	
			<i>Amoebotaenia</i>	1, 13	
			<i>Choanotaenia</i>	1, 13	
		Paruterinidae	<i>Metroliaesthes</i>	1, 13	
		Davaineidae	<i>Davainea</i>	1, 13, 16	
			<i>Raillietina</i>	1, 13, 16	
			<i>Cotugnia</i>	1, 13	
			<i>Houttuynia</i>	1, 16	
		Hymenolepididae	<i>Hymenolepis</i>	1, 13	
			<i>Fimbriaria</i>	1, 13	
			<i>Rodentolepis</i>	1, 15	
		Mesocestoididae	<i>Mesocestoides</i>	1, 12	
		Pseudophyllidea	Diphyllbothriidae	<i>Diphyllbothrium</i>	1, 12
				<i>Spirometra</i>	1, 12

2 VETERINARY PROTOZOOLOGY

Kingdom Protozoa

Phylum	Class	Order (Suborder)	Family	Genus	Chapters		
Amoebozoa	Archamoeba	Amoebida	Entamoebidae	Entamoeba	2, 8, 9, 10, 11, 12, 13, 16		
				Iodamoeba	2, 10		
				Endolimax	2		
			Acantamoebidae	Acanthamoeba	2		
Percolozoa	Heterolobosea	Schizopyrenida	Vahlkampfidae	Naegleria	2		
Euglenozoa	Kinetoplasta	Trypanosomatida	Trypanosomatidae	Leishmania	2, 12		
				Trypanosoma	2, 4, 8, 9, 10, 12, 13, 14, 16		
Parabasalia	Trichomonadea	Trichomonadida	Trichomonadidae	Tritrichomonas	2, 8, 11, 13, 15		
				Trichomonas	2, 12, 13, 16		
				Tetratrichomonas	2, 8, 9, 11, 12, 13, 15		
				Trichomitus	2, 11		
				Pentatrichomonas	2, 12, 16		
				Cochlosoma	2, 13		
			Dientamoebidae	Histomonas	2, 13		
			Monocercomonadidae	Monocercomonas	2, 8, 16		
				Chilomitus	2, 15		
				Dientamoeba	2, 15		
				Honigbergiellida	Hexamastigidae	Hexamastix	2, 15
				Proteromonadida	Proteromonadidae	Proteromonas	2, 15
			Fornicata	Retortamonadea	Retortamonadida	Retortamonadidae	Retortamonas
Chilomastix	2, 11, 13, 15, 16						
Trepamonadea	Diplomonadida	Hexamitidae		Spironucleus	2, 13, 15, 16		
				Caviomonas	2, 15		
		Enteromonadidae		Enteromonas	2, 15		
Metamonadea	Giardiida	Giardiidae		Giardia	2, 8, 9, 10, 11, 12, 15		
Preaxostyla	Anaeromonadea	Oxymonadida	Polymastigidae	Monocercomonoides	2, 15		
Apicomplexa	Conoidasida	Eucoccidiorida	(Eimeriorina)	Eimeriidae	Eimeria	2, 8, 9, 10, 11, 13, 14, 15, 16	
					Cystisopora	2, 11, 12, 14, 16	
					Isospora	2	
					Cyclospora	2, 16	
					Tyzzeria	2, 13, 16	
					Wenyonella	2, 13, 16	
					Caryospora	2, 16	
					Hoarella	2, 16	
					Octosporella	2, 16	
					Pythonella	2, 16	
					Atoxoplasma	2	
					Cryptosporidiidae	Cryptosporidium	2, 8, 9, 10, 11, 12, 13, 14, 15, 16
			Sarcocystiidae	Besnoitia	2, 8, 9, 12, 14, 16		
				Hammondia	2, 12		
				Sarcocystis	2, 8, 9, 10, 11, 12, 13, 14, 15, 16		
				Neospora	2, 8		
				Frenkelia	2		
				Toxoplasma	2, 8, 9, 10, 11, 12, 13, 14, 15, 16		
			Lankesterellidae	Lankesterella	2		
		(Adeleorina)	Klossiellidae	Klossiella	2, 10, 15, 16		

	Aconoidasida	Haemospororida	Haemogregarinidae	<i>Haemogregarina</i>	2, 16
			Hepatozoidae	<i>Hepatozoon</i>	2, 12, 15, 16
			Plasmodiidae	<i>Haemoproteus</i>	2, 13, 16
				<i>Leucocytozoon</i>	2, 13, 16
				<i>Plasmodium</i>	2, 13, 16
				<i>Hepatocystis</i>	2, 15
		Piroplasmorida	Babesiidae	<i>Babesia</i>	2, 8, 9, 10, 11, 12, 14
			Theileriidae	<i>Theileria</i>	2, 8, 9, 10, 14
				<i>Cytauxzoon</i>	2, 12
Ciliophora	Litostomatea	Trichostomatorida	Balantidiidae	<i>Balantidium</i>	2, 11, 16
			Pycnotrichidae	<i>Buxtonella</i>	2, 8, 14
			Nyctotheridae	<i>Nyctotherus</i>	2, 16

Kingdom Fungi

Phylum	Class	Order	Family	Genus	Chapters
Microsporidia	Microsporea	Microspororida	Enterocytozoonidae	<i>Encephalitozoon</i>	2, 12, 15
				<i>Enterocytozoon</i>	2
Ascomycota	Pneumocystidomycetes	Pneumocystidales	Pneumocystidaceae	<i>Pneumocystis</i>	2, 8

Kingdom Chromalveolata

Phylum	Class	Order	Family	Genus	Chapters
Opalinata	Blastocystae	Blastocystida	Blastocystidae	<i>Blastocystis</i>	2, 13, 16

Kingdom Bacteria

Phylum	Class	Order	Family	Genus	Chapters
Proteobacteria	Alphaproteobacteria	Rickettsiales	Rickettsiaceae	<i>Rickettsia</i>	2, 8, 9, 12, 15
				<i>Anaplasma</i>	2, 8, 9, 10, 12, 14
				<i>Ehrlichia</i>	2, 8, 9, 12
				<i>Aegyptianella</i>	2, 13
		Rhizobiales	Bartonellaceae	<i>Rochalimaea</i>	2
				<i>Bartonella</i>	2
				<i>Grahamella</i>	2
		Legionellales	Coxiellaceae	<i>Coxiella</i>	2
				<i>Neorickettsia</i>	2, 10, 12
Firmicutes	Mollicutes	Mycoplasmatales	Mycoplasmataceae	<i>Eperythrozoon</i>	2, 8, 9, 11
				<i>Haemobartonella</i>	2, 12

3 VETERINARY ENTOMOLOGY

Kingdom Animalia

Phylum	Class	Order (Suborder)	Family (Subfamily)	Genus	Chapters		
Arthropoda	Insecta	Hemiptera	Cimicidae	<i>Cimex</i>	3		
			Reduviidae	<i>Triatoma</i>	3, 17		
				<i>Rhodnius</i>	3, 17		
				<i>Panstrongylus</i>	3		
		Diptera					
		(Nematocera)	Ceratopogonidae	<i>Culicoides</i>	3, 17		
			Simuliidae	<i>Simulium</i>	3, 17		
			Psychodidae	<i>Phlebotomus</i>	3, 17		
				<i>Lutzomyia</i>	3, 17		
			Culicidae	<i>Aedes</i>	3, 17		
				<i>Anopheles</i>	3, 17		
				<i>Culex</i>	3, 17		
		(Brachycera)	Tabanidae	<i>Chrysops</i>	3, 17		
				<i>Haematopota</i>	3, 17		
				<i>Tabanus</i>	3, 17		
			Muscidae	<i>Musca</i>	3, 17		
				<i>Hydrotaea</i>	3, 17		
				<i>Stomoxys</i>	3, 17		
				<i>Haematobia</i>	3, 17		
			Fanniidae	<i>Fannia</i>	3, 17		
			Hippoboscidae	<i>Hippobosca</i>	3, 17		
				<i>Melophagus</i>	3, 9		
				<i>Lipoptena</i>	3, 17		
				<i>Pseudolynchia</i>	3, 16		
			Glossinidae	<i>Glossina</i>	3, 17		
			Calliphoridae	<i>Lucilia</i>	3, 8, 9, 17		
				<i>Calliphora</i>	3, 8, 17		
				<i>Protophormia</i>	3, 9, 17		
				<i>Phormia</i>	3, 9, 17		
				<i>Cochliomyia</i>	3, 17		
				<i>Chrysomya</i>	3, 17		
				<i>Cordylobia</i>	3, 17		
			Sarcophagidae	<i>Sarcophaga</i>	3, 17		
				<i>Wohlfahrtia</i>	3, 17		
			Oestridae				
			(Oestrinae)	<i>Oestrus</i>	3, 9, 14		
				<i>Rhinoestrus</i>	3, 10		
				<i>Geddoelstia</i>	3, 9		
				<i>Cephenemyia</i>	3, 14		
				<i>Cephalopina</i>	3, 14		
				<i>Oedemagena</i>	3, 14		
				<i>Pharyngomyia</i>	3, 14		
			(Gasterophilinae)	<i>Gasterophilus</i>	3, 10		
			(Hypodermatinae)	<i>Hypoderma</i>	3, 8, 14		
				<i>Przhevalskiana</i>	3, 9		
			(Cuterebrinae)	<i>Cuterebra</i>	3, 15		
				<i>Dermatobia</i>	3, 17		

Phthiraptera				
	(Anoplura)	Haematopiniidae	<i>Haematopinus</i>	3, 8, 10, 11
		Linognathidae	<i>Linognathus</i>	3, 8, 9, 12
			<i>Solenopotes</i>	3, 8
		Microthoraciidae	<i>Microthoracius</i>	3, 14
		Polyplacidae	<i>Polyplax</i>	3, 15
			<i>Haemodipsus</i>	3
	(Amblycera)	Menoponidae	<i>Menacanthus</i>	3, 13
			<i>Menopon</i>	3, 13
			<i>Holomenopon</i>	3, 13
			<i>Ciconiphilus</i>	3, 13
			<i>Trinoton</i>	3, 13
			<i>Amyrsidea</i>	3, 13
			<i>Mecanthus</i>	3, 13
		Boopidae	<i>Heterodoxus</i>	3, 12
		Gyropidae	<i>Gyropus</i>	3, 15
			<i>Gliricola</i>	3, 15
		Trimenoponidae	<i>Trimenopon</i>	3, 15
	(Ischnocera)	Philopteridae	<i>Cuclotogaster</i>	3, 13
			<i>Lipeurus</i>	3, 13
			<i>Struthiolipeurus</i>	3, 16
			<i>Meinertzhageniella</i>	3, 16
			<i>Dahlehornia</i>	3, 16
			<i>Goniodes</i>	3, 13
			<i>Goniocotes</i>	3, 13
			<i>Anaticola</i>	3, 13
			<i>Acidoproctus</i>	3, 13
			<i>Anatoecus</i>	3, 13
			<i>Ornithobius</i>	3, 13
			<i>Columbicola</i>	3, 16
			<i>Lagopoecus</i>	3, 13
		Trichodectidae	<i>Felicola</i>	1, 12
			<i>Trichodectes</i>	1, 12
		Bovicolidae	<i>Bovicola</i>	1, 8, 9, 10
	Siphonaptera	Ceratophyllidae	<i>Ceratophyllus</i>	3, 17
			<i>Nosopsyllus</i>	3, 15, 17
		Pulicidae	<i>Ctenocephalides</i>	3, 12, 17
			<i>Spilopsyllus</i>	3, 17
			<i>Echidnophaga</i>	3, 17
			<i>Pulex</i>	3, 17
			<i>Xenopsylla</i>	3, 15, 17
			<i>Archaeopsylla</i>	3, 17
			<i>Tunga</i>	3, 17
		Leptopsyllidae	<i>Leptopsylla</i>	3, 17
Arachnida	Ixodida	Ixodidae	<i>Ixodes</i>	3, 17
			<i>Dermacentor</i>	3, 17
			<i>Rhipicephalus</i>	3, 17
			<i>(Boophilus)</i>	3, 17
			<i>Haemaphysalis</i>	3, 17
			<i>Amblyomma</i>	3, 17
			<i>Hyalomma</i>	3, 17

(Continued)

Kingdom Animalia *Continued*

Astigmata	Argasidae	<i>Argas</i>	3, 17
		<i>Otobius</i>	3, 17
		<i>Ornithodoros</i>	3, 17
	Sarcoptidae	<i>Sarcoptes</i>	3, 8, 9, 10, 11, 12, 14
		<i>Notoedres</i>	3, 12, 15
		<i>Trixacarus</i>	3, 15
	Psoroptidae	<i>Psoroptes</i>	3, 8, 9, 10, 14
		<i>Chorioptes</i>	3, 8, 9, 10, 14
		<i>Otodectes</i>	3, 12
	Knemidocoptidae	<i>Knemidocoptes</i>	3, 13
	Listrophoridae	<i>Leporacarus</i>	3, 15
	Myocoptidae	<i>Mycopetes</i>	3, 15
	Cytoditidae	<i>Cytodites</i>	3, 13, 16
	Laminosioptidae	<i>Laminosioptes</i>	3, 13
	Analgidae	<i>Megninia</i>	3, 13
	Atopomelidae	<i>Chirodiscoides</i>	3, 15
	Dermoglyphidae	<i>Dermoglyphus</i>	3, 13
	Freyanidae	<i>Freyana</i>	3, 13
	Epidermoptidae	<i>Epidermoptes</i>	3, 13
		<i>Microlichus</i>	3, 13
		<i>Promyialges</i>	3, 13
	Pterolichidae	<i>Pterolichus</i>	3, 13
		<i>Sideroferus</i>	3, 13
	Gabuciniidae	<i>Gabucinia</i>	3, 16
	Hypoderidae	<i>Hypodectes</i>	3, 13
Prostigmata	Demodicidae	<i>Demodex</i>	3, 8, 9, 10, 11, 12, 15
	Cheyletidae	<i>Cheyletiella</i>	3, 12
	Trombiculidae	<i>Trombicula</i>	3, 17
		<i>Neotrombicula</i>	3, 17
		<i>Eutrombicula</i>	3, 17
		<i>Leptotrombidium</i>	3, 15
		<i>Neoschongastia</i>	3, 13
	Psorergatidae	<i>Psorobia</i>	3, 8, 9, 15
	Pyemotidae	<i>Pyemotes</i>	3, 17
	Myobidae	<i>Myobia</i>	3, 15
		<i>Radfordia</i>	3, 15
	Syringophilidae	<i>Syringophilus</i>	3, 13
	Cloacaridae	<i>Cloacarus</i>	3
	Pterygosomatidae	<i>Geckobiella</i>	3, 16
		<i>Pimeliaphilus</i>	3, 16
		<i>Hirstiella</i>	3, 16
		<i>Ixodiderma</i>	3, 16
		<i>Scapothrix</i>	3, 16
		<i>Zonurobia</i>	3, 16
Mesostigmata	Macronyssidae	<i>Ornithonyssus</i>	3, 13, 15
		<i>Neoliponyssus</i>	3, 16
		<i>Ophionyssus</i>	3, 16

			Dermanyssidae	<i>Dermanyssus</i>	3, 13, 15
				<i>Liponyssoides</i>	3, 15
			Halarachnidae	<i>Pneumonyssoides</i>	3, 12
				<i>Pneumonyssus</i>	3
				<i>Raillietia</i>	3, 8, 9
			Entonyssidae	<i>Entonyssus</i>	3, 16
				<i>Entophionyssus</i>	3, 16
				<i>Mabuyonyssus</i>	3, 16
			Rhinonyssidae	<i>Sternosoma</i>	3, 13
			Laelapidae	<i>Hirstionyssus</i>	3, 15
				<i>Haemogamasus</i>	3, 16
				<i>Eulaelaps</i>	3, 16
				<i>Laelaps</i>	3, 16
				<i>Androlaelaps</i>	3, 16
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(Pentastomida)	Porocephalida	Linguatulidae	<i>Linguatula</i>	3, 16	

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Preface to the first edition

This book is intended for students of veterinary parasitology, for practising veterinarians and for others requiring information on some aspect of parasitic disease.

Originally intended as a modestly expanded version of the printed notes issued to our students in the third and fourth years of the course, the text, perhaps inevitably, has expanded. This was due to three factors. First, a gradual realization of the deficiencies in our notes; secondly, the necessity of including some of the comments normally imparted during the lecture course and thirdly, at the suggestion of the publishers, to the inclusion of certain aspects of parasitic infections not treated in any detail in our course.

We should perhaps repeat that the book is primarily intended for those who are directly involved in the diagnosis, treatment and control of parasitic diseases of domestic animals. The most important of these diseases have therefore been discussed in some detail, the less important dealt with more briefly and the uncommon either omitted or given a brief mention. Also, since details of classification are of limited value to the veterinarian we have deliberately kept these to the minimum sufficient to indicate the relationships between the various species. For a similar reason, taxonomic detail is only presented at the generic level and, occasionally, for certain parasites, at species level. We have also trod lightly on some other areas such as, for example, the identification of species of tropical ticks and the special significance and epidemiology of some parasites of regional importance. In these cases, we feel that instruction is best given by an expert aware of the significance of particular species in that region.

Throughout the text we have generally referred to drugs by their chemical, rather than proprietary, names because of the plethora of the latter throughout the world. Also, because formulations are often different, we have avoided stating doses; for these, reference should be made to the data sheets produced by the manufacturer. However, on occasions when a drug is recommended at an unusual dose, we have noted this in the text.

In the chapters at the end of the book we have attempted to review five aspects of veterinary parasitology, epidemiology, immunity, anthelmintics, ectoparasiticides and laboratory diagnosis. We hope that this broader perspective will be of value to students, and particularly to those dismayed by the many complexities of the subject.

There are no references in the text apart from those at the end of the chapter on diagnosis. This was decided with some regret and much relief on the grounds that it would have meant the inclusion, in a book primarily intended for undergraduates, of hundreds of references. We hope that those of our colleagues throughout the world who recognize the results of their work in the text will accept this by way of explanation and apology.

We would, however, like to acknowledge our indebtedness to the authors of several source books on veterinary parasitology whose work we have frequently consulted. These include *Medical and Veterinary Protozoology* by Adam, Paul & Zaman, *Veterinärmedizinische Parasitologie* by Boch & Supperer, Dunn's *Veterinary Helminthology*, Euzéby's *Les Maladies Vermineuses des Animaux Domestiques*, Georgi's *Parasitology for Veterinarians*, Reinecke's *Veterinary Helminthology*, Service's *A Guide to Medical Entomology* and Soulsby's *Helminths, Arthropods and Protozoa of Domesticated Animals*.

Any student seeking further information on specific topics should consult these or, alternatively, ask his tutor for a suitable review.

The ennui associated with repeated proof reading may occasionally (we hope, rarely) have led to some errors in the text. Notification of these would be welcomed by the authors. Finally we hope that the stresses endured by each of us in this collaborative venture will be more than offset by its value to readers.

G.M. Urquhart
J. Armour
J.L. Duncan
A.M. Dunn
F.W. Jennings
September 1985

Acknowledgements to the first edition

We would like to express our gratitude to the following individuals and organizations that assisted us in the preparation of this book.

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Secondly, to the following individuals and companies who kindly allowed us to use their photographs or material as illustrations or plates:

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Thirdly, to the pharmaceutical companies of Crown Chemical, Kent, England; Hoechst UK, Bucks; Merck Sharp & Dohme, Herts; Pfizer, Kent; Schering, New Jersey; Syntex Agribusiness, California. Their generosity enabled us to present many of the photographs in colour, thus enhancing their value.

Finally, to those members of the Faculty of Veterinary Medicine, Glasgow, whose cooperation was essential in the production of this book. We would especially like to thank Kenneth Bairden, our chief technician, who prepared much of the material for photography, often at inordinately short notice; Archie Finnie and Allan May, of the Photographic Unit, who, almost uncomplainingly, undertook the extra work of photographing many specimens; our two departmental secretaries, Elizabeth Millar and Julie Nybo, without whose skill and attention to detail this book would certainly not have been written.

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A. M. Dunn
F. W. Jennings
September 1985

Preface and acknowledgements to the second edition

The first edition of this book was published in 1987 and the authors considered that a second edition is now necessary for several reasons.

First, the widespread use of drugs such as avermectins and milbemycins, which have had a significant effect on anthelmintic prophylaxis and control. At the time of the first edition only one, ivermectin, was marketed whereas at the present time there are now several such products, supplemented by a number of new, long-acting chemoprophylactic devices.

Secondly, in many countries the production of a number of older anthelmintics and insecticides has largely ceased or many are difficult to find.

Thirdly, several parasitic diseases have now been described, about which little was known at the time of the first edition. Notably these are neosporosis and Lyme disease. Also included is a short description of the nasal mite of dogs, *Pneumonyssus caninum*, kindly provided by Professor Arvid Uggla of the National Veterinary Institute and Swedish University of Agricultural Sciences, Uppsala, Sweden.

Fourthly, we have taken the opportunity of rewriting some parts of the text, which on reflection, were less clear than we had hoped. In many cases, this has been supplemented by new diagrams or photographs.

Another change in this edition is the adoption of the standardized nomenclature of animal parasitic diseases (SNOAPAD) proposed by an expert committee appointed by the World Association for the Advancement of Veterinary Parasitology (WAAVP) published in *Veterinary Parasitology* (1988) 29, 299–326. Although this may have a discomforting effect on those who have used certain familiar terms for animal parasitic diseases for many years, it is designed to improve the clarity of scientific communication by the

general use of uniform terminology and should, in the long term, prove particularly beneficial in facilitating the retrieval of computerized data related to veterinary parasitology.

At the end of the book we have given a list of books and journals, which should be useful to anyone who wishes to pursue a specific subject in greater detail. This is confined to publications which are readily available in most libraries of universities and research institutes.

We wish to thank Drs Ken Bairden, Quintin McKellar and Jacqueline McKeand for helpful comments on the text, also Mr Stuart Brown who assisted in the preparation of some of the new illustrations and Una B. Shanks RSW who prepared all of the new drawings.

We should mention, with great regret, the death of our co-author Dr Angus M. Dunn, who died in 1991 before this review was started, but we are reasonably certain that he would have approved of all the alterations we have made.

At the start of this revision we had intended to include new sections on parasitic disease of both fish and laboratory animals. However, a subsequent review of the literature currently available on these two subjects indicated that both were adequately covered in existing publications and it seemed more sensible to include the titles of these in the list of suggested reading.

Finally we wish to express our appreciation of the reception accorded to the first edition by reviewers, colleagues and students; we hope this second edition will be equally well received.

G. M. Urquhart
J. Armour
J. L. Duncan
A. M. Dunn
F. W. Jennings

Preface and acknowledgements to the third edition

The third edition has been written to accommodate a wider readership which includes teachers and students in veterinary schools, research groups in universities and institutes, veterinarians in practice and in government service and others who are involved in aspects of parasitic disease. In producing the new edition of *Veterinary Parasitology* the authors had several aims.

The first was to preserve the spirit of the first and second editions, which had been compiled by eminent and respected veterinary parasitologists in their field and which provided a solid background on which to consolidate.

The second aim was to expand the sections on protozoa and ectoparasites and to incorporate a larger selection of parasites, which are of veterinary significance in other parts of the world. The book focuses mainly on core information relating to parasites of livestock and companion animals but new sections on parasites of poultry and gamebirds, laboratory animals, exotic pets, and 'farmed' species have been included. The majority of parasitic diseases are now covered in detail using a standardised format for each parasite to allow easy referencing and for comparison between species within a genus. Where appropriate, reference is made to human infections where there is natural transmission of parasitic disease between vertebrate animals and man (zoonoses).

The third aim was to present the information in a format which is compatible with the current parasitology teaching modules used within many university veterinary schools. This inevitably has had to be a compromise, as approaches to teaching veterinary parasitology differ throughout the world, but, by arranging the parasites under host species and their predilection site within the host and providing a comprehensive check list for each section and extensive cross-referencing, it is hoped that information on particular parasites can be easily located. Taxonomy of the main parasitic phyla and classes are provided within an introductory chapter along with generic descriptions and anatomical features of the parasite orders and families. Additional detailed sections are provided at the back of the book on veterinary antiparasitics, with a section on laboratory diagnosis, including numerous tables and identification charts. In keeping with previous editions a series of brief overviews of topics relevant to veterinary parasitology have been included to provide the non-expert with basic background information and to also highlight additional sources of reading.

The classification of parasites has been updated to reflect many of the systematic changes introduced, particularly where molecular genetics-based taxonomic re-organisation has been introduced. Throughout, synonyms have been provided reflecting older taxonomic nomenclature or where controversy remains. As with the previous edition, parasitic infections are described according to the Standardized Nomenclature of Animal Parasitic Diseases guidelines (SNOAPAD, 1988; *Veterinary Parasitology* **29**, 299–326). In considering treatment of parasitic infections we have used the generic names of drugs to avoid listing the wide range of products which are currently marketed in different countries. Dose rates of drugs are not always stated as many vary from country to country, being influenced by the relevant regulatory authorities. In all cases, readers are advised to consult the manufacturer's data sheets for current information and local regulations.

The authors are extremely grateful to Professor Sir James Armour and Professor James Duncan for their interest and support and for reading through the drafts of the text and their constructive comments. Any errors in the book are solely the responsibility of the authors. In order to assist the reader and for clarification we took the decision to produce much of the book and illustrations in colour and we are most grateful for the generous financial support of the following pharmaceutical companies which made this possible: Fort Dodge Animal Health; Pfizer Animal Health; Merial Animal Health; Novartis Animal Health; Intervet UK Ltd.

Finally, the help and support of the following list of people is acknowledged in producing this textbook. Professor Quintin McKellar (previous scientific director) and Professor Julie Fitzpatrick (current scientific director) of the Moredun Research Institute provided support to Dr Coop allowing him full access to the library facilities following his retirement. Dr Frank Jackson for comments on the manuscript. Michelle Moore, Matthew Carroll and Caroline Chaffer provided invaluable assistance with setting up much of the initial file documentation required to develop the re-organised structure of the book. Ralph Marshall at the Veterinary Laboratories Agency provided information on coccidial species of camelids and gamebirds. The technical support of Shelagh Wall is gratefully acknowledged.

Professor Mike Taylor
Dr Bob Coop
Professor Richard Wall

Preface and acknowledgements to the fourth edition

This fourth edition has been written to provide detailed parasite descriptions and reference texts for teachers, research groups in universities and institutes, veterinarians in practice and in government service, and others involved in aspects of parasitic disease. In producing the new edition of *Veterinary Parasitology* the authors had the following aims and objectives.

The first was to preserve the spirit of the first two editions of the textbook *Veterinary Parasitology*, which had been compiled by eminent and respected veterinary parasitologists in their field and which provided a solid background on which to further consolidate.

The second aim was to greatly expand and revise the systematic sections on helminthology, protozoology and entomology and the descriptions of animal parasites which are of veterinary significance in many parts of the world. This edition focuses mainly on core information relating to parasites of livestock and companion animals but sections on parasites of poultry and gamebirds, laboratory animals, exotic pets and 'farmed' species are included. The majority of parasitic diseases are now covered in detail using standardised formats for each parasite to allow easy referencing and for comparison between species within a genus. Where appropriate, reference is made to human infections where there is natural transmission of parasitic disease between vertebrate animals and humans (zoonoses).

The third aim was to present the information in two formats which are considered compatible with the diversity of current parasitology teaching modules used within many universities and veterinary schools, both for teaching parasite systematics and for teaching of diseases on a host–organ basis. The latter is achieved by arranging the parasites under host species and their predilection sites. By providing both approaches, and because teaching of veterinary parasitology differs throughout the world, it is hoped that information on particular parasites can be easily located. Taxonomy of the main parasitic kingdoms, phyla, classes, orders and genera are now provided in much greater detail within the introductory chapters and subsections, along with detailed descriptions and anatomical features of the parasite orders, families and species. Additional detailed and updated sections are provided on veterinary antiparasitics, with an expanded section on laboratory diagnosis, including recent molecular developments and an increased number of tables and identification charts. In keeping with previous editions of the textbook, a series of brief overviews of topics relevant to veterinary parasitology have been included to provide the non-expert with basic background information and also to highlight additional sources of reading. An additional feature is the inclusion of a number of additional figures, diagrams and images of parasites.

The classification of parasites reflects many of the systematic changes, particularly where molecular genetics-based taxonomic reclassification has been introduced. Throughout, synonyms have

been provided reflecting older taxonomic nomenclature, or where controversy remains. As with the earlier textbook editions, parasitic infections are described according to the Standardised Nomenclature of Animal Parasitic Diseases guidelines (SNOAPAD, 1988; *Veterinary Parasitology* 29, 299–326). In considering treatment of parasitic infections we have used the generic names of drugs to avoid listing the wide range of products that are currently marketed in different countries. Dose rates of drugs are not always stated as many vary from country to country, being influenced by the relevant regulatory authorities. In all cases, readers are advised to consult the manufacturer's data sheets for current information and local regulations.

The new edition retains the expertise of the three authors of the previous third edition.

Professor Mike Taylor is a veterinary graduate of Glasgow University Veterinary College, having studied under the authors of the first and second editions of the textbook *Veterinary Parasitology*, whose enthusiasm for their subject greatly influenced his interest in veterinary parasitology. After 6 years in general veterinary practice, a large part of his career was spent at the Central Veterinary Laboratory, Weybridge, later to become the Veterinary Laboratories Agency (VLA), where he worked on the epidemiology and control of parasitic helminths, protozoa and ectoparasites of domestic animals, and in particular parasite chemotherapy, parasite control and anthelmintic resistance. During this time he studied for a PhD at the Royal Veterinary College, London, under the expert guidance of Professor Dennis Jacobs. He has spent over 30 years in veterinary parasitology, published 20 book chapters and has over 250 scientific publications, as well as contributing extensively to the third and current editions of *Veterinary Parasitology*. He retired as Head of Veterinary Surveillance at the Central Science Laboratory York (later to become FERA) in 2011, but remains a visiting Professor of Parasitology at the Royal Veterinary College, London, an Emeritus Fellow of FERA, and now runs his own veterinary parasitology consultancy company. He is a Diplomate of the European College of Veterinary Parasitology, and a Diplomate of the European College of Small Ruminant Health and Management. He has been a Fellow of Edinburgh University, a former Editor-in-Chief of the *Journal Veterinary Parasitology*, and past president of the British Association for Veterinary Parasitology.

Dr Bob Coop graduated in biochemistry from the University of Liverpool and then undertook a PhD in large animal parasitology at the University of Wales, Bangor. He has spent over 35 years in veterinary parasitology research, initially working with lungworm infection in pigs and then on the epidemiology and pathogenesis of gastrointestinal nematode infection in small and large ruminants, and in particular the nutrition–parasite interaction and sustainable control strategies. He has been a Fellow of Edinburgh University

and a past president of the British Association for Veterinary Parasitology. Formerly as Head of the Division of Parasitology at the Moredun Research Institute, Edinburgh and now as a Fellow of the Moredun Foundation, he has considerable experience of knowledge transfer to end-user groups and veterinarians in practice. Dr Coop acknowledges full access to the Information Technology Services at the Moredun Research Institute.

Professor Richard Wall graduated in zoology from the University of Durham followed by a PhD in insect population ecology at the University of Liverpool. He is now Professor of Zoology at the University of Bristol, where he teaches and heads a research group studying a diverse range of arthropods, focusing particularly on ectoparasites of veterinary importance and insect colonisers of dung and carrion. His research ranges widely from fundamental studies of arthropod taxonomy and physiology, through to field population ecology and farm-level investigations of the application of sustainable control technologies.

The help and support of the following people is acknowledged in producing this edition. Dr Philip Skuce of the Moredun Research

Institute (MRI) wrote the section in Chapter 4 on molecular diagnostics for which the authors are extremely grateful. Professor James Duncan provided his collection of photographic slides from the Glasgow University Veterinary School, many of which appear as illustrations or figures, both in this and previous editions. Additional photographic material has been used from a collection of digital images gathered under the auspices of the British Association of Veterinary Parasitology over a period of 20 years. Several of the newer illustrations and figures included in this edition were reproduced from material by former colleagues from the Parasitology Department at the Central Veterinary Laboratory (CVL), Weybridge, which sadly now no longer exists. Acknowledgement is therefore made to the following: Dr Martin Gregory, Dr Len Joiner, Janet Catchpole, Chris Norton, Ralph and Jackie Marshall, Dr Mike Peirce, Dr Richard Cawthorne, Keith Hunt, Colin Hong, Barry Lancaster, Dr Charles Ollerenshaw, Gordon Graham, Dr Joe Donnelly, Paul Phipps, and Drs Alan Kirkwood, David Tarry and Peter Bates whose work and dedication inspired a generation of parasitologists in Britain and around the world. Finally, the authors are grateful to Meriel for providing financial sponsorship for several of the figures appearing in this edition.

CHAPTER 1

Veterinary helminthology

PRINCIPLES OF CLASSIFICATION

When examined, living organisms can be seen to form natural groups with features in common. These similarities may be morphological, but increasingly may be based on DNA analysis. Groups of organisms are combined into biologically meaningful groups, usually attempting to represent evolutionary pathways. A group of this sort is called a **taxon**, and the study of this aspect of biology is called **taxonomy**. The study of the complex systems of interrelationship between living organisms is called **systematics**.

The taxa into which organisms may be placed are recognised by international agreement; the primary ones are **kingdom, phylum, class, order, family, genus** and **species**. The intervals between these are large, and some organisms cannot be allocated to them precisely, so intermediate taxa, prefixed appropriately, have been formed; examples of these are the **suborder** and the **superfamily**. As an example, the taxonomic status of one of the common abomasal parasites of ruminants may be expressed as shown below.

Kingdom	Animalia
Phylum	Nematoda
Class	Secernentea
Order	Strongylida
Suborder	Strongylina
Superfamily	Trichostrongyloidea
Family	Trichostrongylidae
Subfamily	Haemonchinae
Genus	<i>Haemonchus</i>
Species	<i>contortus</i>

The names of taxa must follow a set of internationally agreed rules, but it is permissible to anglicise the endings, so that members of the superfamily Trichostrongyloidea in the example above may also be termed trichostrongylids.

The names of the genus and species are expressed in Latin form, the generic name having a capital letter, and they must be in grammatical agreement. It is customary to print Latin names in italics. Accents are not permitted. If an organism is named after a person, amendment may be necessary; the name of Müller, for example, has been altered in the genus *Muellerius*.

HELMINTHOLOGY

Parasitic helminths can affect humans, animals and plants, with estimated numbers of between 75,000 and 300,000 species. The higher taxa containing helminths of veterinary importance are:

Major

- Nematoda (roundworms)
- Platyhelminthes (flatworms)
 - Trematoda (Flukes)
 - Cestoda (Tapeworms)

Minor

- Acanthocephala (thorny-headed worms)

PHYLUM NEMATODA

The nematodes (Nematoda) are commonly called **roundworms** from their appearance in cross-section, and are parasitic or free-living. In the majority of nematodes the sexes are separate.

CLASS SECERNENTEA

The system of classification of nematodes of veterinary importance, which is based on current taxonomic literature, is given in Table 1.1. In this system, nematode genera and species in the class Secernentea are grouped into 16 **superfamilies** in which nematodes of veterinary importance occur. The superfamilies can be conveniently divided into **bursate** and **non-bursate** groups, the most typical features of which are summarised in Table 1.2.

STRUCTURE AND FUNCTION

Most nematodes have a cylindrical unsegmented form, tapering at either end, and the body is covered by a colourless, somewhat translucent, layer: the cuticle.

The tough cuticle is secreted by the underlying hypodermis, which projects into the body cavity forming two lateral cords, which carry the excretory canals, and a dorsal and ventral cord carrying the nerves (Fig. 1.1). The muscle cells, arranged longitudinally, lie between the hypodermis and the body cavity. The latter contains fluid at a high pressure, which maintains the turgidity and shape of the body (pseudocoelom). Locomotion is effected by undulating waves of muscle contraction and relaxation that alternate on the dorsal and ventral aspects of the worm. A circular muscle layer is absent in nematodes. Most of the internal organs are filamentous and suspended in the fluid-filled body cavity (Fig. 1.1).

The **digestive system** is tubular (Fig. 1.2a). The mouth, or stoma, of many nematodes is a simple opening, which may be surrounded by two or three lips, and leads directly into the oesophagus. Where

Table 1.1 Classification of parasitic nematodes of veterinary importance.

Kingdom	Phylum	Class	Order	Superfamily	Family (Subfamily) Genus
Animalia	Nematoda	Secernentea	Strongylida	Trichostrongyloidea	Trichostrongylidae
					<i>Trichostrongylus</i>
					<i>Marshallagia</i>
					<i>Hyostromylus</i>
					<i>Mecistocirrus</i>
					<i>Graphidium</i>
					<i>Obeliscoides</i>
					<i>Libyostromylus</i>
					<i>Graphinema</i>
					<i>Impalaia</i>
					(Ostertaginae)
					<i>Ostertagia</i>
					<i>Teladorsagia</i>
					<i>Spiculopteragia</i>
					<i>Apteragia</i>
					<i>Camelostromylus</i>
					(Haemonchinae)
					<i>Haemonchus</i>
					Cooperidae
					<i>Cooperia</i>
					Ornithostromylidae
					<i>Ornithostromylus</i>
					Amidostomidae
					<i>Amidostomum</i>
					<i>Epomidiostomum</i>
					Molineidae
					<i>Nematodirus</i>
					<i>Nematodirella</i>
					<i>Lamanema</i>
					<i>Molineus</i>
					<i>Ollulanus</i>
					<i>Tupaiostrongylus</i>
					Heligmonellidae
					<i>Nippostrongylus</i>
					<i>Nematospiroides</i>
					Dictyocaulidae
					<i>Dictyocaulus</i>
			Strongyloidea	Strongylidae (Strongylinae)	<i>Strongylus</i>
					<i>Triodontophorus</i>
					<i>Chabertia</i>
					<i>Oesophagostomum</i>
					<i>Poteriostomum</i>
					<i>Craterostomum</i>
					<i>Oesophagodontus</i>
					<i>Codiostomum</i>
					(Cyathostominae)
					<i>Cyathostomum</i>
					<i>Cylicocycclus</i>
					<i>Cylicodontophorus</i>
					<i>Cylicostephanus</i>
					Syngamidae
					<i>Syngamus</i>
					<i>Cyathostoma</i>
					<i>Mammomonogamus</i>
					<i>Stephanurus</i>
					Deletrocephalidae
					<i>Deletrocephalus</i>
					<i>Paradeletrocephalus</i>
			Ancylostomatoidea	Ancylostomatidae	<i>Ancylostoma</i>
					<i>Uncinaria</i>
					<i>Bunostomum</i>
					<i>Gaigeria</i>
					<i>Necator</i>
					<i>Globocephalus</i>
					<i>Agriostomum</i>
			Diaphanocephaloidea	Diaphanocephalidae	<i>Kalicephalus</i>