

Helminths, Arthropods and Protozoa of Domesticated Animals (Mönnig)

6th EDITION

E. J. L. Soulsby

HELMINTHS, ARTHROPODS
& PROTOZOA
OF DOMESTICATED ANIMALS

(Sixth Edition of Mönnig's Veterinary
Helminthology & Entomology)

E. J. L. SOULSBY

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HELMINTHS, ARTHROPODS & PROTOZOA
OF DOMESTICATED ANIMALS

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PREFACE TO THE SIXTH EDITION

DESPITE the relatively short time since the fifth edition (6 years) there have been so many advances in the field of parasitology that a new edition of 'Mönnig' has become essential. These advances are such that it becomes increasingly difficult to preserve Professor Mönnig's original intention of a practical manual for veterinarians without losing sight of the basic concepts which permit a full appraisal of the biology of parasites. An attempt has therefore been made to incorporate as much as possible of this basic molecular biology. In addition to this, several other departures have occurred, the major one being the introduction of an entirely new section on the protozoa of veterinary importance. The sixth edition is now, within limits, a text of all the parasites of importance in veterinary medicine. A further departure has been a widening of the geographical scope of the book with an attempt to include important parasitic entities of both developed and developing countries. Other alterations include the placing of references, with title citations, at the end of each major section, the introduction of information on immunity to a parasite in the appropriate part of the text, and a reduction in the amount of detail presented about anthelmintics, insecticides, etc. The latter has been done because the field of therapy of parasitic diseases is moving so rapidly that the time lapse between writing and publication must, inevitably, lead to omission of newer compounds. In any case, it is felt that the main emphasis should be on the parasite, its biology and its pathogenic effects on the host.

Further changes from the fifth edition are an adoption of the Chitwood classification for the nematodes and a reorganisation of the presentation of the arthropods of veterinary importance. No changes have been made in the illustrations for the section of helminthology, but those in the entomology section have been somewhat reorganised so that they are more closely related in the text to the subject matter. The illustrations in the protozoology section have been largely drawn from Wenyon's 'Protozoology' or Hoare's 'Handbook of Medical Protozoology', some are original, two (Plates XXIV and XXV, coccidia of sheep, and of cattle) have been redrawn by the author with the kind permission of Dr J. F. Christensen, University of California, Davis, California and the *Journal of Parasitology*, and one (coccidia of swine, Plate XXVI) is used with the kind permission of Dr John M. Vetterling, Beltsville Parasitological Laboratory, Beltsville, Maryland, the University of Illinois and the *Journal of Parasitology*. To these gentlemen, I offer my grateful thanks.

My thanks also are extended to the many research workers in the field of parasitology. They have contributed with distinction to this exciting age of scientific discovery and I hope the bibliographic citations pay

tribute to their efforts. The task of typing, retyping and further re-typing the manuscript and the checking of references has fallen on my secretarial staff Mrs Nancy Barrett, Mrs Helen Roberts, Mrs Nancy Jingoian and Miss Linda Sturgess. To these ladies I owe a debt of gratitude as I do also to Mr Robert Hughes for his expertise in photography. Mr Derek Muncey has now seen four editions of 'Mönnig' prepared; his assistance in the sixth is acknowledged with salutations.

To the publishers I offer my thanks for their co-operation and patience and for the care they have taken in the production of this much revised edition.

Finally, and with the deepest gratitude, I thank my wife for her encouragement, patience and tolerance.

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FROM THE PREFACE TO THE FIRST EDITION

SINCE the publication of Neumann's 'Parasites and Parasitic Diseases of Domesticated Animals' in 1892 no textbook that deals adequately with the helminth and arthropod diseases of domesticated animals has appeared, although great progress in this subject can be recorded. Several very useful books have been written on the morphology of helminth and arthropod parasites, but the parasitic diseases with which the veterinarian is primarily concerned, and of which the parasites are only the aetiological factors, have received very little consideration.

During several years of teaching in these subjects the author has felt the great need of a suitable book for veterinary students and practitioners, and the present volume represents an attempt to supply that need. At the same time he hopes that this compilation of practical facts will serve to bring about a realisation of the importance of veterinary parasitology, which is still underrated in many quarters, and that the veterinary student should receive a more adequate training in it.

It has not been the intention to present a complete manual, in which the information required by the veterinarian is buried in a mass of detail, but to give in a scientific way the most important practical facts of the subject. Many known parasites of domesticated animals are not mentioned because they are rarely seen or because little is known about their pathogenicity. It has naturally been difficult to draw the line here, as well as between the hosts themselves. On the whole an attempt has been made to include the important parasites of all the important domesticated animals of all countries. The parasitic diseases of the fur-bearing animals have also been included, because this branch of livestock farming has assumed an importance that deserves the full attention of the veterinarian. If any important parasites of these animals have been omitted, it is only because discrimination on the subject is difficult at the present stage of our knowledge.

H. O. MÖNNIG

INTRODUCTION

PARASITOLOGY is now a multi-disciplinary subject which embraces the fields of biochemistry, physiology, cell biology, immunology and pharmacology, to mention only a few. Rather than attempt an extensive general introduction as has been done in the past, as much basic biological data as space would allow have been introduced into the text, emphasis being placed on those facts which provide a better understanding of the biology of the parasite, its pathogenic effects and control measures against it.

DEFINITIONS

Parasitology is a study of the phenomenon of parasitism—but immediately upon saying this one is faced with the necessity to define parasitism. Until very recently there has been a desire on the part of authors to separate animal associations into parasitism, commensalism and mutualism (or symbiosis). By these definitions it has been implied that commensalism and mutualism are associations of mutual benefit to both partners; in the former the partners retain their physiological independence, while in the latter they are more interdependent. Parasitism, on the other hand, has implied a harmful association; the parasite living at the expense of the host.

Such definitions have invariably led to further qualifying definitions (e.g., temporary parasite, obligatory parasite, periodic parasite), and also to debate as to what is to be regarded as a harmful effect. There are numerous species of organisms which cannot, by any stretch of the imagination, be regarded as pathogens and yet, because they are parasites, it has been assumed *a priori* that they must produce some harmful effect.

With the growth of molecular biological studies of 'parasites' it is clear that there is no longer any justification for retaining strict definitions of animal associations, and certainly none for retaining the idea that a parasite is a form that causes harm to its host. It would seem much more satisfactory to define parasitism as a state in which an organism (the parasite) is metabolically dependent to a greater or lesser extent on another (the host). Within this framework, it would then be useful to designate those forms which are harmful and those which are harmless, or even beneficial, to the host. Two extreme examples might serve to illustrate this: the ciliates of the rumen of the ruminant or the caecum of the horse are metabolically dependent on the host, yet they are far from pathogenic and there is much to indicate that they are beneficial parasites; on the other hand the abomasal worm of sheep, *Haemonchus contortus*, is also metabolically dependent on the host but it is a serious pathogen.

FORMS WHICH ARE PARASITIC

This book deals only with the helminths, arthropods and protozoa which are parasites of domestic animals. It omits the vast assemblage of other parasitic species which also belong to the three groups mentioned above, and the great number of forms which are spread throughout practically every major phylum of the animal kingdom.

The early beginnings of parasitic life must remain obscure since, being invertebrates without exo- or endo-skeletons, they have left no clue to their ancestry. Nevertheless, since they must have evolved with their hosts, the palaeontological history of the host may shed some light on the evolution of parasites. It is probable that early parasitic forms showed little host specificity, but as they became adapted to the host, and evolved with it, the parasites no doubt became increasingly committed to that host.

A more recent consideration of the evolution of host-parasite relationships is based on immunological phenomena. This suggests that the older and better adapted (i.e. non-pathogenic) parasites have increasingly eliminated antigens (? recognition factors) that were foreign to the host. Ultimately, such parasites became forms that shared a number of common antigens with the host, and the degree of antigenic disparity between the host and the parasite determined the success or otherwise of the parasitic organism.

Such a hypothesis could fit into the concept that the pathogenic species of parasites are those which have been parasites for the shortest period of evolutionary time, since they have yet to evolve to the stage where they incite little or no response on the part of the host.

During the evolution of the host-parasite partnership, it is likely that many biological and morphological characters were lost and also that many were gained. The degree to which these took place would depend, amongst other things, on the host parasitized, the site in the host and the environment of the host. Parasites of hosts that are, today, obviously related and which evolved from a common ancestor, probably underwent similar physiological adaptations as these hosts evolved. It is also likely that the physiological changes were expressed as similar changes in morphology, and today, therefore, one would expect a similar series of species in the same habitat in related hosts.

BIOCHEMISTRY AND PHYSIOLOGY

To attempt any broad statement on these subjects would be foolhardy, even if such remarks were restricted to the parasites of domestic animals. Though there are many aspects of the chemical physiology of parasites which are common to many groups, there are also major differences between the members of a family or a genus and it is likely that these differences will become more apparent as knowledge increases. The student is urged to consult Rogers (1962), Read (1966), Read, Rothman and Simmons (1963), von Brand (1966) and others, on this most important aspect of parasitology.

EFFECT OF PARASITES ON THEIR HOSTS

Though there are many species of parasites which are harmless, there are also many forms which produce pathological changes which may lead to severe ill health or death of the host.

As might be expected, the effects are very varied and in many cases represent a combination of several entities. The parasite may compete with the host for food, and where this is a specific effect (e.g., competition for vitamin B₁₂ by *Diphyllobothrium latum*) the host may suffer a specific deficiency syndrome (e.g. anaemia in the case of *D. latum* infection). More generally, however, the competition for food is much less well defined. The parasite may indirectly be the cause of decreased food utilisation by the host, it may cause a reduced appetite with a concomitant reduction of food intake, or an increased passage of food through the digestive tract. Changes in the absorptive surface of the intestine may result in marked alterations in the efflux and influx of water and sodium and chloride ions into the bowel and in morphological and biochemical changes in epithelial cells and their microvilli.

The removal of the host's tissues and fluids by parasites is best illustrated by the blood-sucking activities of certain nematodes (e.g. hookworms, *Haemonchus*) and arthropods (e.g. ticks, blood-sucking flies) and in some cases death of the host is directly attributable to excessive loss of blood.

One of the most common effects of parasitism is destruction of the host's tissues. This may be by a mechanical action when, for example, parasites or their larval stages migrate through or multiply in tissues or organs, or when various organs of attachment (e.g. head-spines or teeth, claws, suckers, etc.) are inserted into the tissues as anchors. Destruction may be by pressure as a parasite grows larger (e.g. hyatid, coenurus), or by blockage of ducts such as blood vessels to produce infarction (*Strongylus*), or of lymph vessels to produce oedema and elephantiasis (filariasis) or the intestinal canal to produce necrosis and rupture (ascarids).

Often the destruction of tissues is a secondary effect. It may arise from bacterial infection of lesions caused by a parasite (e.g. bowel ulcers) or by the reaction of the host to the parasite. The latter effect may be due to fibrosis of a lesion (e.g. cirrhosis due to *Fasciola hepatica*), excessive proliferation of epithelium (e.g. *Eimeria stiedae* in the bile ducts of the rabbit), endothelium (e.g. aneurysm caused by *Strongylus*), lymphoid tissue (e.g. leishmaniasis) or the initiation of malignant propensities (e.g. *Spirocerca lupi* in the dog). Tissue damage may also be caused by the immunological response of the host, resulting in necrosis, dermatitis (cercarial dermatitis), oedema (ascariasis and dictyocauliasis of the lung) or excessive cell invasion (scabies, ascariasis of the liver).

These are but a few examples of how pathogenic parasites cause their ill effects; many other examples could be quoted but a comparable list could also be given of those forms for which no adequate explanation can

be given of the pathogenic effects. Even with the forms where there is an apparently clear end-result of the parasitism (e.g. anaemia, emaciation or paralysis), often little is known about the chemical pathology and the chronology of the disease process. Anaemia, for example, is a common feature of parasitism and where this is associated with blood sucking parasites the cause and effect may appear relatively clear. Even in these circumstances, however, it is not as simple as has been supposed, and in other parasitic diseases a complex series of nutritional, biochemical and pathological conditions inter-react to manifest themselves as 'anaemia'.

It is clear that a vast amount of investigational work remains to be done on the genesis of the pathology of parasitism.

IMMUNOLOGY

Much evidence has accumulated in the last few decades to indicate that the immune response to parasites is an important phenomenon in the pathology of infection and in the control of parasite populations. Practical uses of the immune response have been the development of immuno-diagnostic tests and the production of vaccines.

The subject of immunology in parasitic infections has now become so immense that, like the biochemistry and physiology of them, it would be unwise to attempt to give a proportionate impression of the vast amount of facts in the limited space of this introduction. This would, inevitably, result in abbreviated treatment of major concepts and in any case, it becomes more and more difficult to present any unified hypothesis, if one exists, of the immunology of parasitism. Consequently, the pertinent facts about immunity to the various species of parasites are presented in the appropriate parts of the text. This aspect of parasitology is very important and the student is urged to consult Sprent (1963), Soulsby (1966, 1962), Garnham, Pierce and Roitt (1963), Kagan (1966), Weinmann (1966), Urquhart, Jarrett and Mulligan (1962), World Health Organisation (1965), International Atomic Energy Agency (1964).

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