

DEER VETERINARY MEDICINE

EDITED BY AIDEN P. FOSTER



Deer Veterinary Medicine

Deer Veterinary Medicine

Edited by Aiden P. Foster

with the British Deer Veterinary Association

This edition first published copyright year 2025 © copyright year copyright holder

All rights reserved, including rights for text and data mining and training of artificial intelligence technologies or similar technologies. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, except as permitted by law. Advice on how to obtain permission to reuse material from this title is available at <http://www.wiley.com/go/permissions>.

The right of Aiden P. Foster to be identified as the editor of this work the editorial material in this work has been asserted in accordance with law.

Registered Office(s)

John Wiley & Sons, Inc., 111 River Street, Hoboken, NJ 07030, USA

John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK

John Wiley & Sons Singapore Pte. Ltd, 134 Jurong Gateway Road, #04-307H, Singapore 600134

For details of our global editorial offices, customer services, and more information about Wiley products visit us at www.wiley.com.

Wiley also publishes its books in a variety of electronic formats and by print-on-demand. Some content that appears in standard print versions of this book may not be available in other formats.

Trademarks: Wiley and the Wiley logo are trademarks or registered trademarks of John Wiley & Sons, Inc. and/or its affiliates in the United States and other countries and may not be used without written permission. All other trademarks are the property of their respective owners. John Wiley & Sons, Inc. is not associated with any product or vendor mentioned in this book.

Limit of Liability/Disclaimer of Warranty

While the publisher and authors have used their best efforts in preparing this work, they make no representations or warranties with respect to the accuracy or completeness of the contents of this work and specifically disclaim all warranties, including without limitation any implied warranties of merchantability or fitness for a particular purpose. No warranty may be created or extended by sales representatives, written sales materials or promotional statements for this work. This work is sold with the understanding that the publisher is not engaged in rendering professional services. The advice and strategies contained herein may not be suitable for your situation. You should consult with a specialist where appropriate. The fact that an organization, website, or product is referred to in this work as a citation and/or potential source of further information does not mean that the publisher and authors endorse the information or services the organization, website, or product may provide or recommendations it may make. Further, readers should be aware that websites listed in this work may have changed or disappeared between when this work was written and when it is read. Neither the publisher nor authors shall be liable for any loss of profit or any other commercial damages, including but not limited to special, incidental, consequential, or other damages.

Library of Congress Cataloging-in-Publication Data has been applied for.

Paperback: 9781394221349

ePDF: 9781394221363

epub: 9781394221356

oBook: 9781394221370

Cover Design: Wiley

Cover Images: Photo by Hannah K. Hill, USDA Agricultural Research Service,
Courtesy of Peter Green, Courtesy of Aiden Foster

Set in 9.5/12.5pts STIXTwo by Lumina Datamatics

Dedication

This book is dedicated to the authors and editors of the Veterinary Deer Society book entitled *Management and Diseases of Deer* (1994), which was our inspiration. We are here today because we stand on the shoulders of these experts.

Contents

| | |
|---|--------------|
| List of Contributors | <i>ix</i> |
| Foreword | <i>xiii</i> |
| Preface | <i>xvii</i> |
| Acknowledgements | <i>xix</i> |
| List of Tables | <i>xxi</i> |
| List of Illustrations/Images | <i>xxiii</i> |
| | |
| 1 Introduction to Cervids | <i>1</i> |
| 2 Managing, Handling and Moving Deer | <i>45</i> |
| 3 Analgesia, euthanasia, restraint and sedation in deer | <i>51</i> |
| 4 Surgical Interventions and Imaging Methods in Deer | <i>63</i> |
| 5 Deer in Deer Parks | <i>69</i> |
| 6 An Overview of Red Deer Farming in the United Kingdom | <i>81</i> |
| 7 Wild Deer in the UK (Health and Welfare, Deer-Vehicle Collisions and Disease Surveillance) | <i>89</i> |
| 8 Venison in the United Kingdom | <i>105</i> |
| 9 Rehabilitation of Deer | <i>115</i> |
| 10 Antlers | <i>123</i> |
| 11 Reproduction in Deer | <i>137</i> |
| 12 Nutrition of Deer | <i>151</i> |
| 13 Notifiable Diseases in Deer – Chronic Wasting Disease | <i>177</i> |
| 14 Notifiable Diseases in Deer – <i>Mycobacterium bovis</i> Infection | <i>183</i> |

| | | |
|----|---|-----|
| 15 | Serological Methods and <i>Mycobacterium bovis</i> Infection in Deer | 197 |
| 16 | Notifiable Diseases in Deer | 205 |
| 17 | Malignant Catarrhal Fever in Deer | 211 |
| 18 | Gastrointestinal Diseases in Deer – <i>Mycobacterium avium</i> Subspecies <i>paratuberculosis</i> and Johne's Disease | 219 |
| 19 | Gastrointestinal and Hepatic Parasite Diseases in Deer | 235 |
| 20 | Gastrointestinal Diseases in Deer | 245 |
| 21 | Zoonotic Agents and Deer (Cryptosporidiosis, Salmonellosis, Toxoplasmosis and SARS-CoV-2) | 251 |
| 22 | Shiga-toxin-producing <i>Escherichia coli</i> in Deer | 265 |
| 23 | Neurological Diseases in Deer | 273 |
| 24 | Respiratory Parasite Diseases in Deer | 283 |
| 25 | Respiratory Diseases in Deer – Bacterial, Fungal and Viral | 293 |
| 26 | Skin Diseases in Deer | 307 |
| 27 | Deer Ophthalmology – A Practical Approach to Deer Ophthalmic Examination | 321 |
| 28 | Lameness and Hoof Problems in Deer | 345 |
| 29 | Vector-borne Infections in Deer – Threat to Deer Health and Role of Deer in Transmission of Diseases of Veterinary and Medical Importance | 359 |
| 30 | Muntjac (<i>Muntiacus reevesi</i>) | 371 |
| 31 | Reindeer | 385 |
| 32 | An Overview of Diseases of Farmed White-tailed Deer | 395 |
| 33 | Anatomical Pathology and Deer – A Guide to Postmortem Examination and Pathology | 423 |
| 34 | Cervine Formulary | 435 |
| | Index | 459 |

List of Contributors

Alex Barlow

Wildlife Network for Disease Surveillance
Rookham Cottage
Dursdon Drove, Wells
Somerset
UK

University of Bristol
Bristol Veterinary School, Langford House,
Langford, North Somerset
UK

Dave J. Bartley

Moredun Research Institute
Pentlands Science Park
Bush Loan, Penicuik
Midlothian
UK

Richard J. Birtles

School of Science, Engineering and
Environment
University of Salford
Salford
UK

Paola Boggiatto

Infectious Bacterial Diseases of Livestock
Research Unit
National Animal Disease Center
Ames, IA
USA

Gareth Boyes

Ark Vet Centre Limited
Lockerbie, Dumfriesshire
UK

Norma Chapman

Larkmead
The Street, Barton Mills, Bury St. Edmunds
Suffolk
UK

Jamie Cordery

Forestry Commission (Retired)
Bucks Horn Oak
Farnham, Surrey
UK

Agnieszka Dabrowska

Food Standards Agency
Foss House, Kings Pool, Peasholme Green
York
UK

Mark P. Dagleish

School of Biodiversity, One Health and
Veterinary Medicine
University of Glasgow
Glasgow
UK

Sam Ecroyd

Tyndale Deer Vets
Lower Wick
Dursley, Gloucestershire
UK

Stephen Fitzgerald

Moredun Research Institute
Pentlands Science Park
Bush Loan, Penicuik
Midlothian
UK

Aiden P. Foster

University of Bristol
Bristol Veterinary School, Langford House,
Langford, North Somerset
UK

Peter Green

South Woolley Farm
Shirwell, Barnstaple
Devon
UK

Clare Hamilton

Moredun Research Institute
Pentlands Science Park
Bush Loan, Penicuik
Midlothian
UK

Kit Heawood

Tyndale Deer Vets
Lower Wick
Dursley, Gloucestershire
UK

Maya Holding

Virology and Pathogenesis Group
UK Health Security Agency
Porton Down, Salisbury
Wiltshire
UK

Carly Kanipe

Infectious Bacterial Diseases of Livestock
Research Unit
National Animal Disease Center
Ames, IA
USA

Carmen Lillo-Llopis

Food Standards Agency
Foss House, Kings Pool, Peasholme Green
York
UK

Jonas Malmsten

Swedish National Deer Health Services
Vallentuna
Sweden

Richard J. McMullen Jr.

Vetsuisse Faculty
Equine Department
University of Zurich
Zurich
Switzerland

Department of Clinical Sciences
College of Veterinary Medicine
Auburn University
Auburn, AL
USA

Tom N. McNeilly

Moredun Research Institute
Pentlands Science Park
Bush Loan, Penicuik
Midlothian
UK

Elena McWatt (nee Gafenco)

Food Standards Scotland
Pilgrim House, Old Ford Road
Aberdeen
UK

Ellie L. Milnes

Wildlife Health, Pathobiology and Population Sciences
 Royal Veterinary College
 University of London
 Hertfordshire
 UK

Centre for Veterinary Wildlife Research
 Faculty of Veterinary Science
 University of Pretoria
 Onderstepoort
 South Africa

Sian Mitchell

Animal and Plant Health Agency
 Carmarthen Veterinary Investigation Centre
 Job's Well Road
 Johnstown
 Carmarthen
 UK

Mitchell Palmer

Infectious Bacterial Diseases of Livestock Research Unit
 National Animal Disease Center
 Ames, IA
 USA

Thomas Passler

Department of Clinical Sciences
 Auburn University College of Veterinary Medicine
 Auburn, AL
 USA

Shelley Rhodes

APHA Weybridge
 Surrey
 UK

Rachel R. Richardson

Moredun Research Institute
 Pentlands Science Park
 Bush Loan, Penicuik
 Midlothian
 UK

Amy L. Robinson

School of Biodiversity, One Health and Veterinary Medicine
 University of Glasgow
 Glasgow
 UK

Mara Rocchi

Moredun Research Institute
 Pentlands Science Park
 Bush Loan, Penicuik
 Midlothian
 UK

Molly Ruder

Watatunga Wildlife Reserve
 Kings Lynn, Norfolk
 UK

George C. Russell

Moredun Research Institute
 Pentlands Science Park
 Bush Loan, Penicuik
 Midlothian
 UK

Philip Skuce

Moredun Research Institute
 Pentlands Science Park
 Bush Loan, Penicuik
 Midlothian
 UK

Robert J. Van Saun

Department of Veterinary and Biomedical Science
 College of Agricultural Science
 Pennsylvania State University
 University Park, PA
 USA

Prerna Vohra

Institute of Immunology and Infection Research
 University of Edinburgh
 Ashworth Laboratories
 Edinburgh
 UK

Don Wagner

Department of Animal Science
College of Agricultural Science
Pennsylvania State University
University Park, PA
USA

Jim Walsh

Sika Lodge
Glencullen, Dublin
Ireland

Craig A. Watkins

Moredun Research Institute
Pentlands Science Park
Bush Loan, Penicuik
Midlothian
UK

Beth Wells

Moredun Research Institute
Pentlands Science Park
Bush Loan, Penicuik
Midlothian
UK

Foreword

This book is a triumph and it is a great privilege to have been asked to write its foreword. That so many contributors could find motivation to write in their own time, in their busy lives, is a testament to their enthusiasm, especially to that of Aiden P. Foster, who has been the editor and organising force.

Its previous iteration, published in 1986, grew out of the Veterinary Deer Society, which today has been renamed as the British Deer Veterinary Association. The Society arose from a conversation that I had with Tom Alexander on the back of a trailer being pulled slowly around Studley Royal park as we tried to approach deer closely enough for me to dart them, initially with a crossbow. That crossbow was the brainchild of the inspirational and brilliant scientist Roger Short. In 1969 I had the extreme good fortune to become a member of a team from the Veterinary School at Cambridge, led by Roger, working with red deer on the Isle of Rum. As well as the wild deer, myself, Gerald Lincoln and Fiona Guinness used a group of hand-reared red deer females to elucidate their oestrous cycle and gestation length and unpick the ways in which testosterone controlled antler growth and rutting behaviour.

I cite this because it is remarkable that, until then, these basic facts were not clearly understood. In America, Caton (1877) had written a scientific treatise about deer and even speculated on their domestication and, in Scotland, Henry Evans (1890) and Fraser Darling (1937) had described the social behaviour and performance of wild red deer in the Highlands and Islands. However, it was not until our work on Rum, followed closely by that on the experimental deer farm at Glensauigh (Blaxter et al. 1974), that in-depth investigations of disease and physiology were published. It was the advent of deer farming that made such research feasible and commercially viable. This book demonstrates just how much has been learnt since that time and when at last we could get our hands on increasingly domesticated living deer.

Humans have kept deer in enclosed 'parks' for over two thousand years as status symbols, for sport, and sometimes for venison, but it took the development of wire fences to make actual farming possible and to create, in red deer, probably the first new domesticated livestock species for at least five thousand years (Fletcher 2001).

Most deer species are, in physiological terms, highly seasonal and adapted to northern temperate climates. Where deer and people co-exist, we have always exploited their antlers, their hides and their meat. Otzi the man preserved in ice for over 5000 years in the Austro-Italian Alps ate venison at one of his last meals, walked in deer skin shoes, wore deer hide clothing, kept his antler-tipped arrows in a quiver constructed from roe deer hide and carried an antler tool probably used to shape flints.

In fact, we talk of the Stone Age, but there was an even longer antler age. The Mesolithic flint mines at Grimes Graves in Norfolk were worked with picks made of red deer antlers. Many of these remain, discarded as worn out but still carrying handprints of the miners in the clay that covers them (Clutton-Brock 1984). Many prehistoric monuments depended on the use of antler tools and it has been calculated that each of the many mine shafts would have used up to 400 antlers each year. How were so many cast antlers found? I like to think that with good knowledge of deer behaviour stags might have been gathered by feeding them browse, such as ivy, which the deer could not reach. There is pollen evidence that ivy was being stored in human settlements (Simmons & Dumbleby 1974) and if the deer were encouraged to stay in the same area during the short period of antler casting, then collecting them before they were covered by the growth of spring vegetation would have been made very much easier. Perhaps such systems foreshadowed future deer parks.

Because deer remained largely inaccessible and only fleetingly glimpsed, they have always been fertile ground for myths and, because the antlers could be seen to regrow each year, deer became symbols of rejuvenation and longevity wherever they existed from Japan to Ireland.

And where have we come to now? The beliefs that motivated deer farming are clear: in their natural environment are not deer better adapted to seasonal climates than the alien cattle and sheep? Yet they remain wild in that they have a rut, which can be difficult to manage on farms, and they are active and carry antlers making handling and containment more expensive. However, they have not been bred and managed to the point where they are subject to the many diseases of overproduction and their meat is better suited to modern human needs than that of conventional livestock, being leaner and high in polyunsaturated fats and iron.

In the United Kingdom, most of the deer industry relates to the production of venison from farms and parks and, especially, by far the largest source, from wild shot deer. There is substantial pressure to reduce deer numbers throughout most of Britain. Notoriously difficult to count, there is no doubt that the native roe, invasive and non-native muntjac, and naturalised fallow deer, in particular, have extended their range whilst their numbers have also grown steadily for decades to reach perhaps the largest cumulative populations at any time in history. These deer are impacting agriculture, forestry and horticulture, the natural environment and causing road traffic accidents with their human toll. Several people die each year in Britain as a result of collisions with deer and many more are injured.

All the governments within the United Kingdom wish to increase woodland in order to lower net greenhouse gas emissions and reduce our dependence on timber imports. Ecologists press for the planting of native woodland to improve biodiversity. Deer of all species negatively impact on tree planting, thus venison from culled deer represents the most sustainable meat available and consumption is rising.

Wild deer provide over 95% of the venison coming to market in Britain and might be assumed to provide a much cheaper source than either farmed or park venison. However, much of this wild venison is derived from red deer in Scotland, and the costs of shooting wild deer and especially the recovery of the carcasses are substantial. Across the UK market, the quality is inevitably highly variable, not least because it comes from a variety of different species as taxonomically removed from each other as cows are to sheep, yet all labelled generically, as venison. The costs of creating a hygienic, marketable product from a carcass that has been eviscerated before it has been skinned and which will usually have sustained damage from the bullet are also high. These factors combine to make farmed venison produced consistently to a uniform standard under stringent quality assurance regulations, killed humanely and processed hygienically, likely to command strong prices in a growing market.

This book wisely avoids much discussion of the worldwide industries that revolve around deer, but antlers drive much of their exploitation. To the outsider the values placed on large antlers as trophies may seem bizarre, yet for many ‘hunters’, who shoot deer in enclosures at close range in order to hang the trophy on the wall, the sky seems to be the limit. Some veterinarians have used artificial reproductive techniques to enable deer breeders to pursue their remorseless quest for ever heavier antlers, fostering the production of some white-tailed deer which can no longer lift their heads from the ground.

The trophy business is probably no larger than the extraordinary farming of deer in much of Asia for the production of the growing antlers harvested by amputation when the growth is at its maximum. In Russia and beyond, wealthy men drink, or even bathe in, the fresh blood as it spurts from the cut surface. The most widely traded commodity is slices of dried growing antler. This velvet is prized by the traditional Chinese medicine trade and is produced in New Zealand with very stringent welfare safeguards. Despite substantial investment, there is no very convincing peer-reviewed literature to substantiate claims of the medicinal value of velvet antlers. The same is true of the many other deer products that are marketed, including sinews, tails and fetuses. Within the United Kingdom and most of Europe, the amputation of growing antlers is illegal except where it may alleviate suffering.

It is the steady growth of the farmed deer industry that has provided the impetus for this book and stimulated the knowledge and veterinary science which also benefit the wild, park and zoo deer.

John Fletcher

Harthill, Reediehill Deer Farm, Auchtermuchty, Fife, KY14 7HS, Scotland

References

- Blaxter KL, Kay RNB, Sharman GAM, Cunningham JMM and Hamilton WJ (1974) Farming the Red Deer – the first report of an investigation by the Rowett Research Institute and the Hill Farming Research Organisation. Department of Agriculture and Fisheries for Scotland, Her Majesty’s Stationery Office, Edinburgh.
- Caton JD (1877) The Antelope and Deer of America. A comprehensive scientific treatise upon the natural history, including the characteristics, habits, affinities and capacity for domestication of the Antilocapra and Cervidae of North America. Cambridge, MA, USA: The Riverside Press.
- Clutton-Brock J (1984) Excavations at Grimes Graves, Norfolk, 1972–1976, Fascicule 1: Neolithic Antler Picks from Grimes Graves, Norfolk, and Durrington Walls, Wiltshire: A Biometrical analysis. London, UK: British Museum Press.
- Evans H (1890) Some Account of Jura Red Deer. Carter, Derby, UK.
- Fletcher TJ (2001) Farmed deer: new domestic animals defined by controlled breeding. *Reproduction, Fertility and Development* 13:511–516. doi: 10.1071/rd01094.
- Fraser Darling F (1946) *A Herd of Red Deer*. Oxford, UK: Oxford University Press.
- Simmons IG and Dimbleby GW (1974) The Possible Role of Ivy (*Hedera helix*, L.) in the Mesolithic Economy of Western Europe. *Journal of Archaeological Science* 1:291–296. doi: 10.1016/0305-4403(74)90029-6.

Preface

In 1994, the Veterinary Deer Society (VDS) published the second edition of their book *Management and Diseases of Deer (A Handbook for Veterinary Surgeons)* edited by Tom Alexander and David Buxton. The book is out of print and was converted into a CD-ROM version, which is available from the British Deer Veterinary Association (BDVA).

In commissioning the current book, the primary aims were to build on the substantial content of the VDS book and to compile a series of chapters that would form a useful handbook for veterinary surgeons/veterinarians when dealing with deer. It is acknowledged that while the book is aimed at veterinary surgeons who may not know a great deal about deer – given that most veterinarians will have limited scope for undertaking deer work – that deer owners, managers, stalkers and others will find the book of interest and assistance.

There are 38 authors, including members of the BDVA committee, who have also read all of the chapters. The committee includes Gareth Boyes, Sam Ecroyd, Peter Green, Kit Heawood and Ken Urquhart. The authors are largely drawn from across the UK, with colleagues from Ireland, Sweden, Switzerland and the United States.

Deer are enclosed and managed within a variety of settings from farms to parks to zoological collections, with some kept in a manner akin to companion animals or pets. In the United Kingdom, there are six species of wild deer and many other species in zoological collections.

- The first part of the book introduces deer species and how they can be handled, restrained and managed in farms, parks and in the wild, leading onto the submission of deer carcasses into the human food chain. Subsequent chapters provide overviews of the nutritional needs of deer, dealing with antlers, reproductive interventions and the needs of wild deer with particular reference to emergency situations.
- Deer are susceptible to notifiable diseases, most notably chronic wasting disease and infection with *Mycobacterium bovis* (TB). These and other notifiable conditions are discussed.
- Diseases of deer are presented using a systems-based approach (including gut, nervous, respiratory and skin) and there is an associated chapter that includes some of the important zoonotic diseases and agents that they may harbour.
- Given their importance, both here in the United Kingdom and elsewhere, there are specific chapters about muntjac, reindeer and white-tailed deer.
- Finally, there are two key chapters on postmortem examination and a drug formulary.

The aims of the book also included the inclusion of illustrations and sources of further reading and references to help provide an evidence base for dealing with situations and disease in deer.

Given the structure of the book, it is inevitable that chapters have some overlapping content. Where possible, the overlaps have been signposted and covered in the index. Readers should treat each chapter as a separate stand-alone item, albeit with potential links to several chapters within the book.

Acknowledgements

The BDVA would like to express its appreciation for the time and effort that the authors have committed to sharing their expertise in writing their chapters. There has been considerable support from prospective authors and colleagues in terms of recruiting authors and gaining access to images. I am particularly grateful to Peter Green and Jim Walsh who have shared much of their extensive collections of deer images. I am particularly grateful to David Buxton and Tom Alexander, the editors of the 1994 Veterinary Deer Society (VDS) book, also to John Fletcher, Pete Goddard and Ranald Munro, who wrote many of the chapters; they provided lots of useful contacts and advice.

While the book was in preparation, one of the leading authors of the 1994 VDS book, Hugh Reid, passed away. Hugh made a major contribution to veterinary virology and this included important research into agents that affect deer. He worked for many years at the Moredun Research Institute and his legacy is well reflected in the large group of authors who are based at the Moredun and who have provided detailed expert chapters on a variety of diseases that affect deer (and humans potentially).

My thanks go to Dominic Alexander for commenting on parts of the text and to Alun Murphy for providing information about lead analyses.

Additional specific acknowledgements in relation to the chapters are given below, including those provided by the authors.

Chapter 10 Antlers – Acknowledgements for images including Jim Walsh, Paul Rodgers, Pavel Scherer and Gemma Thorpe.

Chapter 15 Tb Serology

For the co-authors and contributors to Defra project SE3315 (Barton P, Robinson N, Middleton S, O'Brien A, Clarke J, Dominguez M, Gillgan S, Selmes J and Rhodes S). Additional thanks to Ricardo de la Rua-Domenech (APHA TB Policy Veterinary Advisor to Defra), David Harris (Wales TB Veterinary Adviser) and Martyn Blissitt (Scotland Veterinary Adviser [Notifiable Diseases]) for review of this chapter, also Patricia Touw and Charlotte Pritchard (past and present APHA veterinary advisors for TB delivery) for supporting and enabling deer testing at APHA.

Chapter 17 MCF This chapter is an update of a previous edition written by Hugh Reid, whose contribution to MCF research was considerable. The structure of the article and much of the background was Hugh's, while the more modern aspects were added by the current authors.

Chapter 26 Skin – For the provision of images and advice Gareth Boyes, John Fletcher, Toby Floyd, Mark Fox, Peter Green, Pavel Scherer, Ken Urquhart and Richard Wall.

Chapter 30 Muntjac

The late Donald Chapman initiated the field studies that gave rise to these data, setting up the project with permission of the Forestry Commission. After his untimely death in a road traffic

accident in 1982, overall supervision of the field studies was undertaken by Professor Stephen Harris, who supervised several PhD students undertaking ecological research in the study area. The authors acknowledge the invaluable input of Mick Claydon, Cathy Claydon, Diane Blakely and the many volunteers who participated in the flushing, netting and processing of the deer. The authors are grateful to John Cooper and Andrew B. Forbes for their involvement with the collection of samples and to Sam Pearce for assistance with statistical analysis.

Photographs

Marc Baldwin, Alex Barlow, Suzi Bell, Matt Colson, Mark Dagleish, Sam Ecroyd, John Fletcher, Peter Green, Beckie Diston, Angie Nelson, Iain Richards, Paul Rodgers, Pavel Scherer, Alex Smith, Tilly Smith, Daniel Sproule, Gemma Thorpe, Jim Walsh. Please see figure legends for details of the permission to publish.

Disclaimer

Whist every care has been taken to ensure the accuracy of the information contained in this book, the editor, contributors, publishers and the BDVA can accept no responsibility for any error or misleading statement which may inadvertently have been included. Neither can they accept any responsibility for the consequences of any course of action which may be followed as the result of any such error or misleading statement.

It should be noted particularly that the responsibility in the United Kingdom for prescribing or supplying medicinal products accurately and appropriately for the animals under their care remains squarely with the veterinary surgeon. In this connection the advice given by the Royal College of Veterinary Surgeons (<https://www.rcvs.org.uk/setting-standards/advice-and-guidance/code-of-professional-conduct-for-veterinary-surgeons/>) and the British Veterinary Association (see for example <https://www.bva.co.uk/resources-support/medicines/under-care-resources-for-veterinary-practices/>) should be borne carefully in mind. In any case of doubt the licence holder of the medicinal product in question should be consulted.

List of Tables

| | |
|------------|--|
| Table 1.1 | A taxonomy of deer species. |
| Table 2.1 | Space allocation for housing deer at different life stages. |
| Table 5.1 | Trace element ranges for park deer. |
| Table 6.1 | Wormer categories (for gut worms, lungworm and liver fluke). |
| Table 7.1 | A brief outline of deer management and varying statutory regulations in some European countries. |
| Table 7.2 | A summary of disease surveillance reports for roe deer in selected European countries. |
| Table 8.1 | Legislation applicable to foodstuffs in Great Britain. |
| Table 11.1 | Breeding and antler windows for UK deer species across the calendar year. |
| Table 11.2 | Approximate measurements used in fetal ageing of red deer. |
| Table 12.1 | Comparison of ruminant species relative to feeding pattern. |
| Table 12.2 | Predicted dietary energy and protein requirements (dry matter basis) of deer. |
| Table 12.3 | Predicted dietary calcium and phosphorus and vitamins A and E requirements for deer at different life stages (NRC 2007). |
| Table 12.4 | Suggested dietary mineral concentrations (dry matter basis) for captive deer diets based on modified recommendations for goats (NRC 2007). |
| Table 14.1 | Prevalence of <i>Mycobacterium bovis</i> infection in English wild deer sampled between 2000 and 2003. |
| Table 15.1 | Summary of antibody test sensitivity and specificity for TB in deer. |
| Table 15.2 | Antibody test comparisons using Kappa and McNemar statistical tests for Tb in deer. |
| Table 15.3 | Test performance in terms of sensitivity and specificity of deer antibody tests for TB at APHA. |
| Table 16.1 | Summary of findings in deer species infected with foot and mouth virus. |
| Table 18.1 | Deer species and premise type where infection with <i>Mycobacterium avium paratuberculosis</i> (MAP) has been reported. |
| Table 19.1 | Species of roundworms identified in wild deer across Europe. |
| Table 19.2 | Possible reasons for animals being underdosed with anthelmintics. |

| | |
|------------|---|
| Table 24.1 | Species of pulmonary associated parasites identified in wild deer (and reindeer) across Europe. |
| Table 26.1 | Diagnostic tests for investigating skin disease. |
| Table 27.1 | Diagnostic instruments and supplies necessary to perform an ophthalmic examination. |
| Table 27.2 | Intraocular pressure and reflex tear production values of various deer species using the Tono-Pen-XL applanation and TonoVet rebound tonometers and Schirmer Tear Test I (STT I), respectively. |
| Table 30.1 | Haematological values for combined free-living and captive populations. |
| Table 30.2 | Biochemical values for the combined free-living and captive populations. |
| Table 30.3 | Haematological values for the free-living population. |
| Table 30.4 | Haematological values for the captive population. |
| Table 31.1 | Summary of analyses of deer samples for assessing selenium and Vitamin E status. |
| Table 33.1 | Equipment lists for undertaking postmortem examination. |
| Table 34.1 | Antimicrobials. |
| Table 34.2 | Anthelmintics, coccidiostats and ectoparasiticides. |
| Table 34.3 | Non-steroidal anti-inflammatory agents. |
| Table 34.4 | Glucocorticoids. |
| Table 34.5 | Sedatives and anaesthetic agents. |
| Table 34.6 | Sedation reversal agents. |
| Table 34.7 | Reproductive hormones. |
| Table 34.8 | Vitamins, minerals and trace-elements. |
| Table 34.9 | Miscellaneous. |

List of Illustrations/Images

| | |
|--------------|--|
| Figure 1.1 | Axis deer. |
| Figure 1.2 | Axis deer. |
| Figure 1.3 | Barasingha deer. |
| Figure 1.4 | Barasingha deer. |
| Figure 1.5 | Fallow buck with recent rutting penetration of eye. |
| Figure 1.6a | Fallow does and fawns (various colours). |
| Figure 1.6b | Fallow deer bucks - showing common, melanistic and menil colour forms. |
| Figure 1.7 | Fallow deer antler. |
| Figure 1.8 | Mule deer. |
| Figure 1.9 | Mule deer. |
| Figure 1.10 | Muntjac. |
| Figure 1.11 | Père David's stags in velvet. |
| Figure 1.12 | Père David deer. |
| Figure 1.13 | Red hind and calf. |
| Figure 1.14 | Red stag. |
| Figure 1.15 | Red deer antler. |
| Figure 1.16 | Reindeer stag. |
| Figure 1.17 | Reindeer calf. |
| Figure 1.18 | Female reindeer and their calves in winter. |
| Figure 1.19 | Reindeer antler. |
| Figure 1.20 | Roe buck. |
| Figure 1.21 | Roe doe. |
| Figure 1.22 | Roe deer antler. |
| Figure 1.23 | Sika deer. |
| Figure 1.24 | Wapiti hind. |
| Figure 1.25 | Wapiti in Canada. |
| Figure 1.26a | Water deer fawn. |

| | |
|--------------|--|
| Figure 1.26b | Water deer buck. |
| Figure 1.27 | White-tailed deer - does. |
| Figure 1.28 | White-tailed deer buck. |
| Figure 4.1 | A view of a reindeer being prepared for a CT scan. |
| Figure 8.1 | An example of a hunter's declaration. |
| Figure 8.2 | (a) A well-kept game larder for deer. (b) An onward transport vehicle to an animal game handling establishment. |
| Figure 8.3 | Routes for the supply of the wild game including the use of the collection centres. |
| Figure 10.1 | Illustrating the terms used to describe an antler. |
| Figure 10.2 | (a) Red deer with cast antler showing the pedicle from where the new antler will grow. (b) Red deer with new antler growth showing from the pedicle. |
| Figure 10.3 | (a) Perruque in a red deer castrate - an uncommon condition in this species. (b) Perruque in a castrated roe deer. |
| Figure 10.4 | The figure represents the seasonal pattern of antler growth in male and female reindeer in relation to their reproductive cycle. |
| Figure 10.5 | Hyperplastic fibrous changes to velvet skin (antleroma) in a castrated reindeer. |
| Figure 12.1 | Cumulative fetal weight for white-tailed deer fetus throughout gestation. |
| Figure 12.2 | Wild white-tailed deer foraging in Valley Forge, Pennsylvania, USA, where the population exceeded carrying capacity resulting in various stages of malnutrition. |
| Figure 13.1 | Excess salivation in an elk (<i>Cervus elaphus canadensis</i>) with CWD. |
| Figure 13.2 | Distribution of classical and atypical cases of CWD in reindeer, moose and red deer in Scandinavia. |
| Figure 14.1 | Fallow buck with TB; sanguinous nasal discharge. |
| Figure 14.2 | Buck in poor condition due to TB. |
| Figure 14.3 | TB abscesses in red hind lung. |
| Figure 14.4 | TB abscesses in mesenteric chain. |
| Figure 14.5 | Miliary lesions of TB on the rumen serosa. |
| Figure 14.6 | TB abscesses of bronchial lymph nodes. |
| Figure 14.7 | Red hind with TB abscesses visible in the retropharyngeal / throat area. |
| Figure 14.8 | Multiple TB abscesses in omentum. |
| Figure 14.9 | TB abscesses in diaphragm and liver. |
| Figure 14.10 | Encapsulated firm abscess in lung tissue. |
| Figure 14.11 | Small firm abscess in the mesenteric lymph node. |
| Figure 14.12 | Soft custard like abscess material adjacent in popliteal lymph node adjacent to muscle tissue. |
| Figure 14.13 | Large firm gritty abscess in an inguinal lymph node. |

- Figure 14.14 Brown liquid abscess in a popliteal lymph node.
- Figure 14.15 Multiple firm to gritty abscess lesions in mammary gland tissue.
- Figure 14.16 Multifocal variably sized soft Tb lesions in the liver.
- Figure 17.1 Phylogenetic tree of MCF viruses and herpes viruses infecting deer.
- Figure 18.1 The life cycle of infection and transmission of Johne's Disease in deer.
- Figure 18.2 Postmortem image showing the corrugated appearance of the mucosa of the terminal ileum in a sheep with Johne's disease.
- Figure 18.3 Histological findings in the gut of sheep with Johne's disease (infection with *Mycobacterium avium paratuberculosis*-MAP).
- Figure 19.1 Individual faecal egg counts from farmed red deer.
- Figure 19.2 (a) Low power image of a faecal sample containing liver and rumen fluke eggs stained with methylene blue. (b) Higher power images of silvery rumen fluke egg (left) and brown fluke egg (right) for comparison. (c) Mixed roundworm species eggs, including *Oesophagostomum* and *Nematodirus*.
- Figure 19.3 (a) Whole pluck from red deer, note marked cirrhosis with areas of atrophy and scarring at the bottom of the picture and evidence of compensatory regeneration. (b) Liver with extensive fluke damage collected from culled roe deer with no obvious clinical signs. (c) Nodular lesions on abomasum folds resulting from *Ostertagia* infection.
- Figure 24.1 *Pilobolus* fungi with water droplets.
- Figure 24.2 (a) Incised lung nodules associated with *Protostrongylus* spp. (b) External view of lung nodules in a roe deer with *Protostrongylus* spp.
- Figure 24.3 (a) *Dictyocaulus viviparus* larvae, isolated from faeces. (b) *Dictyocaulus viviparus* larvae, isolated from faeces.
- Figure 24.4 Posterior (Top row) and full body (bottom row) line drawings of lungworm first stage larvae A. *Dictyocaulus filaria*; B. *Protostrongylus rufescens*; C. *Muellerius capillaris*; D. *Cystocaulus ocreatus*; E. *Neostongylus linearis* (posterior only); F. *Dictyocaulus viviparus* (full body only).
- Figure 24.5 Adult *Dictyocaulus* spp. in the opened trachea of a red deer.
- Figure 24.6 Adult *Dictyocaulus eckerti* showing kidney shaped buccal ring.
- Figure 25.1 (a) Postmortem examination of a reindeer with extensive *Cephenemyia* infestation (nasal bots). (b) Postmortem examination of a moose with *Cephenemyia* infestation (nasal bots). (c) *Cephenemyia* (nasal bots) from (b).
- Figure 26.1 (a) Warble fly lesions due to *Hypoderma diana* in a red deer from Scotland. (b) Warble fly lesions due to *Hypoderma diana* in a red deer from Scotland. (c) Warble fly lesions due to *Hypoderma diana* in a red deer from Scotland.
- Figure 26.2 Low power histology image (haematoxylin and eosin) of skin, showing a follicle with demodex mites in the lumen and in the adjacent sebaceous gland with mild perifollicular inflammation.

- Figure 26.3 (a) Red deer hind with severe cutaneous ulceration due to cutaneous lymphoma. (b) Red deer hind with severe cutaneous ulceration due to cutaneous lymphoma.
- Figure 26.4 (a) Papillomatous lesions in a red deer. (b) Papillomatous lesions in a roe deer.
- Figure 27.1 Six-year-old white-tailed deer (*Odocoileus virginianus*) buck strapped onto a stretcher following sedation facilitated by darting.
- Figure 27.2 White-tailed deer buck immobilized by darting.
- Figure 27.3 Distant examination of a herd of roe deer.
- Figure 27.4 Assessment of bilateral ocular and periocular symmetry.
- Figure 27.5 (a) The meibomian gland openings are readily seen along both the upper and lower eyelid margins (light dots). (b) The meibomian gland openings are readily seen along both the upper and lower eyelid margins (light dots).
- Figure 27.6 (a) Multiple periorbital skin lacerations in a young white-tailed deer. (b) Multiple periorbital skin lacerations in a young white-tailed deer. (c) Multiple periorbital skin lacerations in a young white-tailed deer.
- Figure 27.7 (a) Series of still image screenshots from a short iPhone video of the third eyelid being prolapsed via manual digital pressure to the dorsal aspect of the globe through the upper eyelid. (b) Series of still image screenshots from a short iPhone video of the third eyelid being prolapsed via manual digital pressure to the dorsal aspect of the globe through the upper eyelid. (c) Series of still image screenshots from a short iPhone video of the third eyelid being prolapsed via manual digital pressure to the dorsal aspect of the globe through the upper eyelid.
- Figure 27.8 (a) Direct retroillumination being performed in a young white-tailed deer under manual restraint. (b) Note the position of the transilluminator next to the examiner's right eye.
- Figure 27.9 (a) Screen shots from a short video sequence taken with an iPhone 15 ProMax using the standard camera app on the phone. (b) Pupil constricts due to direct illumination into the right eye. This is a very useful way of evaluating direct pupillary light reflexes, allowing for direct visualization and documentation that can be reviewed later.
- Figure 27.10 Topical application of 1% tropicamide ophthalmic solution is achieved using a 1-ml syringe/30-gauge needle combination after the needle has been broken off.
- Figure 27.11 Direct ophthalmoscopy being performed by one of the authors (TP) of the right eye in a six-year-old white-tailed deer buck.
- Figure 27.12 (a) Fundus images being captured using a Kowa Genesis-D handheld digital fundus retinal camera. (b) Fundus images from two different six-year-old male white-tailed deer. (c) Fundus images from two different six-year-old male white-tailed deer.

- Figure 27.13 (a) Tapetal reflex obtained by shining a Finoff transilluminator into the left eye of a sedated six-year-old male white-tailed deer. (b) The condensing lens (+20D) is then slid up into the field of view, directly in front of the eye being examined to allow indirect visualization of the fundus. (c) The upside down and backwards fundus can be seen in within the confines of the condensing lens frame. (d) The upside down and backwards fundus can be seen in within the confines of the condensing lens frame.
- Figure 27.14 (a) Schirmer tear test (STT) strips placed bilaterally within the temporal palpebral fissure of a six-year-old white-tailed deer buck under sedation. (b) Expanded view of the STT strip in the left eye. Note the blue indicator dye marking at 8 mm.
- Figure 27.15 Rebound tonometry being performed on a six-year-old white-tailed deer buck under sedation using an iCare TONOVET Plus rebound tonometer.
- Figure 27.16 Two white-tailed deer fawns under sedation. The eyes are covered to minimize visual stimuli.
- Figure 27.17 Field recovery of a white-tailed deer buck following sedation.
- Figure 27.18 Overview of a group of white-tailed deer fawns.
- Figure 28.1 Yersinia septic arthritis in a muntjac deer.
- Figure 28.2 Yersinia septic arthritis and carpal valgus in a muntjac deer.
- Figure 28.3 Radiograph of Yersinia septic arthritis in a fallow deer.
- Figure 28.4 Boiled out elbow joint of Yersinia septic arthritis in a muntjac deer.
- Figure 28.5 Aladdin's slipper feet in a red hind.
- Figure 28.6 Field case of fallow deer with treponeme associated hoof disease with large round ulcerated lesion.
- Figure 28.7 Field case of fallow deer with treponeme associated hoof disease with erythema and erosion of the dorsal interdigital skin.
- Figure 28.8 Postmortem image of a focal erosion on the palmar interdigital aspect of a fallow deer limb with treponeme associated hoof disease.
- Figure 28.9 Postmortem image of a focal erosion on the palmar-lateral aspect of a fallow deer limb with treponeme associated hoof disease.
- Figure 28.10 Postmortem image of a focal erosion on the dorsal-lateral aspect of the distal forelimb in a fallow deer with treponeme associated hoof disease.
- Figure 30.1 Muntjac skull buck with pre-orbital fossa.
- Figure 30.2 Muntjac buck.
- Figure 31.1 Reindeer at postmortem examination with 10-day history of corneal opacity – death was due to MCF.
- Figure 31.2 (a) Postmortem examination of a pregnant reindeer with death associated with MCF. (b) Postmortem examination of a pregnant reindeer with death associated with MCF.

- Figure 32.1 (a) Medial retropharyngeal lymph nodes from *Mycobacterium bovis* infected white-tailed deer. (b) The lesion is more abscess-like.
- Figure 32.2 Heart from white-tailed deer. Cause of death epizootic haemorrhagic disease (EHD).
- Figure 32.3 Adductor muscles from white-tailed deer.
- Figure 33.1 Ventral view of the neck indicating the area of incision (arrow) through the hyoid apparatus.
- Figure 33.2 *Dictyocaulus* spp. in the trachea of a red deer.
- Figure 33.3 (a) Recommended dissection lines for the heart. (b) Opened right ventricle for examination of the right atrioventricular valve.
- Figure 33.4 Opened left ventricle for examination of the left atrioventricular and aortic semilunar valves.
- Figure 33.5 ‘Chicken fat clot’, a common incidental postmortem finding in the heart.
- Figure 33.6 Ileum of a cow with Johne’s disease.
- Figure 33.7 Suggested cuts for removal of the brain.