

# Diseases of Cattle in Australasia



A comprehensive textbook

TJ Parkinson, JJ Vermunt and J Malmo

# Diseases of Cattle in Australasia

A comprehensive  
textbook

TJ Parkinson  
JJ Vermunt  
J Malmo

Published by The New Zealand Veterinary Association Foundation  
for Continuing Education (VetLearn™)



Supported by





Published by The New Zealand Veterinary Association Foundation for Continuing Education (VetLearn®).

Copyright © VetLearn® 2010.

The copyright holders assert their moral rights in the work. The rights of the authors as attributed on each chapter to be identified as the authors of this work in terms of Section 96 of the Copyright Act 1994 are hereby asserted. All rights reserved.

This book is copyright. Except for the purposes of fair reviewing, no part of this publication may be reproduced or transmitted in any form or by any means, whether electronic, digital or mechanical, including photocopying, recording, any digital or computerised format, or any information storage and retrieval system, including by any means via the Internet, without permission in writing from the Publisher:  
Infringers of copyright render themselves liable to prosecution.

ISBN 978-0-9583634-4-7

Managing Editor: *Peter D Jolly, BVSc, BPhil, PhD*

Consulting Editor: *Richard A Laven, BVetMed, PhD, MRCVS*

Editorial Assistant: *Gina deNicolo, BSc (Hons), PhD, Dipl Farm Management*

Copy Editor: *Carolyn Lagabetau*

Production: *Ansley TeHiwi*

Indexing: *Robin Briggs*

Cover design, original artwork and page layout: *Peter Parkinson*

Prepress: *Cheryl Rowe, Murray Lock*

#### Notice

Neither the publisher, editors, publishing staff nor the authors assume any liability for any injury or damage whatsoever to persons, animals or property arising out of or related to any use of the material contained in this publication. Where trade names appear, no discrimination is intended, and no endorsement either by the authors, editors or publishers is implied. Readers are advised to check the most current information provided (a) on procedures described and (b) by the manufacturer of each product to be administered, to verify these and the recommended dose or formulation, the method and duration of administration, and contra-indications.

VetLearn®

PO Box 11212

Wellington 6142

New Zealand

Email: [vetlearn@vets.org.nz](mailto:vetlearn@vets.org.nz) | Phone: +64 4 471 0484 | [www.vetlearn.org.nz](http://www.vetlearn.org.nz)

“Diseases in of Cattle in Australasia” provides cattle practitioners and veterinary students with an authoritative text on cattle diseases that may be encountered in the predominantly pasture-based environments in New Zealand and Australia. The cattle industry in Australasia is the largest animal industry in the region, and includes the dairy, pasture-fed beef, feedlot, and live-export sectors. The industry operates across a wide range of environments and production systems, and more than half of the produced dairy and beef commodities are exported.

This textbook is arranged in 25 chapters, commencing with an overview of the dairy and beef industries in New Zealand and Australia and ending with a chapter on practical therapeutics, and comes with an extensive image library on CD-ROM. The text has been mainly co-authored by Tim Parkinson, Jos Vermunt and Jakob Malmo, with additional contributions from fifteen other authors. The book is written from the perspective of the veterinary practitioner encountering the diseases in cattle on a farm. The reader is provided with a detailed outline of the diagnostic methodology based on clinical examination of body systems, with confirmation by ancillary tests and responses to treatment.

The principal authors are eminently qualified and experienced. Tim Parkinson is currently Professor of Farm Animal Reproduction and Health at Massey University in New Zealand, and a Diplomate of the European College of Animal Reproduction and Fellow of the Royal College of Veterinary Surgeons. Tim has extensive practical, academic and research experience with cattle in both the United Kingdom and New Zealand. Jos Vermunt is a registered veterinary specialist in cattle medicine and Fellow of the Australian College of Veterinary Scientists, and has combined cattle practice in the Netherlands, Middle East, Canada, New Zealand and Australia, with academic teaching and research. Jakob Malmo is a registered veterinary specialist in cattle medicine and Fellow of the Australian College of Veterinary Scientists, and has combined a career in private practice while running two dairy farms, with teaching cattle medicine to undergraduate veterinary science students at the University of Melbourne, and supervising postgraduate students undertaking research projects in commercial dairy herds. Together, these principal authors bring a wealth of practical, academic and research experience to this text.

This is the definitive textbook on diseases of cattle in Australasia. All of the important diseases of cattle are covered, with particular emphasis on clinical examination, diseases of the gastrointestinal tract, lameness, mastitis, and reproductive disorders. The textbook will be an essential reference for cattle practitioners throughout Australia and New Zealand, and will have application where cattle are kept under similar conditions in other countries. The chapter on practical therapeutics for the cattle veterinarian will be of great value for veterinary students, and for the young cattle veterinarian to have in the car for reference during on-farm consultations.

Ivan W Caple  
Professor Emeritus  
Faculty of Veterinary Science  
The University of Melbourne

# CONTRIBUTORS

**Timothy J Parkinson**, BVSc, DBR, DipECAR, MEd, PhD, FRCVS, Registered Specialist (RCVS) in Veterinary Reproduction (cattle and sheep). Professor of Farm Animal Reproduction & Health, Institute of Veterinary, Animal & Biomedical Sciences, Massey University, Palmerston North, New Zealand.

**Jos J Vermunt**, DVM (cum laude), BAgSc, MSc, FACVSc, Registered Veterinary Specialist in Cattle Medicine. Senior Advisor (Animal Imports and Exports), Ministry of Agriculture and Forestry Biosecurity New Zealand, Wellington, New Zealand.

**Jakob Malmo**, AO, BVSc, FACVSc, DVSc (honoris causa), Registered Veterinary Specialist in Cattle Medicine. Honorary Senior Fellow, Faculty of Veterinary Science, University of Melbourne; Maffra Veterinary Centre, Maffra, Victoria, Australia.

**Norman Anderson**, BVSc, PhD. Honorary Research Fellow, Faculty of Veterinary Science, University of Melbourne, Melbourne, Victoria, Australia.

**Paul MV Cusack**, BSc BVSc MVSt MACVSc. Director Australian Livestock Production Services, Cowra, New South Wales, Australia.

**Christopher Grainger**, BAgSc, MAgSc, PhD. Principal Scientist-Livestock Systems, Department of Primary Industries, Melbourne, Victoria, Australia.

**Colin W Holmes**, BAg, PhD. New Zealand Dairy Industry Chair in Dairy Production Systems, Institute of Veterinary, Animal & Biomedical Sciences, Massey University, Palmerston North, New Zealand.

**Robert D Jolly**, BVSc, PhD, DSc, FACVSc, FRCPA, Honorary dip ACVP, FRSNZ, MNZM. Professor Emeritus, Institute of Veterinary, Animal & Biomedical Sciences, Massey University, Palmerston North, New Zealand.

**Richard A Laven**, BVetMed, PhD, MRCVS. Senior Lecturer in Dairy Cattle Medicine, Institute of Veterinary, Animal & Biomedical Sciences, Massey University, Palmerston North, New Zealand.

**Ian J Lean**, BVSc, PhD, MACVSc, Registered Veterinary Specialist in Cattle Medicine. Managing Director, Strategic Bovine Services, Camden, New South Wales, Australia Camden, New South Wales, Australia.

**Steven T Morris**, BAgSc, MAgSc, PhD. Professor of Animal Science, Institute of Veterinary, Animal & Biomedical Sciences, Massey University, Palmerston North, New Zealand.

**Michael J Nunn**, BVSc, MSc, MACVSc, MASM, GDipMgt. Principal Scientist (Animal Biosecurity), Australian Government Department of Agriculture, Fisheries and Forestry, Canberra, Australia.

**Kiro R Petrovski**, DVM, MVS. Institute of Veterinary, Animal & Biomedical Sciences, Massey University, Palmerston North, New Zealand.

**Keith G Thompson**, BVSc, DipACVP, PhD. Professor of Veterinary Pathology, Institute of Veterinary, Animal & Biomedical Sciences, Massey University, Palmerston North, New Zealand.

**William P Tranter**, BVSc, PhD. Adjunct Professor in Dairy Cattle Medicine, James Cook University, Townsville; Tableland Veterinary Service, Atherton Road, Malanda, Queensland, Australia.

**Jenny F Weston**, BVSc, BPhil, MACVSc. Senior Lecturer in Dairy Cattle Medicine, Institute of Veterinary, Animal & Biomedical Sciences, Massey University, Palmerston North, New Zealand.

**Charlotte T Westwood**, BVSc, PhD, MACVSc. 2 Kiln Lane, Prebbleton, Christchurch, New Zealand.

**Peter A Windsor**, BVSc, GradCertEd, PhD, DVSc. Faculty of Veterinary Science, University of Sydney, Camden, New South Wales, Australia.

---

**Chapter 1: Dairy and beef production systems in Australia and New Zealand**

CW Holmes, C Grainger, PMV Cusack, ST Morris

---

**Chapter 2: Clinical examination**

J Malmo, JJ Vermunt, TJ Parkinson

---

**Chapter 3: Diseases of the gastrointestinal tract**

J Malmo, JJ Vermunt, TJ Parkinson

---

**Chapter 4: Diseases causing diarrhoea**

TJ Parkinson, JJ Vermunt, J Malmo, N Anderson

---

**Chapter 5: Respiratory conditions**

JJ Vermunt, J Malmo, TJ Parkinson

---

**Chapter 6: Disorders of the cardiovascular system**

JJ Vermunt, J Malmo, TJ Parkinson

---

**Chapter 7: Diseases of the hepatobiliary system**

JJ Vermunt, J Malmo, TJ Parkinson

---

**Chapter 8: Diseases of the urinary tract**

JJ Vermunt, J Malmo, TJ Parkinson

---

**Chapter 9: Neurological disease**

RA Laven, J Malmo, JJ Vermunt, TJ Parkinson

---

**Chapter 10: Mastitis**

J Malmo, JJ Vermunt, TJ Parkinson, KR Petrovski

---

**Chapter 11: Reproduction and disorders of the reproductive system**

TJ Parkinson, JJ Vermunt, J Malmo, JF Weston

---

**Chapter 12: Metabolic disorders**

J Malmo, JJ Vermunt, TJ Parkinson

---

**Chapter 13: Trace elements and vitamin nutrition**

CT Westwood, IJ Lean

---

**Chapter 14: Disorders of the skin**

JJ Vermunt, J Malmo, TJ Parkinson

---

**Chapter 15: Ectoparasites**

JJ Vermunt, J Malmo, TJ Parkinson

---

**Chapter 16: Disorders of the head**

TJ Parkinson, JJ Vermunt, J Malmo

---

**Chapter 17: Calves: management and diseases**

TJ Parkinson, JJ Vermunt, J Malmo

---

**Chapter 18: Lameness: causes and management**

JJ Vermunt, J Malmo, TJ Parkinson

---

**Chapter 19: Diseases of cattle in tropical regions of Australia**

WP Tranter, J Malmo, JJ Vermunt, TJ Parkinson

---

**Chapter 20: Exotic diseases**

MJ Nunn, JJ Vermunt, J Malmo, TJ Parkinson

---

**Chapter 21: Genetic diseases of cattle**

RD Jolly, PA Windsor

---

**Chapter 22: Raising young stock well**

JJ Vermunt, J Malmo, TJ Parkinson

---

**Chapter 23: Causes of sudden death**

JJ Vermunt, J Malmo, TJ Parkinson

---

**Chapter 24: Miscellaneous disorders**

JJ Vermunt, J Malmo, TJ Parkinson

---

**Chapter 25: Practical therapeutics for the cattle veterinarian**

J Malmo, JJ Vermunt, TJ Parkinson

---

# CONTENTS

Foreword	iii
Contributors	iv
Chapters	v
Contents	vii
Preface	xii
Acknowledgements	xiii
About the principal authors	xiv
Contributors of illustrations	xv
List of acronyms and abbreviations	xvi

## Chapter 1: Dairy and beef production systems in Australia and New Zealand

Dairy production systems in Australia and New Zealand	1
Dairying in Australia and New Zealand	1
Dairy systems	5
Future dairying	12
Beef production systems in Australia	14
Overview of Australian Systems	15
Northern Australia	16
Southern Australia	17
General	21
Beef production systems in New Zealand	23
Overview of New Zealand beef production systems	23
Beef production in New Zealand	24
Farm production levels	25
Issues facing the beef industry	28

## Chapter 2: Clinical examination

Diagnosis	33
Making a diagnosis	33
Veterinary information management	36
Clinical examination of the individual animal	37
Presentation	37
Complete examination	37
Close physical examination of the standing cow	40
Diagnostic ultrasound in cattle	51
Investigating herd disease outbreaks and productivity problems	54
The aims and objectives of disease investigations	54
Approach to the problem	54
Principles of investigating a herd problem	55
When, where and why is the disease occurring?	57
Analysing the data and arriving at a diagnosis	58
Reporting the findings	59
Summary	59
Laboratory tests used in cattle practice	60
Biochemistry	60
Clinical haematology in cattle	62
Acid-base balance	68
Electrolyte imbalances	69
Zoonoses and cattle	70
Introduction	70
Specific conditions	70

## Chapter 3: Diseases of the gastrointestinal tract

Examination of the gastrointestinal tract	75
Percussion, auscultation and ballottement	75
Collection and assessment of rumen contents	76
Disorders of the forestomachs	80
Rumen acidosis	80
Rumen tympany (bloat)	85
Indigestion	89
Traumatic reticuloperitonitis	90
Vagus indigestion	92
Other disorders of the forestomachs	94
Diseases of the abomasum	96
Displaced abomasum	96
Ulceration of the abomasum	106
Other disorders of the abomasum	108
Disorders of the intestines not associated with enteritis	109
Abdominal pain in cattle	109
Disorders of the intestines	111
Neoplasia	122
Other rare abdominal disorders	122
Miscellaneous abdominal disorders	123
Conditions involving other abdominal organs	123
Other conditions resulting in abdominal distension	125

## Chapter 4: Diseases causing diarrhoea

Aetiological agents	127
Bacterial causes	129
Salmonellosis	129
Yersiniosis	135
<i>Clostridium perfringens</i>	136
John's disease (paratuberculosis)	136
Viral causes	143
Bovine viral diarrhoea	143
Malignant catarrhal fever	151
Enteric leukosis	154
Winter dysentery	154
Rinderpest	154
Nematodes and cestodes	155
Parasitic gastroenteritis	155
Other nematodes and cestodes	172
Protozoan parasites	175
Coccidiosis	175
Conditions of organs other than the gastrointestinal system that may present with diarrhoea	178

## Chapter 5: Respiratory conditions

Pathophysiology of the respiratory tract	182
The respiratory tract	182
Pneumonia	182
Dyspnoea	183
Bovine respiratory disease in Australia and New Zealand	184
Special examination of the respiratory tract	184

Respiratory diseases of calves and young stock	186
Enzootic calf pneumonia	186
Oral and laryngeal necrobacillosis	188
The <i>Histophilus somni</i> disease complex	189
Lungworm infection	191
Respiratory diseases primarily affecting growing and adult cattle	194
Respiratory disease in feedlot cattle: bovine respiratory disease complex	194
Bovine pneumonic pasteurellosis ('shipping fever')	197
Other conditions	199
Other conditions of the lungs	207
Interstitial pneumonias	207
Tuberculosis	209
Miscellaneous conditions of the respiratory tract	211
Disorders of the upper airway	211
Other rare respiratory disorders	213
Systemic conditions that present with respiratory signs	214
Anaphylaxis	214
Congestive heart failure	215

## Chapter 6: Disorders of the cardiovascular system

Clinical examination of the cardiovascular system	216
Examination of the heart	216
Examination of the peripheral circulatory system	218
Assessment of the lymphatic system	220
The spleen	221
Diseases of the heart and pericardium	221
Pericardium	221
Heart	224
Diseases of the blood and blood-forming organs	231
Leukosis	231
Other retrovirus infections	235
Anaemia	236
Oedema	241
Conditions causing localised or generalised oedema	242
Miscellaneous conditions	245
Haemangioma/haemangiosarcoma	245
Venous thrombosis	246
Dihydroxycoumarin (dicoumarol) toxicity	247

## Chapter 7: Diseases of the hepatobiliary system

Pathophysiology	248
Liver form and function	248
Failure of liver function	249
Disease processes of the liver	251
Post-mortem evidence of grossly impaired liver circulation	252
Biochemical assessment of liver function and damage	252
Liver biopsy	254
Inflammation of the liver and biliary tract (hepatitis)	254
Bacterial liver disease	255
Viral liver disease	256
Parasitic liver disease	256
Hepatotoxicities	261
Acute hepatotoxicities	261

Chronic hepatotoxicities	262
Chronic, non-fatal hepatotoxicities	263
Chronic, fatal hepatotoxicities	264
Facial eczema	267
Neoplastic liver disease	272
Other conditions affecting the liver	272

## Chapter 8: Diseases of the urinary tract

Pathophysiology of the urinary system	273
Functions of the urinary tract	273
Infections of the kidney	274
Character and distribution of nephritic lesions	274
Principles of treating urinary tract disease	275
Assessment of the urinary system	275
Rectal palpation of parts of the urinary tract	275
Collection and examination of urine	275
Serum biochemistry	277
Other tests of renal function	278
Diseases of the kidney	278
Diseases presenting with haematuria	281
Diseases presenting with haemoglobinuria	283
Leptospirosis	283
Other causes of haemoglobinuria	289
Conditions of the bladder	291
Cystitis	291
Prolapse and eversion of the bladder	291
Other bladder conditions	292
Urolithiasis	292
Toxicities affecting the urinary system	296
Oak or acorn poisoning	296
Oxalates	297
Mercury	297
Superphosphate poisoning	297

## Chapter 9: Neurological disease

Causes of neurological disease	298
Special examination of the nervous system	299
Head	300
Cerebral disease	300
Cerebellar disease	300
Brain stem and cranial nerves	300
Gait and posture	302
Spinal cord and spinal reflexes	303
Peripheral nerve dysfunction	305
Additional tests	305
Neurological diseases of neonatal calves	306
Congenital neurological disease	306
Viral causes	307
Bacterial causes	308
Other causes	312
Neurological diseases of weaned calves and older cattle	312
Infectious causes	312
Disorders due to deficiencies	325
Disorders due to toxicities	328
Other disorders causing neurological signs	339

## Chapter 10: Mastitis

Pathogenesis	340
Epidemiology	341
Incidence of clinical mastitis	341
Prevalence of subclinical mastitis	341
Exposure to mastitis pathogens	342



Defence mechanisms of the mammary gland	343
Risk factors for mastitis	346
Economics of mastitis and mastitis control	349
Direct costs	349
Indirect costs	349
Production losses from mastitis	350
Detection and diagnosis of mastitis	351
Monitoring mastitis at the herd level	351
Detection of mastitis at the individual cow level	353
Investigating a mastitis problem in a dairy herd	361
Mastitis control programmes	366
Minimising the number of new infections that occur	366
Minimising the duration of mastitis infections	373
Treatment of infected quarters	375
Pharmacological considerations	375
Antibiotics used for the treatment of mastitis	376
Specific mastitis treatments	379
The major mastitides	384
Staphylococcal mastitis	384
Streptococcal mastitis	388
Coliform mastitis	394
Less common causes of mastitis	397
Uncommon causes of mastitis	399
Heifer mastitis	399
Udder oedema	401
Teat lesions	401
Milking machine-induced teat lesions	401
Infectious causes of teat damage	403
Environmental injury	406
Dermatitis of the udder and teats	407

## Chapter 11: Reproduction and disorders of the reproductive system

Management of reproduction	414
Reproductive outcomes	414
Reproductive technologies	422
Assessing herd reproductive performance	423
Pharmacological tools for managing reproduction	424
Disorders of reproduction in the female	433
Non-observed oestrus	433
Cystic ovarian disease	438
Uterine infections	440
Metritis complex	440
'At-risk' and repeat breeder cows	451
Irregular intervals to returns to service	453
Venereal diseases	453
Venereal diseases of major importance	454
Minor venereal pathogens	459
Embryonic and fetal loss	461
Occurrence	461
Approach to investigation of abortions in cattle herds	461
Bacterial infections causing abortion	464
Abortion due to mycoplasmas and related organisms	468
Viral causes of abortion	468
Protozoal causes of abortion	471
Fungal causes of abortion	474
General infectious causes	475
Non-infectious causes of embryonic loss/fetal abortion	476
Fetal mummification and maceration	479

Other congenital and acquired abnormalities affecting reproduction	480
Congenital abnormalities	480
Acquired lesions	483
Male fertility	484
Management of bulls	484
Reproductive abnormalities of bulls	488
Conditions of the penis	488
Lesions of the prepuce preventing extension of the penis	494
Penile neoplasia	495
Failure of ejaculation	495
Disorders associated with fertilisation failure	496

## Chapter 12: Metabolic disorders

The transition cow	503
Disorders of energy metabolism	506
Energy metabolism in the pregnant and lactating cow	506
Energy deficiency syndromes	510
Disorders of calcium, magnesium and phosphorus metabolism	520
Hypocalcaemia	520
Disorders of magnesium metabolism	532
Disorders of phosphorus metabolism: hypophosphataemia	538
Recumbency and the downer cow syndrome	541
Metabolic imbalances	548
Electrolyte imbalances	548

## Chapter 13: Trace elements and vitamin nutrition

Minerals in nutrition	551
Classification of minerals	551
Trace minerals	551
Specific trace elements	552
Copper	552
Selenium	559
Cobalt	564
Iodine	568
Zinc	570
Manganese	572
Chromium	573
Vitamin requirements of Australasian dairy cattle	573
Fat-soluble vitamins	573
B complex vitamins	573

## Chapter 14: Disorders of the skin

Common skin lesions of cattle	577
Clinical examination of the integument	577
Diseases due to infectious agents	578
Dermatophilosis	578
Other bacterial skin diseases	580
Fungal skin diseases	581
Major viral causes of skin diseases	582
Other viral skin diseases	584
Neoplastic skin disease	585
Skin disorders due to deficiencies and toxicities	586
Photosensitisation	588
Other physical skin disorders	590
Allergic skin conditions	591
Congenital skin disorders	592
Parasitic skin conditions	592

## Chapter 15: Ectoparasites

Mites	593
Non-burrowing mites	593
Burrowing mites	594
Follicular mites	595
Other mites	595
Lice	596
Flies	598
Stable flies	599
The Australian bush fly	600
Blowflies	600
Midges	601
Warble flies	601
Tropical ectoparasites	602
Flies	602
Screw-worm flies	603
Ticks	604

## Chapter 16: Disorders of the head

Diseases and disorders of the alimentary system	608
The palate	608
The incisors	609
The molars	609
Fluorosis	609
Disorders of the jaw and surrounding tissues	610
Oral trauma, infections and foreign bodies	612
Choke	615
Oral vesicles and erosions	615
Diseases and disorders of the respiratory tract	615
Nasal foreign bodies	616
Abscesses and infections	616
Miscellaneous conditions	616
Conditions of the eye	616
Infectious conditions	616
Squamous cell carcinoma (cancer eye)	620
Other lesions of the eyes	624
Conditions of the ear	625
Otitis externa	625
Otitis media	625
Miscellaneous conditions	626
Neoplasia	626
Facial paralysis	626
In-grown horn	626

## Chapter 17: Calves: management and diseases

Calf management	627
Feeding	627
Housing	633
Acquisition of calves for calf-rearing units	634
Bobby calves	635
Clinical examination of the calf	636
Diseases of the gastrointestinal system associated with abdominal distension	637
Left-sided abdominal distension	637
Right-sided abdominal distension	638
Bilateral abdominal distension	639
Undifferentiated neonatal diarrhoea	640
Aetiology and pathogenesis	640
Consequences of diarrhoea	643
History, presenting signs, clinical signs and diagnosis	644
Diagnosis	647
Prognosis and treatment	647

Prevention and control	652
Other diseases caused by bacteria	654
Navel infections	654
<i>Mycoplasma mycoides</i> subsp. <i>mycoides</i> (Large Colony) infection	657
<i>Fusobacterium necrophorum</i> infection	657
Umbilical hernia	658
Other diseases of calves	659
Respiratory diseases	659
Neurological diseases	659
Genetic disorders	659

## Chapter 18: Lameness: causes and management

Incidence and economics	660
The incidence of lameness	660
The types of lameness	661
The cost of lameness	661
The animal welfare implications of lameness	663
The causes of lameness	663
The multifactorial concept	663
Cow comfort	664
Nutritional factors and lameness	665
Genetics and lameness	668
Environmental influences on lameness (rainfall and heat stress)	668
Other factors and lameness	668
Examination of the lame cow	669
Restraint and handling facilities	669
Examination of the individual lame cow	671
Anaesthesia of the bovine digit	672
Examination of herd lameness	674
Climate	675
Locomotion scoring	675
Lower limb lameness	675
Conditions of the digital skin and subcutis (dermis)	675
Conditions of the horn and sensitive laminae	681
Conditions of the deep structures of the digit	692
Treatment of lower limb lameness	694
Upper limb lameness	701
Conditions affecting the pelvis and hip	701
Conditions affecting other parts of the limb	703
Wounds	708
Conditions affecting the axial skeleton	709
Peripheral nerve injuries	709
Control and prevention of lameness	713
Farm tracks	714
Effects of management on cow behaviour and lameness	715
Nutritional effects	716
Genetic effects	717
Additional measures to reduce the impact of lameness	717
Transport of lame cows for slaughter	717

## Chapter 19: Diseases of cattle in tropical regions of Australia

Infectious diseases	721
Blood parasites	721
Viral diseases	725
Nematode infestations	729
Arthropod infestations	730
Other diseases	730

Black soil blindness	730
Heat stress	731

Clostridial diseases	787
Other bacterial causes	797
Infectious diseases not primarily characterised by sudden death	801
Toxicities	801
Mineral poisons	801
Plant poisons	803
Acute bovine pulmonary oedema and emphysema	812
Nutritional accidents	813
Death due to misadventure	815

## Chapter 20: Exotic diseases

Major viral and prion diseases	736
Bluetongue	736
Bovine spongiform encephalopathy	737
Foot-and-mouth disease	739
Other viral diseases	741
Aujeszky's disease	741
Borna disease	742
Lumpy skin disease	742
Rabies	743
Rift Valley fever	745
Rinderpest	746
Vesicular stomatitis	747
Bacterial and mycoplasmal diseases	749
Bovine brucellosis	749
Contagious bovine pleuropneumonia	750
Haemorrhagic septicaemia	751
Lyme disease	752
Rickettsial, ehrlichial and protozoal diseases	753
Bovine theileriosis	753
Heartwater	754
Surra	755
Parasitic diseases	755
Stephanofilarosis and parafilarosis	757
Action to be taken if an exotic disease is suspected	757

## Chapter 24: Miscellaneous disorders

Diseases of uncertain aetiology	819
Diseases characterised by systemic involvement	819
Diseases characterised by alimentary tract involvement	822
Diseases characterised by respiratory tract involvement	823
Diseases characterised by involvement of the musculoskeletal system	823
Diseases due to toxicities	826
Nutrition-related poisonings	829
Plant poisonings	829
Feedstuffs	832
Other conditions	833
Sporadic bovine encephalomyelitis	833
Sarcocystosis	833
Diabetes mellitus	834

## Chapter 21: Genetic diseases of cattle

General aspects concerning genetic disorders of cattle	759
Occurrence and epidemiology	759
Modes of inheritance	759
Diagnosis of genetic disorders	760
Prevalence of genetic disorders	761
Control of genetic disorders	761
Animal welfare considerations	762
Emotive and ethical issues	762
Examples of genetic disorders of cattle with Mendelian inheritance	762
Disorders presenting with neurological signs	762
Diseases presenting with primary signs of muscle dysfunction	765
Diseases affecting functions of blood	766
Diseases of bone and joints	767
Diseases of skin	772
Miscellaneous disorders	775

## Chapter 25: Practical therapeutics for the cattle veterinarian

Properties of drugs	835
Drug absorption	835
Drug distribution	836
Drug metabolism (biotransformation)	836
Drug elimination	836
Pharmacokinetics	836
Pharmacodynamics	837
Antibiotics	837
Penicillins and related $\beta$ -lactam antibiotics	838
Cephalosporins	839
Sulphonamides and potentiated sulphonamides	840
Tetracyclines	840
Aminoglycosides	841
Macrolides	841
Fluoroquinolones	842
Other antibiotics and antibacterials	842
Non-steroidal anti-inflammatory drugs	842
Specific drugs	843
Sedatives, tranquilisers, neuroleptics and anaesthetics	843
Supportive fluid therapy	846
Fluids and electrolytes	846
Blood transfusion	847

## Chapter 22: Raising youngstock well

Heifer rearing	778
Growth rates	778
Heifer liveweight and reproductive performance	781
Heifer liveweight and subsequent milk production	782
Investigating ill-thrift in weaner cattle	782
Weaner performance	783

## Chapter 23: Causes of sudden death

Introduction	787
Infectious causes	787

Index	849
-------	-----

# PREFACE

Over the years, several major books on large animal medicine in general, and cattle in particular, have become established as comprehensive and definitive reference works. However, during the many years that the authors have worked with cattle in Australia and New Zealand, we have not been able to access a textbook on the diseases of cattle which had been specifically written for the subject in this part of the world. We have considered this to be a major deficiency and that a specific need exists for establishing such a book. Writing this particular textbook seemed a logical and fitting response to this deficiency.

This book has had a long gestation. It was conceived somewhere between 2000 and 2001, during late-night conversations at conferences of the Society of Dairy Cattle Veterinarians of the New Zealand Veterinary Association, between members of that society and the principal authors. In hindsight, as for many conceptions, what seemed a great idea on a dark night seemed less rosy when the hard graft of writing began. But, nonetheless, by somewhere around 2004, it was clear that pregnancy had become established, and scoping and drafting of the text began.

The book has been written to serve as a reference book for the subject of diseases of cattle in Australasia, and with the intention to provide an immediate source of reference and information to veterinary students and veterinary graduates working in clinical practice, in particular. It is also intended that the book should be useful to the progressive farmer, professional agricultural advisors, and those in other scientific disciplines who require access to both general and detailed knowledge on diseases of cattle in Australasia.

None of us had written a textbook of this size from 'the ground up', although all of us have written, revised, contributed to and edited other works. But we knew, from hard-won experience, the difficulty of getting manuscripts from far-flung scribes with no obligation other than a cheerfully and hastily given promise to write a chapter for a particular volume. In the present case, we have been blessed with colleagues who have been willing to make an extraordinary effort to bring their labours to fruition at the agreed time. For this we are grateful, as we are to the many colleagues who have commented on, and constructively criticised, our developing manuscript.

There has been a determined effort to prevent this book growing into an unwieldy text. In making this attempt, it has been the intention to concentrate on those aspects that will be of most assistance to the veterinary student and the veterinarian in the field. Hence, whilst not being fully referenced, the chapters include recommendations as to further reading that should assist those who wish to obtain more detailed information on that particular topic. Key references to new, controversial or pivotal discoveries have, however, been included. On the other hand, we have wanted to illustrate as many of the conditions described in the text as fully as possible. Many colleagues have contributed illustrations to the book; Keith Thompson has been especially generous in allowing us to trawl through more than 30 years of accumulated pathology slides: a unique collection that we are privileged to have had the opportunity to access.

While each of us has been responsible for the initial draft of portions of the text, the final version represents the consensus (sometimes hard-won) of our views. We like to think that there has been advantage in our having gained extensive experience in clinical cattle practice, as well as at a variety of veterinary schools. We are also grateful for other specialists who, from practice or academia, have generously contributed to this work.

In preparing this book, care has been taken to ensure accuracy of reference ranges, dose rates, normal values, etc. It is possible, however, that some errors or inconsistencies may appear. Therefore, clinicians are urged to read the manufacturer's recommendations carefully when administering medications. Similarly, reference ranges specific to the laboratory used should be consulted when interpreting laboratory results. In some situations, it may be necessary for the clinician to use his/her own clinical judgement. Likewise, we have tried to ensure that all material, illustrations or data, has been properly attributed. If there are any that we have not fully acknowledged, we apologise.

November 2009

Tim Parkinson  
Jos Vermunt  
Jakob Malmo

# ACKNOWLEDGEMENTS

This project was conceived in discussions between the principal authors and the Society of Dairy Cattle Veterinarians (DCV) of the New Zealand Veterinary Association (NZVA), in 2000 and 2001. Initially, Warren Webber and Peter Jolly from VetLearn® (the NZVA Foundation for Continuing Education) helped turn the project from an idea into reality, while Peter Jolly continued to manage the publication as a continual advocate and facilitator despite his many commitments.

Ansley TeHiwi and the staff of VetLearn have undertaken a great deal of detailed work in the production of the book, which we gratefully acknowledge. Likewise, the input of Gina deNicolo has been invaluable as an editorial assistant, especially for the coordination of contributions from authors and all the myriad 'chasings-up' that a book of this nature requires. The graphic art and original artwork was created by Peter Parkinson, who also completed the initial graphic design and layout. Final editing and prepress was completed by Carolyn Lagahetau, Cheryl Rowe and Murray Lock, and the indexing completed by Robin Briggs. William Hickson, Aaron Fulton and Sam Spencer from VetLearn created the extended image library on CD-Rom.

The contribution of Richard Laven in his critical comments upon early drafts of several of the chapters is also gratefully acknowledged. Thanks also to Peter deGaris for his comments on the chapter on metabolic disorders. We are particularly grateful to Keith Thompson and Rob Fairley for giving us unlimited access to their collection of pathology images which have been used extensively throughout the text.

Financial support has been provided by VetLearn, the DCV and the NZVA Society of Sheep and Beef Cattle Veterinarians. Generous sponsorship and support has been granted by Intervet Schering-Plough Animal Health in both Australia and New Zealand, and Merial Ancare in New Zealand, facilitating access and affordability of this text by veterinary students and practitioners. Particular thanks go to Mike Stephens and Craig Stevenson from Intervet Schering-Plough Animal Health, and Justin Hurst from Merial Ancare.

For each of us, the most rewarding function of the acknowledgements is the opportunity it affords us of thanking those who have deeply assisted us in our work. Our wives have been especially generous in their encouragement over the past years, and their support of absentee husbands who have spent myriad evenings crouched over a glowing computer screen. To Jennie, Ans and Jay we are undyingly grateful, for your encouragement and sustained patience in this endeavour, especially when we were despairing. During the many years of writing, you have continuously reminded us that, after all, there is life beyond this book.

Tim Parkinson  
Jos Vermunt  
Jakob Malmo

# About the principal authors

---

## **Tim Parkinson**

Devonshire, in the 1960s, was still a deeply rural part of Britain that was dominated by the farming of dairy cattle, beef cattle and sheep. Growing up in rural Devon and rural Sussex meant that cattle and sheep were an inevitable, formative, part of one's life. Studying veterinary science at Bristol University progressively confirmed that my core interests were in these species, and working in practice in Dorset confirmed that livestock farming was my absorbing passion (and that dogs and cats were not!). Time spent working in the cattle AI industry, in Nottingham University's agriculture faculty and, later, in a lectureship in Veterinary Reproduction and Obstetrics at Bristol University, developed my interests in these areas: interests that I was later able to bring to a new focus in leading the Dairy Systems academic group in New Zealand at Massey University. In the decade or so that I have spent in New Zealand, two things have emerged as being of paramount importance to me: namely, the breeding health and welfare of cattle, and the well-being of the rural veterinary industries of that country and its western neighbour. It is my hope that this text will be of benefit to both.

---

## **Jos Vermunt**

My initial interest in cattle was stimulated as a boy by the many summer holidays that I spent with my grandfather and uncle on their dairy farm in the Netherlands. It was further nursed by the excellent teaching of the various aspects of cattle medicine at the Faculty of Veterinary Medicine in Utrecht, and during the annual foot-and-mouth disease vaccination campaign that was in place at that time in the Netherlands, and in which I was intimately involved as a veterinary student. It provided me not only with a great source of student income support but also ample opportunity to see cattle practice when accompanying practicing veterinarians on their evening and night calls. Their continual interest and devotion to cattle medicine served as an example to me, and I have learnt a great deal from them indeed. My interest in cattle medicine and management continued to grow while I was working in clinical practice in the Netherlands, the Middle East and ultimately New Zealand. After working for more than 25 years in cattle practice in Australasia, interspersed with short stints in academia in Canada and New Zealand, the physical demands of this profession forced me to make a career change. I endeavour nevertheless to stay up to date and continue to maintain a keen interest in the animal welfare and health issues associated with both dairy and beef cattle farming in this part of the world. Nowadays, cattle farmers are more informed about the health and care of their animals, and are asking and prepared to pay for quality veterinary services. My contribution to this book will prove worthwhile if it assists in the development of a better understanding and appreciation of the issues involved in providing such quality service by veterinary students and cattle practitioners alike.

---

## **Jakob Malmo**

As the son of a large animal veterinarian I spent a considerable amount of time seeing cattle practice with my father and this inspired me to undertake a career in veterinary science. Upon graduation from the University of Sydney I settled into mixed (primarily cattle) practice in the Macalister Irrigation District of Victoria. In the late 70s I was approached by Prof. Douglas Blood to work with him in the development of the University of Melbourne Rural Veterinary Unit at Maffra. This facility, located in our veterinary practice, was developed with a view to exposing final year veterinary students to various aspects of cattle medicine and production. Since its inception I estimate that we have had over 1500 undergraduates spent time at the unit. While very many members of the veterinary profession have supported me during my career, four stand out as being particular sources of inspiration to me. These were my father, Sigurd, who was very highly regarded throughout Gippsland, Dr. Neville Beasley, a very dedicated and enthusiastic beef cattle veterinarian in my neighbouring practice, Prof. Douglas Blood, a world-renowned veterinarian, and Prof. Ivan Caple, the recently retired Dean of the Faculty of Veterinary Science at the University of Melbourne. To them, and to the many members of the veterinary profession who have supported me during my career, my very sincere thanks. I have been privileged to witness the development of large animal practice, and of the beef and dairy industries in Australia, over the last 45 years. In the words of the late Otto Radostits, I have had the opportunity to work in the golden age of cattle practice. I am very grateful for the opportunities that both the veterinary profession and the cattle industries have given to me. I hope that this text will be of benefit to cattle veterinarians, and the industries that they serve, both in Australia and New Zealand.

# Contributors of illustrations

---

**V Beasley**

University of Illinois at Urbana-Champaign, Urbana, Illinois, USA

---

**RF Bishop**

Pets n Vets Group Limited, Cromwell, New Zealand

---

**H Black**

AsureQuality Limited, Whangarei, New Zealand

---

**SN Bruere**

Chapel Street Veterinary Centre, Masterton, New Zealand

---

**JSE David**

Late of Department of Veterinary Clinical Sciences, University of Bristol, Langford, Bristol, UK

---

**L Denholm**

Department of Primary Industries, Orange, New South Wales, Australia

---

**RA Fairley**

Gribbles Veterinary Pathology, Christchurch, New Zealand

---

**A Familton**

Ancrum Consultancies, Christchurch City, New Zealand

---

**M Fernandes**

Novartis Animal Health, Sao Paulo, Brazil

---

**ML Gilmour**

Southern Rangitikei Veterinary Services, Bulls, New Zealand

---

**DG Harwood**

Veterinary Laboratories Agency, Itchen Abbas, Winchester, UK

---

**CA Hassell**

Taranaki Veterinary Centre, Stratford, New Zealand

---

**ACG Heath**

AgResearch, Wallaceville, New Zealand

---

**FJ Hill**

Gribbles Veterinary Pathology, Palmerston North, New Zealand

---

---

**AC Johnstone**

Institute of Veterinary, Animal & Biomedical Sciences, Massey University, Palmerston North, New Zealand

---

**TF Jubb**

Department of Primary Industries, Epsom Victoria, Australia. MAF Biosecurity, Wellington, New Zealand

---

**IG Mayhew**

Institute of Veterinary, Animal & Biomedical Sciences, Massey University, Palmerston North, New Zealand

---

**K O'Grady**

New Zealand Food Safety Authority - Verification Agency, Christchurch, New Zealand

---

**DA Reid**

BouMatic, Madison, Wisconsin, USA

---

**Schering-Plough Animal Health**

Upper Hutt, New Zealand

---

**MA Stevenson**

Institute of Veterinary, Animal & Biomedical Sciences, Massey University, Palmerston North, New Zealand

---

**PC Stromberg**

Department of Veterinary Biosciences, College of Veterinary Medicine, Ohio State University, Columbus, Ohio, USA

---

**L Turner**

Department of Primary Industries, Brisbane, Queensland, Australia

---

**US Department of Agriculture**

1400 Independence Ave. S.W., Washington DC, USA.

---

**DM West**

Institute of Veterinary, Animal & Biomedical Sciences, Massey University, Palmerston North, New Zealand

---

# List of acronyms and abbreviations

1,25DHD	1,25-dihydroxyvitamin D	BVD	bovine viral diarrhoea
AA	anovulatory anoestrus	BVDV	bovine viral diarrhoea virus
AB	artificial breeding	BVLWt	breeding value for liveweight
ABARE	The Australian Bureau of Agriculture and Resource Economics	BW	Breeding Worth
ABLD	acute bovine liver disease	Ca-EDTA	calcium disodium ethylenediamine tetra-acetate
ABPEE	acute bovine pulmonary oedema and emphysema	CBC	complete blood count
ABV	Australian Breeding Values	CBPP	contagious bovine pleuropneumonia
AcAc	acetoacetate	CCN	cerebrocortical necrosis
ACAN	aggrecan	CCP	corpus cavernosum penis
ACV	Australian Cattle Veterinarians	CCT	comparative cervical test
ADH	anti-diuretic hormone	CFA	colonisation factor antigens
ADHIS	The Australian Dairy Herd Improvement Scheme	CFE	<i>Campylobacter fetus</i> subsp. <i>fetus</i>
AGID	agar-gel immunodiffusion test	CFT	caudal fold test
AHB	New Zealand Animal Health Board	CFT	complement fixation test
AI	artificial insemination	CFU	colony forming units
AIOD	artificial insemination on detection of heat	CFV	<i>Campylobacter fetus</i> subsp. <i>venerealis</i>
AIP	atypical interstitial pneumonia	CHF	congestive heart failure
δ-ALAD	delta-aminolevulinatase	CIDR	controlled internal drug release
ALP	alkaline phosphatase	CJD	Creutzfeldt-Jakob Disease
ARGT	annual ryegrass toxicity/staggers	CK	creatinine kinase
ASS	argininosuccinate synthetase	CL	corpus luteum
AST	aspartate aminotransferase	C <sub>max</sub>	concentration maximum
AV	artificial vagina	CMI	cell-mediated immune response
BAL	British Anti-Lewisite, or bronchoalveolar lavage	CMR	commercial milk replacer
BCG	Bacillus Calmette Guérin	CMT	California Mastitis Test
BCS	body condition score	CN	cranial nerves
BDV	Borna disease virus	CNS	central nervous system
BEF	bovine ephemeral fever	CNS	coagulase-negative <i>Staphylococcus</i> spp.
BEFV	bovine ephemeral fever virus	COD	cystic ovarian disease
BEH	bovine enzootic haematuria	COWP	copper oxide wire products
BHM	bovine herpes mamillitis	COX	cyclo-oxygenase
BIV	bovine immunodeficiency-like virus	CP	crude protein
BLAD	bovine leukocyte adhesion deficiency disease	CR	conception rate
BLUP	Best Linear Unbiased Prediction	CSF	cerebrospinal fluid
BLV	bovine leukaemia virus	CUM	creatinine-corrected urinary Mg concentration
BMD	bovine mucosal disease	CVCT	caudal or posterior vena cava thrombosis
BMSCC	bulk milk (somatic) cell counts	DCAD	dietary cation-anion difference
βOHB	beta-hydroxybutyrate	DCT	dry cow treatment
BoHV	bovine herpesvirus	DD	digital dermatitis
BPS	bovine papular stomatitis	DDBSA	dodecyl benzene sulfonic acid
BPV	bovine papillomavirus	DFA	d-hydrofolic acid
BRD	bovine respiratory disease	DIC	disseminated intravascular coagulopathy
BSV, BRSV	bovine respiratory syncytial virus	DIM	days-in-milk
BSE	bovine spongiform encephalopathy	DJD	degenerative joint disease
BSP	bromsulphalein	DM	dry matter
BTEC	Brucellosis and Tuberculosis Eradication Campaign	DMI	dry matter intake
BTM	bulk tank milk	DMSA	meso-2,3-dimercaptosuccinic acid
BTV	bluetongue virus	DUMP	deficiency of uridine monophosphate synthetase
BV	breeding values		



EB	epidermolysis bullosa	IPB	infectious pustular balanoposthitis
EBL	enzootic bovine leukosis	IPV	infectious pustular vulvovaginitis
eCG	equine chorionic gonadotrophin	ISF	interstitial fluid
ECP	oestradiol cypionate	ITEME	infectious thromboembolic meningoencephalitis
ED1	ectodysplasmin gene	IVF	<i>in vitro</i> fertilisation
Edn	edition	IVM	<i>in vitro</i> maturation
ELISA	enzyme-linked immunosorbent assay	IVRA	intravenous regional anaesthesia
eNDF	effective neutral detergent fibre		
EPAF	enteropathic adhesive factors		
epg	eggs per gram	JHS	jejunal haemorrhage syndrome
ε toxin	epsilon toxin		
ET	embryo transfer	LC	lactating cow intramammary formulation
EV	economic values	LDA	left displaced abomasum
		LDH	lactate dehydrogenase
FARAD	The Food Animal Residue Avoidance Databank	LH	luteinising hormone
FAT	fluorescent antibody test	LIC	NZ Livestock Improvement Corporation
FEC	faecal egg count		
FFA	free fatty acids	LMN	lower motor neuron
FIGLU	forminoglutamic acid	LPA	Livestock Production Assurance
FMD	foot-and-mouth disease	LSD	lumpy skin disease
FPT	failure of passive transfer	LWt	liveweight
FSE	focal symmetrical encephalomalacia	LYST	lysosomal trafficking regulator
FSH	follicle stimulating hormone		
FTAI	fixed-time artificial insemination	MAC	MacConkey agar
		MAM	methylazoxymethanol
g/h	grams per hour	MAT	microscopic agglutination test
GABA	gamma-aminobutyric acid	MCF	malignant catarrhal fever
GDH, GLDH	glutamate dehydrogenase	MCH	mean corpuscular haemoglobin
GGT	gamma glutamyl transferase	MCHC	mean corpuscular haemoglobin concentration
GH	growth hormone	MCV	mean corpuscular volume
GHR	growth hormone receptors	MD	mucosal disease
GMA	glycerol monoacetate	ME	metabolisable energy
GnRH	gonadotrophin releasing hormone	mEq/L	milliequivalents per litre
GPG	GnRH-prostaglandin-GnRH programme	MethB	methaemoglobin
GPX	glutathione peroxidases	MIC	minimum inhibitory concentration
GREP	Global Rinderpest Eradication Programme	MJME	megajoules of metabolisable energy
		ML	macrocytic lactones
Hb	haemoglobin	MLA	Meat and Livestock Australia
HCN	hydrogen cyanide	MLWt	mature liveweight
HE	haematoxylin and eosin	MMA	methylmalonic acid
HGP	hormonal growth promotants	MMACoA	methylmalonyl-CoA
HMD	heat-mount detectors	MMP	metallo-proteinases
HSS	hypertonic saline solution	MRP	maternal recognition of pregnancy
		MRSA	methicillin-resistant <i>Staph. aureus</i>
IAA	indole-acetic acid	MS	milksolids
IBK	infectious bovine keratoconjunctivitis	MSA	mannitol salt agar
IBR	infectious bovine rhinotracheitis	MSD	Mating Start Date (Australia)
ICSCC	individual cow somatic cell counts		
ICT	immunochromatographic test	NAGase	N-acetyl-β-D-glucosaminidase
ID	interdigital dermatitis	NAIT	National Animal Identification and Tracing project
IDC	Investigation and Diagnostic Centre	NDF	neutral detergent fibre
IDH	L-iditol dehydrogenase	NEFA	non-esterified fatty acids
IFAT	indirect fluorescent antibody test	NFC	non-fibre carbohydrates
IFN-γ	interferon-gamma	NID	national identification of cattle
		NIR	near infra-red
Ig	immunoglobulin	NLIS	National Livestock Identification Scheme
IgA	immunoglobulin A		
IgE	immunoglobulin E	NMD	nutritional muscular dystrophy
IGF-1	insulin-like growth factor 1	NPMS	National Pest Management Strategy
IgG	immunoglobulin G	NPN	non-protein nitrogen
IH	intermediate host	NPV	negative predictive value
IHC	immunohistochemical, immunohistochemistry	NRG	non-regenerative
		NRR	non-return rate
IL	ineffective length (of teat-cup liner)	NSAID	non-steroidal anti-inflammatory drug
IMI	intramammary infection	NSC	non-structural carbohydrate
IP	inorganic phosphorus		

NVL	no visible lesion	S/P	sample-to-positive ratio
NZVA	New Zealand Veterinary Association	SAMM	Seasonal Approach to Managing Mastitis
OA	ocular albinism	SARA	subacute rumen acidosis
OAA	oxaloacetic acid	SBE	sporadic bovine encephalomyelitis
OAD	once-a-day (milking)	SC	subcutaneously
OCA	oculocutaneous albinism	SCC	somatic cell count
OCD	osteochondrosis dissecans	SDH	sorbitol dehydrogenase
ODB	oestradiol benzoate	SID	strong ion difference
OIE	World Organisation for Animal Health	SM	staphylococcal medium 110
OR	odds ratio	SMCO	S-methyl L-cysteine sulphoxide
OSCC	ocular squamous cell carcinoma	SOD	super-oxide dismutases
		SPC	standard plate counts
PABA	para-aminobenzoic acid	SR	stocking rate
PAE	post-antibiotic effect	SR	submission rate
PBP	penicillin-binding protein	SWF	screw-worm fly
PCR	polymerase chain reaction		
PCV	packed cell volume	Tb	bovine tuberculosis
PEM	polioencephalomalacia	TBA	tryptose blood agar
PFGE	pulsed-field gel electrophoresis	TCA	tricarboxylic acid
PGF <sub>2α</sub>	prostaglandin F <sub>2α</sub>	TEC	teat-end callosity
PI	persistently infected	TEME	thromboembolic meningoencephalitis
PI3	parainfluenza virus 3	TeNT	tetanus neurotoxin, tetanospasmin
P-insert	progesterone releasing insert	TG	triglyceride
PMN	polymorphonuclear neutrophils	THI	temperature heat index
PPD	purified protein derivative	TMA	trimethylamine
PPH	postparturient haemoglobinuria	T <sub>max</sub>	time at which concentration is reached
PPV	positive predictive value		
PRID	progesterone releasing intra-vaginal device	TME	thrombotic meningoencephalitis
PrP	prion proteins	TMR	total mixed rations
PSC	planned start of calving	TPP	total plasma protein
PSDP	premature spiral deviation of the penis	TSE	transmissible spongiform encephalopathies
PSM	Planned Start of Mating (New Zealand)	UMN	upper motor neuron
PSP	phenosulphophthalein	vCJD	variant Creutzfeldt-Jakob Disease
PTH	parathyroid hormone	Vd	volume of distribution
PUFA	polyunsaturated fatty acids	VFA	volatile fatty acids
		VLDL	very low density lipoprotein
QC	quality control	VNT	virus neutralisation test
		VRE	vancomycin-resistant enterococci
RAFGAR	Reference Advisory Group of Fermentative Acidosis of Ruminants	VS	vesicular stomatitis
		w/v	weight per volume
RAPD	random amplified polymorphic DNA	WBC	white blood cell
RBC	red blood cell	WBCC	white blood cell count
RDA	right displaced abomasum	WD	winter dysentery
RDF	rumen degradable fibre	WMD	white muscle disease
RFID	radio frequency identification		
RFM	retained fetal membranes		
RG	regenerative		
RGS	ryegrass staggers		
RMT	Rapid Mastitis Test		
RVF	Rift Valley fever		