THIRD EDITION

Veterinary Parasitology

M A Taylor
R L Coop
R L Wall

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M.A. Taylor BVMS, PhD, MRCVS, DipEVPC, CBiol, MIBiol
R.L. Coop BSc, PhD
R.L. Wall BSc, MBA, PhD, FRES

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Introduction

Unlike previous editions, parasites are now organised under the hosts and organ systems in which they are found. As many parasites have features in common, the first chapter of this book provides a background to the taxonomic classification and common morphological features of the many groups of parasites found in domestic animals. More detailed individual descriptions are then provided under the respective host chapters. Throughout the book extensive indexing and cross-referencing are provided both in the overview that follows, and at the end of each host chapter. Non-obligate ectoparasites, that may be found on several hosts, are now grouped in a separate chapter, Chapter 11: Facultative parasites and arthropod vectors.

Further general chapters are provided on The epidemiology of parasitic diseases (Chapter 12); Resistance to parasitic diseases (Chapter 13); Antiparasitics (Chapter 14); and The laboratory diagnosis of parasitism (Chapter 15).

1 PARASITE TAXONOMY AND MORPHOLOGY

A. VETERINARY HELMINTHOLOGY

Phylum	**Class**	**Superfamily** Family Sub-family	**Genus**	**Chapters**
Nemathelminthes	Nematoda	**Trichostrongyloidea**	*Ostertagia*	***1, 2, 3, 8***
			Teladorsagia	***1, 3, 8***
			Haemonchus	***1, 2, 3, 8***
			Marshallagia	***1, 3, 8***
			Mecistocirrus	***1, 2, 3, 5***
			Hyostrongylus	***1, 5***
			Trichostrongylus	***1, 2, 3, 4, 5, 7, 8, 9, 10***
			Cooperia	***1, 2, 3, 8***
			Nematodirus	***1, 2, 3, 8***
			Dictyocaulus	***1, 2, 3, 4, 8***
			Amidostomum	***1, 7***
			Ollulanus	***1, 5, 6***
			Ornithostrongylus	***1, 10***
			Impalaia	***1, 8***
			Graphinema	***8***
			Spiculopteragia	***8***

(*continued*)

Phylum	Class	Superfamily Family Sub-family	Genus	Chapters
			Apteragia	***8***
			Rinadia	***8***
			Camelostrongylus	***8***
			Nematodirella	***8***
			Lamanema	***8***
			Graphidium	***9***
			Obeliscoides	***9***
			Nippostrongylus	***9***
			Nematospiroides	***9***
			Libyostrongylus	***10***
			Epomidiostomum	***7***
		Strongyloidea	*Strongylus*	***1, 4***
		Strongylinae	*Triodontophorus*	***1, 4***
			Chabertia	***1, 2, 3, 8***
			Oesophagostomum	***1, 2, 3, 5, 8***
			Stephanurus	***1, 2, 5***
			Syngamus	***1, 2, 7, 10***
			Mammomonogamus	***1, 2, 3, 6***
			Globocephalus	***5***
			Deletrocephalus	***10***
			Paradeletrocephalus	***10***
			Kalicephalus	***10***
			Codiostomum	***10***
			Poteriostomum	***4***
			Craterostomum	***4***
			Oesophagodontus	***4***
			Cyathostoma	***4, 10***
		Cyathostominae	*Cyathostomum*	***1, 4***
			Cylicocyclus	***1, 4***
			Cylicodontophorus	***1, 4***
			Cylicostephanus	***1, 4***
		Ancylostomatoidea	*Ancylostoma*	***1, 6***
			Uncinaria	***1, 6***
			Bunostomum	***1, 2, 3, 8***
			Gaigeria	***1, 3***
			Agriostomum	***2***
			Necator	***1, 1***
		Metastrongyloidea	*Metastrongylus*	***1, 5***
			Muellerius	***1, 3, 8***
			Protostrongylus	***1, 3, 8***
			Cystocaulus	***1, 3, 8***
			Spiculocaulus	***1, 3***
			Neostrongylus	***1, 3***

(*continued*)

Phylum	Class	Superfamily Family Sub-family	Genus	Chapters
			Oslerus	***1, 6***
			Filaroides	***1, 6***
			Aelurostrongylus	***1, 6***
			Angiostrongylus	***1, 6, 9***
			Crenosoma	***1, 6***
			Anafilaroides	***1, 6***
			Vogeloides	***6***
			Gurltia	***1***
			Parelophostrongylus	***1, 8***
			Elaphostrongylus	***1, 8***
			Varestrongylus	***3, 8***
		Rhabditoidea	*Strongyloides*	***1, 2, 3, 5, 6, 7***
			Halicephalobus	***1, 4***
			Rhabditis	***1, 4***
			Rhabdias	***10***
		Ascaridoidea	*Ascaris*	***1, 5***
			Toxocara	***2, 6***
			Toxascaris	***1, 6***
			Parascaris	***1, 4***
			Ascaridia	***1, 7, 10***
			Heterakis	***1, 7, 10***
			Paraspidodera	***9***
			Sulcascaris	***10***
			Ophidascaris	***10***
			Porrocaecum	***7***
			Polydelphus	***10***
		Anisakidae	*Anisakis*	***1***
			Contracaecum	***1, 7***
			Hysterothylacium	***1***
			Pseudoterranova	***1***
			Angusticaecum	***1, 10***
		Oxyuroidea	*Oxyuris*	***1, 4***
			Probstmayria	***1, 4***
			Skrjabinema	***1, 2, 3, 8***
			Paraspidodera	***1, 9***
			Enterobius	***1***
			Aspicularis	***9***
			Passalurus	***9***
			Syphacia	***9***
		‘Subuluroidea’	*Subulura*	***1, 7***
		Spiruroidea	*Spirocerca*	***1, 6***
			Habronema	***1, 4***

(*continued*)

Phylum	Class	Superfamily Family	Genus	Chapters
			Draschia	***1, 4***
			Parabronema	***1, 2, 3, 8***
			Thelazia	***1, 2, 4, 6, 8***
			Gnathostoma	***1, 5, 6***
			Gongylonema	***1, 2, 3, 5, 7, 8***
			Ascarops	***1, 5***
			Physocephalus	***1, 5***
			Simondsia	***1, 5***
			Physaloptera	***1, 6***
			Spirura	***1, 6, 10***
			Echinuria	***1, 7***
			Dispharynx	***1, 7, 10***
			Tetrameres	***1, 7, 10***
			Streptocara	***1, 7***
			Cheilospirura	***1, 7***
			Histiocephalus	***1, 7***
			Hartertia	***1, 7***
			Oxyspirura	***1, 7***
			Odontospirura	***10***
		Filarioidea	*Parafilaria*	***1, 2, 4***
			Stephanofilaria	***1, 2***
			Dirofilaria	***1, 6***
			Dipetalonema	***1, 6, 8***
			Onchocerca	***1, 2, 4, 8***
			Setaria	***1, 2, 4***
			Elaeophora	***1, 2, 3, 4, 8***
			Ornithofilaria	***1***
			Pelecitus	***1***
			Brugia	***1***
			Loa	***1***
			Wuchereria	***1***
			Mansonella	***1***
			Suifilaria	***5***
			Paronchocercaria	***10***
		Trichuroidea	*Trichuris*	***1, 2, 3, 5, 6, 8, 9***
			Capillaria	***1, 2, 3, 6, 7, 8, 9, 10***
			Trichinella	***1, 4, 5, 6***
			Trichosomoides	***9***
		Dioctophymatoidea	*Dioctophyma*	***1, 5, 6***
			Hystrichis	***1, 7***
			Eustrongylides	***1, 7***
		Dracunculoidea	*Dracunculus*	***1, 2***
			Avioserpens	***1, 7***
Acanthocephala		**Oligacanthorhynchidae**	*Macracanthorhynchus*	***1, 4, 5***
		Polymorphidae	*Polymorphus*	***1, 7***
			Filicollis	***1, 7***

(*continued*)

Phylum	Class Sub-class	Family	Genus	Chapters
Platyhelminthes	Trematoda			
	Digenea	Fasciolidae	*Fasciola*	***1, 2, 3, 4, 5, 6, 8***
			Fascioloides	***1, 2, 3, 8***
			Fasciolopsis	***1, 5***
		Dicrocoeliidae	*Dicrocoelium*	***1, 2, 3, 8***
			Eurytrema	***1, 2, 3, 5, 6, 8***
			Platynosomum	***1, 6***
		Paramphistomatidae	*Paramphistomum*	***1, 2, 3, 8***
			Orthocoelium (syn Ceylonocotyle)	***1, 2, 3, 8***
			Cotylophoron	***1, 2, 3***
			Bothriophoron	***1***
			Gastrodiscus	***1, 4, 5***
			Homologaster	***1, 2***
			Explanatum (syn Gigantocotyle)	***1***
			Pseudodiscus	***4***
	Digenea	Troglotrematidae	*Paragonimus*	***1, 6***
			Nanophyetus	***1, 6***
			Collyriclum	***1, 7***
		Cyclocoelidae	*Typhlocoelum*	***1, 7***
			Hyptiasmus	***1, 7***
		Opisthorchiidae	*Opisthorchis (syn Clonorchis)*	***1, 6***
			Metorchis	***1, 6***
			Parametorchis	***1, 6***
			Pseudamphistomum	***1, 6***
		Schistosomatidae	*Schistosoma*	***1, 2, 3, 4, 5, 6, 8***
			Bilharziella	***1, 7***
			Trichobilharzia	***1***
			Orientobilharzia	***1, 3***
			Ornithobilharzia	***1***
			Heterobilharzia	***1***
			Austrobilharzia	***1***
		Diplostomatidae	*Alaria*	***1, 6***
			Diplostomum	***1***
		Echinostomatidae	*Echinostoma*	***1, 6, 7, 10***
			Echinoparyphium	***1, 7, 10***
			Hypoderaeum	***1, 7, 10***
			Echinochasmus	***1, 6***
			Euparyphium	***1, 6***
		Notocotylidae	*Notocotylus*	***1, 7***
			Catatropis	***1, 7***
			Cymbiforma	***1, 2, 3***
		Brachylaemidae	*Brachylaemus*	***1, 7, 10***
			Skrjabinotrema	***1, 3***
		Plagiorchiidae	*Plagiorchis*	***1, 7***
		Prosthogonimidae	*Prosthogonimus*	***1, 7***

(*continued*)

Phylum	Class Sub-class	Family	Genus	Chapters
		Heterophyidae	*Heterophyes*	***1, 6***
			Metagonimus	***1, 6***
			Apophallus	***6***
			Cryptocotyle	***6***
			Haplorchis	***1, 6***
		Strigeidae	*Apatemon*	***7***
			Cotylurus	***7***
			Parastrigea	***7***

Phylum	Class Order	Family	Genus	Chapters
Platyhelminthes	**Cestoda**			
	Cyclophyllidea	Taeniidae	*Taenia* *(syn Multiceps)*	***1, 2, 3, 5, 6, 8, 9***
			Echinococcus	***1, 2, 3, 4, 5, 6, 8***
		Anoplocephalidae	*Anoplocephala*	***1, 4***
			Paranoplocephala	***1, 4***
			Moniezia	***1, 2, 3, 8***
			Cittotaenia	***9***
		Dilepididae	*Dipylidium*	***1, 6***
			Amoebotaenia	***1, 7***
			Choanotaenia	***1, 7***
			Metroliasthes	***1, 7***
		Davaineidae	*Davainea*	***1, 7, 10***
			Raillietina	***1, 7, 10***
			Cotugnia	***1, 7***
			Huttuynia	***10***
		Hymenolepididae	*Hymenolepis*	***1, 7***
			Fimbriaria	***1, 7***
			Rodentolepis	***1, 9***
		Mesocestoididae	*Mesocestoides*	***1, 6***
		Thysanosomidae	*Stilesia*	***1, 2, 3, 8***
			Thysanosoma	***1, 2, 3***
			Thysaniezia	***1, 2, 3, 8***
			Avitellina	***1, 2, 3, 8***
	Pseudophyllidea	Diphyllobothriidae	*Diphyllobothrium*	***1, 6***
			Spirometra	***1, 6***

(*continued*)

B. VETERINARY ENTOMOLOGY

Phylum	CLASS Order Sub-order	Family	Genus	Chapters
Arthropoda	**Insecta**			
	Hemiptera	Cimicidae	*Cimex*	***1***
		Reduviidae	*Triatoma*	***1, 11***
			Rhodnius	***1, 11***
			Panstrongylus	***1***
	Diptera			
	Nematocera	Ceratopogonidae	*Culicoides*	***1, 11***
		Simuliidae	*Simulium*	***1, 11***
		Psychodidae	*Phlebotomus*	***1, 11***
			Lutzomyia	***1, 11***
		Culicidae	*Aedes*	***1, 11***
			Anopheles	***1, 11***
			Culex	***1, 11***
	Brachycera	Tabanidae	*Chrysops*	***1, 11***
			Haematopota	***1, 11***
			Tabanus	***1, 11***
	Cyclorrhapha	Muscidae	*Musca*	***1, 11***
			Hydrotaea	***1, 11***
			Stomoxys	***1, 11***
			Haematobia	***1, 11***
		Fanniidae	*Fannia*	***1, 11***
		Hippoboscidae	*Hippobosca*	***1, 11***
			Melophagus	***1, 3***
			Lipoptera	***11***
		Glossinidae	*Glossina*	***1, 11***
		Calliphoridae	*Lucilia*	***1, 2, 3, 11***
			Calliphora	***1, 3, 11***
			Protophormia	***1, 3, 11***
			Phormia	***1, 3, 11***
			Cochliomyia (syn *Callitroga*)	***1, 11***
			Chrysomya	***1, 11***
			Cordylobia	***1, 11***
		Sarcophagidae	*Sarcophaga*	***11***
			Wohlfahrtia	***1, 11***
		Oestridae	*Hypoderma*	***1, 2, 8***
			Oestrus	***1, 3, 8***
			Dermatobia	***1, 11***
			Przhevalskiana (syn *Crivellia*)	***1, 3***
			Cephenemyia	***1, 8***
			Oedemagena	***1, 8***
			Gedoelstia	***1, 3***
			Cephalopina (syn *Cephalopsis*)	***1, 8***
			Rhinoestrus	***1, 4***
			Pharyngomyia	***8***
			Cuterebra	***1, 9***
			Gasterophilus	***1, 4***

(*continued*)

Phylum	CLASS Order Sub-order	Family	Genus	Chapters
	Phthiraptera			
	Anoplura	Haematopinidae	*Haematopinus*	***1, 2, 4, 5***
		Microthoraciidae	*Microthoracius*	***1, 8***
		Linognathidae	*Linognathus*	***1, 2, 3, 6***
			Solenopotes	***1, 2***
		Polyplacidae	*Polyplax*	***1, 9***
	Amblycera	Menoponidae	*Menacanthus*	***1, 7***
			Menopon	***1, 7***
			Holomenopon	***1, 7***
			Ciconiphilus	***7***
			Trinoton	***7***
			Amyrsidea	***1, 7***
			Mecanthus	***7***
		Boopidae	*Heterodoxus*	***1, 6***
		Gyropidae	*Gyropus*	***1, 9***
			Gliricola	***1, 9***
		Trimenoponidae	*Trimenopon*	
	Ischnocera	Philopteridae	*Cuclotogaster*	***1, 7***
			Lipeurus	***1, 7***
			Goniodes	***1, 7***
			Goniocotes	***1, 7***
			Anaticola	***7***
			Acidoproctus	***7***
			Anatoecus	***7***
			Ornithobius	***7***
			Columbicola	***1, 10***
		Trichodectidae	*Bovicola* (*syn Damalinia*)	***1, 2, 3, 4***
			Felicola	***1, 6***
			Trichodectes	***1, 6***
		Degeeriellidae	*Lagopoecus*	***7***
	Siphonaptera	Ceratophyllidae	*Ceratophyllus*	***1, 11***
			Nosopsyllus	***1, 9***
		Pulicidae	*Ctenocephalides*	***1, 6, 11***
			Spilopsyllus	***1, 11***
			Echidnophaga	***1, 11***
			Pulex	***1, 11***
			Xenopsylla	***1, 9***
			Archaeopsylla	***1, 11***
			Tunga	***1, 11***
		Leptopsyllidae	*Leptopsylla*	***1, 9***

(*continued*)

Phylum	CLASS Sub-class Sub-order	Family	Genus	Chapters
Arthropoda	**Arachnida**			
	Acari			
	Ixodida (Metastigmata)	Ixodidae	*Ixodes*	***1, 10, 11***
			Dermacentor	***1, 11***
			Rhipicephalus	***1, 11***
			Haemaphysalis	***1, 10, 11***
			Boophilus	***1, 11***
			Amblyomma	***1, 10, 11***
			Hyalomma	***1, 10, 11***
			Aponomma	***1, 10***
		Argasidae	*Argas*	***1, 10, 11***
			Otobius	***1, 11***
			Ornithodoros	***1, 10, 11***
	Sarcoptiformes (Astigmata)	Sarcoptidae	*Sarcoptes*	***1, 2, 3, 4, 5, 6, 8***
			Notoedres	***1, 6, 9***
			Trixacarus	***1, 9***
		Psoroptidae	*Psoroptes*	***1, 2, 3, 4, 8***
			Chorioptes	***1, 2, 3, 4, 8***
			Otodectes	***1, 6***
		Knemidokoptidae	*Knemidokoptes*	***1, 7***
		Listeropheridae	*Mycoptes*	***1, 9***
		Cytoditidae	*Cytodites*	***1, 7, 10***
		Laminosioptidae	*Laminosioptes*	***1, 7***
		Analgidae	*Megninia*	***1, 7***
		Atopomelidae	*Chirodiscoides*	***1, 9***
		Dermoglyphidae	*Dermoglyphus*	***1, 7***
		Freyanidae	*Freyana*	***1, 7***
		Epidermoptidae	*Epidermoptes*	***1, 7***
			Microlichus	***1, 7***
			Promyialges	***1, 7***
		Pterolichidae	*Pterolichus*	***1, 7***
			Sideroferus	***1, 7***
		Hypoderidae	*Hypodectes*	***1, 7***
	Trombidiformes (Prostigmata)	Demodicidae	*Demodex*	***1, 2, 3, 4, 5, 6, 9***
		Cheyletidae	*Cheyletiella*	***1, 6***
		Trombiculidae	*Neotrombicula*	***1, 11***
			Eutrombicula	***1, 11***
			Leptotrombidium	***1, 9***
			Neoschongastia	***1, 7***
		Psorergatidae	*Psorergates*	***1, 2, 3, 9***
		Pyemotidae	*Pyemotes*	***1, 11***
		Myobidae	*Myobia*	***1, 9***
			Radfordia	***1, 9***
		Syringophilidae	*Syringophilus*	***1, 7***
		Pterygosomatidae	*Geckobiella*	***1, 10***
			Pimeliaphilus	***1, 10***
			Hirstiella	***1, 10***
			Ixodiderma	***1, 10***

(*continued*)

Phylum	CLASS Sub-class Sub-order	Family	Genus	Chapters
			Scapothrix	***1, 10***
			Zonurobia	***1, 10***
	Mesostigmata	Macronyssidae	*Ornithonyssus*	***1, 7, 9***
	(**Gamesid Mites)**		*Neoliponyssus*	***10***
			Ophionyssus	***1, 10***
		Dermanyssidae	*Dermanyssus*	***1, 7, 9***
			Liponyssoides	***1, 9***
		Halarachnidae	*Pneumonyssus*	***1, 6***
		Entonyssidae	*Entonyssus*	***1, 10***
			Entophionyssus	***1, 10***
			Mabuyonysus	***1, 10***
		Rhinonyssidae	*Sternosoma*	***1, 7***
		Laelapidae	*Hirstionyssus*	***1, 9***
			Haemogamasus	***1, 9***
			Eulaelaps	***1, 9***
			Laelaps	***1, 9***
			Androlaelaps	***1, 9***
Arthropoda	**Pentastomida**			
		Linguatulidae	*Linguatula*	***1, 10***

C. VETERINARY PROTOZOOLOGY

Phylum Sub-phylum	Order Sub-order	Family	Genus	Chapters
PROTISTA				
Sarcomastigophora				
Sarcodina	**Amoebidorida**	**Endamoebidae**	*Entamoeba*	***1, 2, 3, 4, 5, 6, 9, 10***
			Endolimax	***1***
Mastigophora	**Kinetoplastorida**	**Trypanosomatidae**	*Leishmania*	***1, 6***
			Trypanosoma	***1, 2, 3, 4, 5, 6, 7, 8, 10***
	Trichomonadorida	**Trichomonadidae**	*Tritrichomonas*	***1, 2, 5, 7, 9***
			Trichomonas	***1, 6, 7, 10***
			Tetratrichomonas	***1, 2, 3, 5, 6, 7, 9***
			Trichomitus	***1, 5***
			Pentatrichomonas	***1, 6, 10***
			Chilomastix	***7, 10***
			Enteromonas	***10***
			Eutrichomonas	***10***
			Herpatomonas	***10***
			Leptomonas	***10***
			Proteromonas	***10***
		Monocercomonadidae	*Histomonas*	***1, 7***
			Monocercomonas	***1, 2, 10***
		Retortamonadorididae	*Retortamonas*	***1, 2, 3, 9***

(*continued*)

Phylum Sub-phylum	Order Sub-order	Family	Genus	Chapters
	Diplomonadorida	**Diplomonadidae**	*Giardia*	***1, 2, 3, 4, 5, 6, 9***
			Spironucleus (syn Hexamita)	***1, 7, 9, 10***
			Caviomonas	***1, 9***
			Monocercomonoides	***1, 9***
			Protomonas	***1, 9***
			Hexamastix	***1, 9***
			Chilomitus	***1, 9***
		Cochlosomatidae	*Cochlosoma*	***1, 7***
Apicomplexa	**Eucoccidiorida**			
	Eimeriorina	**Eimeriidae**	*Eimeria*	***1, 2, 3, 4, 5, 7, 8, 9, 10***
			Isospora	***1, 5, 6, 8, 10***
			Cyclospora	***1, 10***
			Tyzzeria	***1, 7, 10***
			Wenyonella	***1, 7, 10***
			Caryospora	***1, 10***
			Hoarella	***1, 10***
			Octosporella	***1, 10***
			Pythonella	***1, 10***
			Dorisella	***1, 10***
		Cryptosporidiidae	*Cryptosporidium*	***1, 2, 3, 4, 5, 6, 7, 8, 9, 10***
		Sarcocystiidae	*Besnoitia*	***1, 2, 3, 6, 8, 10***
			Hammondia	***1, 6***
			Sarcocystis	***1, 2, 3, 4, 5, 6, 7, 8, 9, 10***
			Neospora	***1, 2***
			Frenkelia	***1***
			Toxoplasma	***1, 2, 3, 4, 5, 6, 7, 8, 9, 10***
		Lankesterellidae	*Lankesterella*	***1***
			Schellakia	***1, 10***
		Atoxoplasmatidae	*Atoxoplasma*	***1***
		Klossiellidae	*Klossiella*	***1, 4, 9, 10***
		Hepatozoidae	*Hepatozoon*	***1, 6, 9, 10***
		Haemogregarinidae	*Haemogregarina*	***10***
	Haemosporida	**Plasmodiidae**	*Haemoproteus*	***1, 7, 10***
			Hepatocystis	***1***
			Leucocytozoon	***1, 7, 10***
			Plasmodium	***1, 7, 10***
	Piroplasmorida	**Babesiidae**	*Babesia*	***1, 2, 3, 4, 5, 6, 8***
		Theileriidae	*Theileria*	***1, 2, 3, 4, 8***
			Cytauxzoon	***1, 6***

(*continued*)

Phylum Sub-phylum	**Order** Sub-order	**Family**	**Genus**	**Chapters**
Microspora	**Microsporidia**	**Nosematidae**	*Encephalitozoon*	***1, 6, 9***
		Enterocytozoonidae	*Enterocytozoon*	***1***
Ciliophora	**Trichostomatorida**	**Balantidiidae**	*Balantidium*	***1, 5, 10***
		Pycnotrichidae	*Buxtonella*	***2, 8***
		Nyctotheridae	*Nyctotherus*	***1, 10***
Bigyra Blastocysta	**Blastocystida**	**Blastocystidae**	*Blastocystis*	***1***
Ascomycota	**Pneumocystida**	**Pneumocystidaceae**	*Pneumocystis*	***1, 2***

D. RICKETTSIAE

Kingdom	**Order**	**Family** Sub-family	**Genus**	**Chapters**
Monera	**Rickettsiales**	**Rickettsiaceae**		
		Rickettsieae	*Rickettsia*	***1, 2, 3, 6, 9***
			Rochalimaea	***1***
			Coxiella	***1***
			Neorickettsia	***4***
		Ehrlichieae	*Ehrlichia*	***1, 2, 3, 6***
			*'Cowdria'**	***1, 2, 3***
		Bartonellaceae	*Bartonella*	***1***
			Grahamella	***1***
		Anaplasmataceae	*Anaplasma*	***1, 2, 3, 4, 6, 8***
			Aegyptianella	***1, 7***
			Eperythrozoon	***1, 2, 3, 5***
			Haemobartonella (syn Mycoplasma)	***1, 6***

* Genus *Cowdria* now classified as *Ehrlichia*.

Foreword 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. Firstly, 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, *Veterinaermedizinische 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 or her tutor for a suitable review.

The ennui associated with repeated proofreading 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.

Acknowledgements to the first edition

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

Firstly, to Drs R. Ashford and W. Beesley of Liverpool; Dr J. Bogan, Glasgow; Dr W. Campbell, Rahway, USA; Dr R. Dalgleish, Brisbane; Dr L. Joyner, Weybridge, England; Dr T. Miller, Florida; Dr M. Murray, Nairobi; Dr R. Purnell, Sandwich, England; Dr S.M. Taylor, Belfast; Professor K. Vickerman, Glasgow. Each of these read and commented on sections of the text in which they are expert. Any errors in these areas are, however, solely the responsibility of the authors.

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

Dr E. Allonby, Nairobi (Plate I d, e, f); Dr K. Angus, Edinburgh (Fig. 167); Dr J. Arbuckle, Guildford, England (Fig. 61); Dr E. Batte, North Carolina, USA (Plate IIIf); Dr I. Carmichael, Johannesburg, S. Africa (Fig. 142); Dr L. Cramer, Sao Paulo (Fig. 126b); Crown Copyright, UK (Plate XIVb); Dr J. Dunsmore, Murdoch, W. Australia (Plate IVd); Professor J. Eckert, Zurich (Fig. 96); Glaxovet, Harefield, England (Plate IIf); Dr I. Herbert, Bangor, Wales (Fig. 172); Dr A. Heydorn, W. Berlin (Figs 170, 171); Professor F. Hörning, Berne (Fig. 82; Plate Ve); Dr B. Iovanitti, Balcarce, Argentina (Figs 22, 23); Dr D. Jacobs, London (Fig. 38); Drs D. Kelly and A. Longstaffe, Bristol (Figs 156, 157); The late Dr I. Lauder, Glasgow (Fig. 65, Plate XIc, e, XIIb); Drs B. Lindemann and J. McCall, Georgia, USA (Fig. 67); Dr N. McEwan, Glasgow (Plate XId, XIIe); Dr G. Mitchell, Ayr, Scotland (Plate VIe); Professor M. Murray, Glasgow (Figs 68, 84, 152); Dr A. Nash, Glasgow (Fig. 138b, Plate XIIc); Dr Julia Nicholls, Adelaide, Australia (Figs 6, 14c, d); Dr R. Purnell, Sandwich, England (Fig. 173, Plate VIIId, e, f); Professor H. Pirie, Glasgow (Fig. 40); Dr J. Reid, Brussels (Plate XIIa); Dr Elaine Rose, Houghton Poultry Research Station, Huntingdon, England (Figs 160, 163b, 164a, b); Professor I. Selman, Glasgow (Plate XIf); Dr D. Taylor, Glasgow (Plate XIVc); Dr M. Taylor, London (Fig. 85); Dr S. Taylor, Belfast (Plate IIa); Dr H. Thompson, Glasgow (Fig. 92, Plate IVb, c, VId); Dr R. Titchener, Ayr, Scotland (Fig. 113b, Plate VIIIa); Dr A. Waddell, Brisbane, Australia (Fig. 66, Plate IVe); Wellcome Research Laboratories, Berkhamsted, England (Plate VIIIc); Dr A. Wright, Bristol (Plate VIb, XIb, XIId, f). In this context we are also extremely grateful to Miss E. Urquhart, Wrexham, Wales who prepared many of the line drawings.

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.

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

Foreword 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.

Firstly, 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.

Foreword to the third edition

On behalf of the original authors of the first and second editions of *Veterinary Parasitology*, I would like to congratulate the new team of authors responsible for the third edition, which has expanded considerably from the previous two in order to include new areas of interest in the subject at local, national and international levels.

It is worth reflecting that the first edition was essentially a written and illustrated expansion of the printed notes issued to undergraduate veterinary students at the University of Glasgow. These notes very much mirrored the research interests of the staff within the Department of Veterinary Parasitology, which were principally in the helminthology branch of the subject, and to a lesser extent the protozoology and entomology components. Understandably this bias was reflected in the first edition, which was aimed at a readership of veterinary undergraduates and practising veterinary surgeons.

In the second edition, apart from the inclusion of some new and emerging diseases, the main change was the adoption of the standardised nomenclature of animal parasitic diseases (SNAOPAD) proposed by an expert committee of the World Association for the Advancement of Veterinary Parasitology (WAAVP).

By the time edition three was sought there was a clamour from the ever expanding population of those interested in the subject to produce a book that was not only suitable for students and practitioners but also provided more detailed information required by those researching the subject whether in academia, government institutions or industry.

This was a difficult task to undertake but the current authors have managed to produce a well illustrated text suitable for those studying and researching the subject. I particularly liked the re-vamped sections on entomology and protozoology and the updating of that on helminthology. The new chapters on parasites of laboratory animals and exotic pets were needed and the highlighting of zoonotic potential, where appropriate, was a welcome feature.

Despite the wealth of new material the original flavour of the first edition can still be detected, which gives great pleasure to myself, and my former colleagues at Glasgow.

I am sure the new edition will command great interest and respect from the international community of veterinary students, researchers and practitioners.

Professor Sir James Armour

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 reorganisation 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 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, 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 Division of Pfizer Ltd; Merial Animal Health; Novartis Animal Health; Schering-Plough Animal Health; Bayer Animal Health; Virbac Ltd.

The new edition has benefited considerably from the range of expertise of the three authors:

Professor Mike Taylor is a veterinary graduate of Glasgow University Veterinary College, having studied under the authors of the first and second editions, 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 VLA, where he worked on the epidemiology and control of parasitic helminths, protozoa and ectoparasites of domestic animals, and in particular parasite chemotherapy and anthelmintic resistance. During this time he studied for a PhD at the Royal Veterinary College (RVC), London, under the expert guidance of Professor Dennis Jacobs. He is currently head of Veterinary Surveillance at the Central Science Laboratory York, a visiting Professor of Parasitology at the Royal Veterinary College, London and at the University of Wales, Bangor, a Fellow of Edinburgh University, a Diplomate of the European College of Veterinary Parasitology and Editor-in-Chief of *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 ruminants, and in particular the nutrition–parasite interaction and sustainable control strategies. Formerly as Head of the Division of Parasitology at the Moredun Research Institute, and now as a Fellow of the Moredun Foundation, he has considerable experience of knowledge transfer to end-user groups and veterinarians in practice.

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.

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.

The following individuals kindly allowed us to use their photographs or material as illustrations or figures: Dr L. Gibbons – Fig. 8.2; Dr J. McGarry – Figs. 2.10, 7.1, 7.4 and 8.1.

1
Parasite taxonomy and morphology

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 inter-relationship 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	Nemathelminthes
Class	Nematoda
Order	Strongylida
Suborder	Strongylina
Superfamily	Trichostrongyloidea
Family	Trichostrongylidae
Subfamily	Haemonchinae
Genus	*Haemonchus*
Species	*contortus*

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 trichostrongyloids.

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

The higher taxa containing helminths of veterinary importance are:

Major
Nemathelminthes (roundworms)
Platyhelminthes (flatworms)

Minor
Acanthocephala (thornyheaded worms)

Phylum NEMATHELMINTHES

The phylum Nemathelminthes has six classes but only one of these, the **nematoda**, contains worms of parasitic significance. The nematodes are commonly called **roundworms**, from their appearance in cross-section.

Class NEMATODA

A system of classification of nematodes of veterinary importance is given in Table 1.1. It must be emphasised that this is not an exact expression of the general system for parasitic nematodes, but is a simplified presentation intended for use in the study of veterinary parasitology. It is based on the ten superfamilies in which nematodes of veterinary importance occur, and which are conveniently divided into **bursate** and **non-bursate** groups.

STRUCTURE AND FUNCTION

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

The cuticle is secreted by the underlying hypodermis, which projects into the body cavity forming two lateral

Table 1.1 Parasitic Nematoda of veterinary importance: simplified classification.

Superfamily	Typical features
Bursate nematodes	
Trichostrongyloidea *Trichostrongylus*, *Ostertagia*, *Dictyocaulus*, *Haemonchus* etc.	Buccal capsule small. Life cycle **direct**; infection by L_3
Strongyloidea *Strongylus*, *Syngamus* etc.	Buccal capsule well developed; leaf crowns and teeth usually present. Life cycle **direct**; infection by L_3
Ancylostomatoidea *Ancylostoma*, *Uncinaria* etc.	
Metastrongyloidea *Metastrongylus*, *Muellerius*, *Protostrongylus* etc.	Buccal capsule small. Life cycle **indirect**; infection by L_3 in intermediate host
Non-bursate nematodes	
Rhabditoidea *Strongyloides*, *Rhabditis* etc.	Very small worms; buccal capsule small. Free-living and parasitic generations. Life cycle **direct**; infection by L_3
Ascaridoidea *Ascaris*, *Toxocara*, *Parascaris* etc.	Large white worms. Life cycle **direct**; infection by L_2 in egg
Oxyuroidea *Oxyuris*, *Skrjabinema* etc.	Female has long, pointed tail. Life cycle **direct**; infection by L_3 in egg
Spiruroidea *Spirocerca*, *Habronema*, *Thelazia* etc.	Spiral tail in male. Life cycle **indirect**; infection by L_3 from insect
Filarioidea *Dirofilaria*, *Onchocerca*, *Parafilaria* etc.	Long thin worms. Life cycle **indirect**; infection by L_3 from insect
Trichuroidea *Trichuris*, *Capillaria, Trichinella* etc.	Whip-like or hair-like worms. Life cycle **direct** or **indirect**; infection by L_1
Dioctophymatoidea *Dioctophyma* etc.	Very large worms. Life cycle **indirect**; infection by L_3 in aquatic annelids

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. Locomotion is effected by undulating waves of muscle contraction and relaxation that alternate on the dorsal and ventral aspects of the worm. Most of the internal organs are filamentous and suspended in the fluid-filled body cavity (Fig. 1.1).

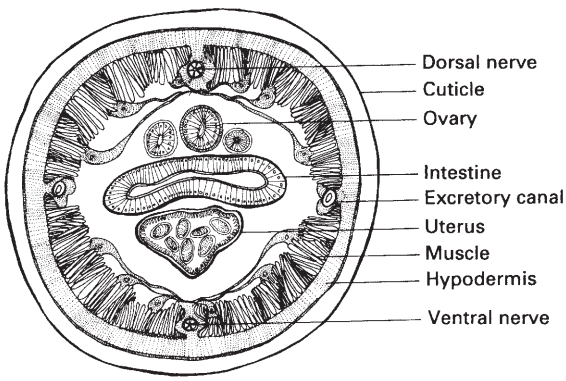

Fig. 1.1 Transverse section of a generalised female nematode.

The **digestive system** is tubular (Fig. 1.2a). The mouth of many nematodes is a simple opening, which may be surrounded by two or three lips, and leads directly into the oesophagus. In others, such as the strongyloids, it is large, and opens into a **buccal capsule**, which may contain teeth. Such parasites, when feeding, draw a plug of mucosa into the buccal capsule, where it is broken down by the action of enzymes, which are secreted into the capsule from adjacent glands. Some of these worms may also secrete anticoagulant, and small vessels, ruptured in the digestion of the mucosal plug, may continue to bleed for some minutes after the worm has moved to a fresh site.

Those with very small buccal capsules, like the trichostrongyloids, or simple oral openings, like the