Self-Assessment Colour Review

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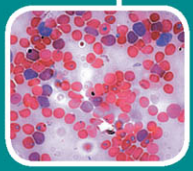
Veterinary Parasitology



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Veterinary Parasitology

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Preface

The rationale behind this first edition of *Self-Assessment Colour Review Veterinary Parasitology* developed out of our experience with case-based teaching and teaching parasitology to undergraduate veterinary students for more than 17 years. It became clear as we strived to develop a course that would encourage understanding and enhance learning that parasitology is best taught in a format that fosters students' interest, reasoning and critical thinking. The continuous development and evolution of the discipline of veterinary parasitology add another challenge as concepts change and new discoveries are recognized.

Parasitic diseases are encountered on a daily basis in veterinary practice and there has been a flood of new information in the literature in recent years. This clinically oriented book brings together a wide variety of cases and clinical situations relating to diseases caused by parasitic agents in domestic livestock, wild animals and exotic animals. Each case scenario includes key questions regarding diagnosis, treatment and control of the infection. For example, what are the pearls in the clinical presentation that suggest a specific parasitic agent? How do you interpret these findings? What is the best therapeutic option? The questions are followed by explanatory answers.

This book is not meant to be a reference book, but rather it is a compilation of useful diagnostic scenarios seen in livestock and companion small animals (primarily) and is representative of common parasitic problems. Many of the described situations are accompanied by detailed and challenging epidemiological input, which will encourage the reader to think about differential diagnoses.

There are interesting and important inclusions for exotic species and for fish. Cases are randomly mixed throughout the book, but a broad classification of cases by body system (e.g. cardiovascular, gastrointestinal, nervous) and an index of host and parasite species are provided to guide the reader to specific areas of interest.

With its unique case-based approach, veterinary practitioners, animal health advisers, industry technical representatives, livestock producers and veterinary students should find this book an indispensable addition to the resources they access to expand their knowledge of parasitic diseases of concern and, in addition, be a resource for continuing professional development.

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Abbreviations

ALP	alkaline phosphatase
ALT	alanine aminotransferase
AST	aspartate aminotransferase
Bands	immature neutrophils
BBB	blood–brain barrier
BRSV	bovine respiratory syncytial virus
BUN	blood urea nitrogen
BVD	bovine viral diarrhoea
BW	body weight
CBC	complete blood count
CK	creatine kinase
CNS	central nervous system
CPK	creatine phosphokinase
CSF	cerebrospinal fluid
CT	computed tomography
CVSM	cervical vertebral stenotic myelopathy
DIC	disseminated intravascular coagulation
DMSO	dimethyl sulphoxide
DNA	deoxyribonucleic acid
DSH	domestic shorthair
EDM	equine degenerative myelopathy
EEE	Eastern equine encephalitis
EGS	equine grass sickness
EL4	early fourth stage larvae
ELISA	enzyme-linked immunosorbent assay
EM	encysted metacercariae
epg	eggs per gram
EPM	equine protozoal myeloencephalitis
GABA	gamma-aminobutyric acid
GGT	gamma glutamyl transferase
GI	gastrointestinal
Hb	haemoglobin
HCl	hydrochloric acid
H&E	haematoxylin and eosin
IBR	infectious bovine rhinotracheitis
IFA	indirect fluorescent antibody
IgG	immunoglobulin G
IGR	insect growth regulator
IH	intermediate hosts
IM	intramuscular
IV	intravenous
L1	first-stage larva
L2	second-stage larva
L3	third-stage larva
L4	fourth-stage larva
MCH	mean corpuscular haemoglobin
MCHC	mean corpuscular haemoglobin concentration
MCV	mean cell volume
MF	microfilariae
ML	macrocyclic lactone
MRI	magnetic resonance imaging
NSAID	nonsteroidal anti-inflammatory drug
PAIR	puncture, aspiration, injection and re-aspiration
PCR	polymerase chain reaction
PCV	packed cell volume/ haematocrit
PI-3	parainfluenza-3 (virus)
PO	per os
PT	post treatment
RA	right atrium
RBCs	red blood cells
RLB	reverse line blot hybridization
RMSF	Rocky Mountain spotted fever
RV	right ventricle
SACs	South American camelids
SC	subcutaneous
Segmenters	mature neutrophils
TCBZ	triclabendazole
WBCs	white blood cells
WNV	West Nile virus

Acknowledgements

This book brings together a diverse group of authors from four continents, including experts in a variety of disciplines from academia, industry, research and private practice settings. We are profoundly grateful to all the authors who contributed their time and effort to this book.

All the cases were reviewed by eminent parasitologists from Europe and North America, and we would like to thank them for their detailed comments and helpful suggestions.

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Classification of cases by organ systems

Note: Some cases appear under more than one system. Numbers in bold denote cases that have zoonotic implications.

Cardiovascular: 14, 23, 89, 112, **126**, **140**, 159, 164, **176**, 191

Gastrointestinal: 1, 2, 3, 4, 6, 9, 18, 25, 26, 29, 32, **33**, **35**, 41, 43, 45, 47, 54, **55**, **57**, 60, 62, 63, 67, 72, 80, 81, 85, 91, 100, **101**, 102, 103, 105, 107, **108**, 118, 120, 121, 143, 144, 145, 147, 148, 151, 152, 153, 156, 158, **167**, **169**, 171, 172, 177, 180, 183, 187, **189**, **190**, 193, 194, 195, **197**, 198, 201, 203, 205, **206**, **207**

Liver and pancreas: 1, 26, 61, 63, 69, 87, **110**, **149**, 162, 165, 175, **178**, **190**, **202**

Nervous: 12, 13, 16, **33**, 34, 46, 51, 76, 78, 82, 83, 90, 106, 115, 116, 123, **146**, **150**

Ocular: 20, 86

Polysystemic: 21, 71, 91, 97, 104, 119, 125, 130, 132, 136, 141, **170**, 173, 192

Respiratory: 2, 10, 15, 22, 27, 36, 37, 65, 66, 77, **124**, 133, 139, 154, 163, 174, 179, 198, 203

Skin, muscles and soft tissue: 3, 5, 7, 8, 11, 17, 19, 24, **28**, **30**, 31, **33**, **38**, **39**, 42, 44, 48, 49, 50, **52**, **53**, 56, 58, 59, 64, 68, 70, 73, **74**, 75, 77, 79, 84, 86, 88, 91, 92, 93, 94, 95, 96, **97**, 98, 99, **106**, 109, 111, 112, 113, 114, 117, 122, **126**, 127, 128, 129, 131, 134, 135, 137, 138, 142, 155, 157, 160, **161**, 166, **168**, 181, **182**, 184, 185, 186, 188, **199**, **196**, **200**, **204**

Urogenital: 40, **146**, **170**

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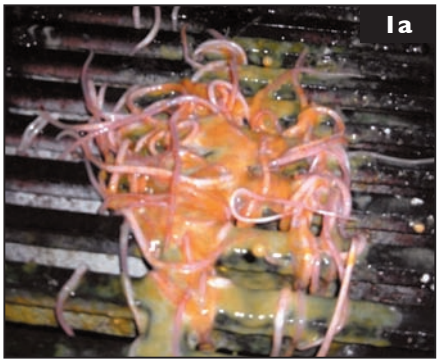
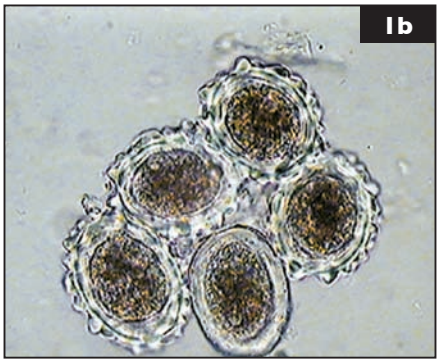
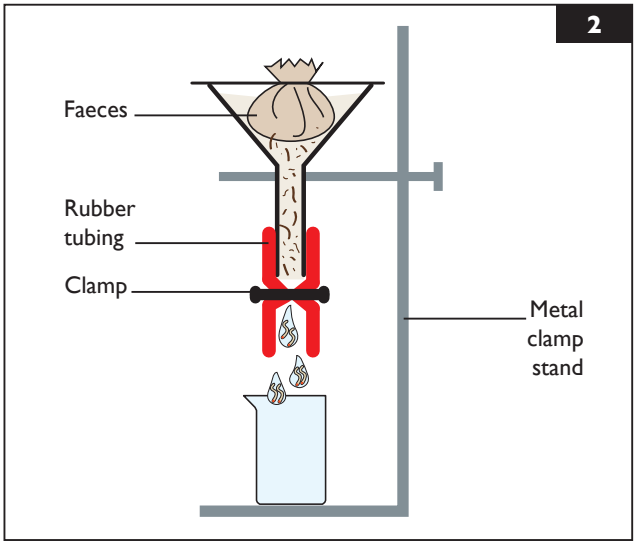




1 The viscera from a group of 100-kg pigs are presented at a slaughter facility with multifocal fibrotic lesions in their livers and noticeable nematodes within the small intestine (**1a**). The pigs had been raised in a semi-outdoor management farm system with groups of 30- to 100-kg pigs kept on the same site. A faecal flotation examination of cohort 90-kg pigs is made (**1b**).
i. What is your parasitic diagnosis, and what is the prepatent period of this parasite?
ii. Explain why this problem is less likely on a conventional indoor pig farm.
iii. What treatments are most suitable for this problem?



2 What is this apparatus (**2**)?

1, 2: Answers

1 i. Intestinal parasitism due to the nematode *Ascaris suum*. Its life cycle includes larval movement through the liver and lungs, then maturity in the intestines, with a 6- to 8-week prepatent period after ingestion of an infective ascarid egg from residual faecal material. Larval movement of *A. suum* is the cause of the 'milk spot' liver lesions.
ii. The incidence of ascariosis declined with the construction of indoor farms in the 1970s, with raised, slatted concrete floors breaking the oral–faecal cycle. The incidence is increasing again and is significantly higher in outdoor and 'organic' farm systems. Infection of farm sites requires only a small number of infected pigs from variable sources to enter the site. The thick-coated *A. suum* eggs (**1b**) are highly stable and infectious in the environment of outdoor systems for several years.
iii. Endemically infected farms should employ on-going medication programmes. Routine benzimidazoles or ivermectins are adequate. Medication is aimed at prevention of mature intestinal infections by medicating finisher pigs at monthly intervals. In outdoor pig systems, careful attention must be paid to stock management, with field rotations, light stocking densities and regular anthelmintic treatment. Clearing sites of ascarid eggs is not practical unless floor surfaces can be flame treated.

2 A Baermann apparatus, used to detect, separate and concentrate larvae from faeces, grass, tissue or soil. The Baermann technique is based on active migration or movement of larvae from the faeces, minced tissue, grass or soil into water of a warmer temperature, which is brought into contact with the bottom of the material to be examined. Faeces are suspended in lukewarm water. The larvae move into the water, sink to the bottom and are collected for identification. Larvae may be observed migrating into the water within 10–15 minutes (usually); however, the largest recovery can be obtained by allowing the material to remain in the funnel for 24 hours. The technique is used mainly for diagnosing lungworm infection and for isolating larvae from a faecal culture. It is relatively insensitive for low larvae intensities, therefore sequential samples taken days apart should be obtained and analysed.

3 A 12-year-old Thoroughbred horse is presented in late autumn as an emergency because of signs of distress. On arrival at the livery yard you note that the horse has a bloody tail head (**3**) from rubbing on the walls of the stable. The whole livery yard has a worming protocol that involves a yearly rotation of dewormers and this year the horses have been dewormed with ivermectin every 8 weeks and were treated for tapeworm infection 2 months ago with an appropriate dose of pyrantel. Physical examination reveals no other obvious abnormalities, although the horse is extremely difficult to evaluate because of its stressed condition.

i. What is your differential diagnosis for this case?

ii. How would you confirm your most likely diagnosis?

iii. Why might this animal have this condition despite regular anthelmintic treatment?

iv. How might you treat this animal?

4 A 12-week-old dwarf lop rabbit is presented with a history of acute lethargy and diarrhoea. A fresh faecal smear reveals large numbers of two different organisms (**4**).

i. Identify the larger organism.

ii. Identify the smaller organisms.

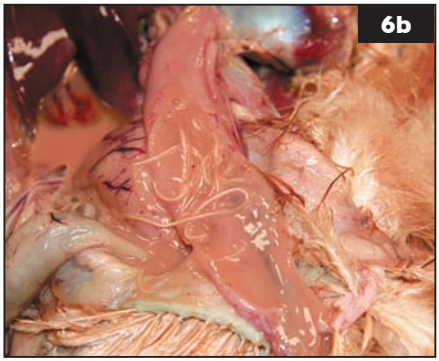
iii. How would you treat this patient?

3, 4: Answers

3 i. The most likely differential diagnosis is *Oxyuris equi* (pinworm) infection. Other possible causes include *Culicoides* hypersensensitivity (although not likely at this time of year, and there likely would be some mane involvement), a foreign body embedded within or beneath the tail head and irritation of the perineum (e.g. secondary to loose faeces).
ii. Adult pinworms are found in the colon. However, adult female worms migrate to the anus to deposit eggs, which are then cemented in the perianal region. Diagnosis is made by microscopic evaluation of sellotape preparations taken from around the anus.
iii. In this horse it seems most likely that either the drug had not been administered or that the horse had received a sub-therapeutic dose. Questioning revealed that the horse was extremely difficult to deworm.
iv. A suitable anthelmintic needs to be administered and assessment of the horse's worm burden performed. Options include a different oral anthelmintic (which the clients were unwilling to administer) or, alternatively, administration of a parenteral avermectin administered off-label with warnings of potential adverse consequences. A worm egg count in this animal revealed that there were <50 epg. However, worm egg counts are very insensitive for *Oxyuris* eggs and are not normally used in this situation because the worms produce eggs in the perianal region. Management of the excoriated, oozing wound should include oral prednisolone and topical broad-spectrum antimicrobial ointment. Antimicrobials may be required if the pruritus does not improve quickly.

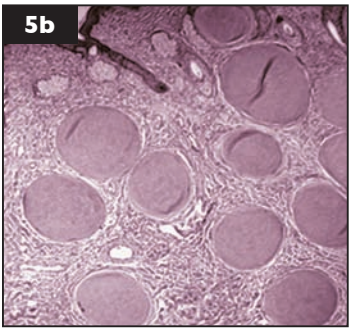
4 i. Coccidia (*Eimeria* species) oocyst; 13 species of intestinal *Eimeria* have been described in the rabbit, the two most pathogenic being *E. magna* and *E. irresidua*. A single species, *E. stiedae*, affects the liver. Oocysts of all species are excreted in the faeces.
ii. *Saccharomyces guttulatus*, a commensal yeast.
iii. Toltrazuril (25 mg/kg PO for 2 days, repeated after 5 days), trimethoprim/sulphadiazine (30 mg/kg PO q12h for 7 days) or trimethoprim/sulphamethoxazole (40 mg/kg PO q12h for 7 days) are all effective against coccidiosis. *Saccharomyces* requires no treatment.

5 What is this instrument (**5a**), and how is it used?



6 These worms (**6a**) were collected from the small intestine of a chicken during post-mortem examination (**6b**).
i. What are these worms? How do chickens become infected?
ii. What is their clinical significance?
iii. What treatment and control options would you recommend?

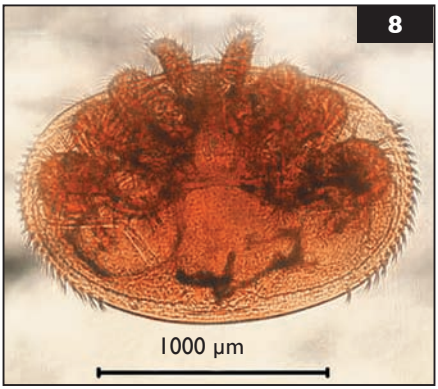
5, 6: Answers



5 A biopsy punch, a surgical instrument used to punch a hole through the uppermost layers of the skin to collect a sample of skin tissue. Skin punch biopsy is a quick, simple and safe procedure and a valuable aid in diagnosing many skin conditions. It offers a suitable histological specimen with a minimum amount of scarring and little or no discomfort to the patient. Some skin biopsies can be done with injection of local anaesthetic (e.g. lidocaine) into the subcutaneous tissue. When using a punch biopsy, rotate in one direction and use the punch only once as the blade is easily dulled and may cause the tissue to tear during the procedure. Use the 6- or 7-mm size punches because they provide a good sample size. There are a number of parasitic skin infections for which punch biopsy and histopathology are important tools for confirming the diagnosis. For example, a punch biopsy taken from a donkey with skin lesions that failed to respond to conventional treatments was processed for histopathology with H&E staining. Microscopical examination revealed parasite cysts of *Besnoitia* species in the skin (**5b**), therefore more specific treatment was decided based on these findings.

6 i. The ascarid nematode *Ascaridia galli*, a common parasite of chickens. Birds become infected via ingestion of ascarid egg-contaminated food or water. Earthworms may act as paratenic hosts.
ii. *A. galli* infection can cause reduced weight gain and feed efficiency, diarrhoea and death, but it is not generally a problem in broiler chickens because of the short grow-out time. These clinical signs are due to toxins produced by the worms, which adversely influence enzyme systems of the intestinal mucosa and interfere with the normal digestion and absorption of nutrients.
iii. Most anthelmintics, including fenbendazole, piperazine, levamisole and ivermectin, are effective. Regular deworming every 2–3 months may be necessary. Control also involves breaking the life cycle by reducing contact with the source of contamination (e.g. faeces) by caging. Good sanitation (e.g. removal of dead birds, removal of contaminated litter) followed by disinfection and restrictions on the movement of equipment and personnel can help reduce infection, especially when parasite numbers become excessive. Birds of different ages should not be raised in close proximity, as older birds can serve as a reservoir for infection of young birds.

7 This organism (7) was isolated from the gills of a catfish.
i. What is it?
ii. Is it male or female?
iii. What is its clinical significance?
iv. How would you treat infested fish?

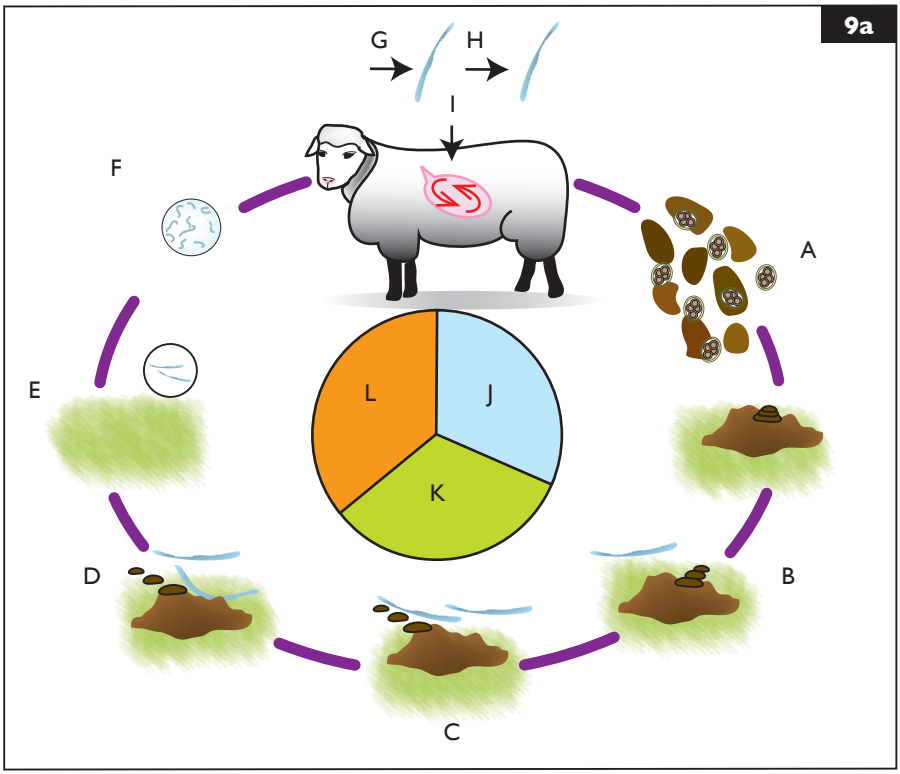


8 This organism (8) was found on a dead European honey bee.
i. What is it?
ii. Is it important?
iii. What is the link between this organism and decreased bee populations?
iv. What recent change has allowed this organism to become more problematic?

7, 8: Answers

7 i. The crustacean copepod parasite *Lamproglena* species. Diagnosis of copepod infestation can be made by gross visualization or wet mount examination.
ii. An adult female. Mature females are differentiated based on the presence of two easily recognized egg sacs.
iii. The impact of *Lamproglena* infestation can range from mild pathological damage to stress-induced mortality of infested fish. Also, during the infestation process the damage and minor wounds caused by attachment and feeding of *Lamproglena* may afford portals of entry to more serious secondary bacterial, viral and fungal infections.
iv. There is no ideal treatment. However, organophosphates can be effective; prolonged immersion treatment should be repeated weekly for 4 weeks. Diflubenzuron is less toxic to fish and is effective. It is not inactivated at high temperatures, as are organophosphates. However, diflubenzuron can be harmful to non-target arthropods. Formalin or potassium permanganate baths are also effective. Formalin is carcinogenic and depletes oxygen, so additional aeration is required. Some fish are very sensitive to this treatment. Drugs should be used as part of an integrated health management strategy to mitigate the losses.

8 i. *Varroa* mite (*V. destructor* or *V. jacobsoni*).
ii. Yes. *Varroa* is a highly damaging ectoparasite of honey bees. The demise of billions of honey bees has been attributed to *Varroa* infestation. The widespread population decline of honey bees on this scale also affects the pollination of economically important crops and exotic plants.
iii. *Varroa* feed on the haemolymph of honey bee pupae and adults, and in so doing they transmit infections that reduce the life expectancy of the bees and cause the colony to decline. For example, *Varroa*-borne viral infections can cause permanent physical impairment (e.g. deformed wing virus) or even death of affected bees.
iv. Recent climate changes might have allowed increased mite persistence during winter and expansion beyond its normal range, thus increasing the risk of transmission over larger geographical regions.

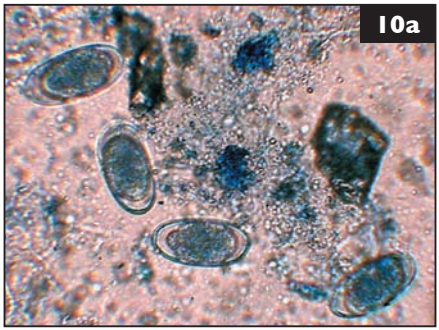


9 i. With which type of parasite is this life cycle (**9a**) associated?
ii. Name and describe each of the lettered stages.
iii. What are the main clinical signs characterizing acute infection by this parasite?

9: Answer

9 i. The sheep abomasal nematodes *Haemonchus contortus* and *Teladorsagia circumcincta*. In this case it is *H. contortus* based on the morphology of the male worm posterior end, which has a characteristic bursa (copulatory organ) with its asymmetrical dorsal lobe and y-shaped dorsal ray (**9b**).
ii. (A) immature eggs passed in dung; (B) first larval stage (L1) in dung; (C) second larval stage (L2) in dung; (D) third larval stage (L3) in dung; (E) L3 (infective stage) on grass; (F) L3 is eaten in water droplet on grass; (G) L3 moults to fourth larval stage (L4) in abomasal glands; (H) L4 moults to fifth larval stage (L5) in abomasal glands; (I) adult nematode reaches maturity in abomasal lumen; (J) contamination phase; (K) free-living phase; (L) parasitic phase.
iii. Anorexia, depression, loss of condition, anaemia and pale mucous membranes due to blood loss. Also, submandibular oedema (bottle jaw) due to the accumulation of fluid caused by hypoproteinaemia.

10 A gamebird farm suffers reduced egg production and increased mortality among the breeding stock. Birds of different species show sneezing, coughing, head shaking and respiratory distress. Some birds open their beaks and stretch their necks, gasping for air ('gaping posture'). Faecal examination reveals a large number of worm eggs (**10a**).


10a

i. What is the name of the parasite that produces these eggs? What anatomical structure(s) is/are primarily affected in birds? Which avian groups are most susceptible to this infection?
ii. What is your differential diagnosis?
iii. What is the suggested treatment?

11 Microscopical examination of a skin scraping from a koi carp during a routine health check reveals this organism (**11**).
i. What is this organism?
ii. Is it significant?
iii. Describe its life cycle.
iv. What treatment would you advise?

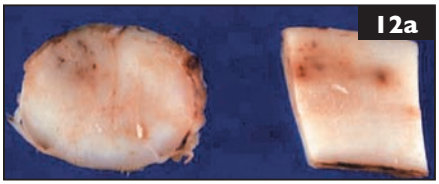

11

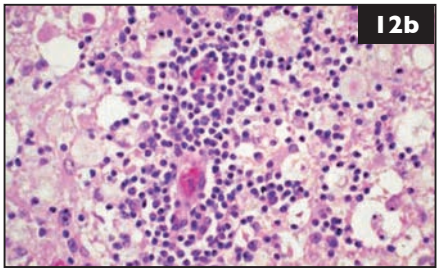
10, 11: Answers

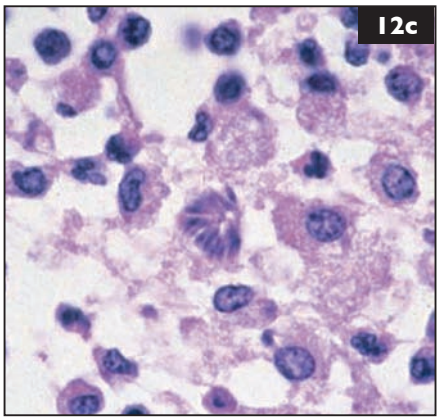

10b

10 i. *Syngamus trachea* (**10b**), a 'gapeworm' commonly found in the trachea of gamebirds and pheasants, although it can infect any species of cage and aviary bird. The infection rate in some groups of wild birds is high and young birds are most commonly affected. Fertilized eggs are swallowed by the bird and spread with the faeces or directly expelled onto the ground from the trachea. Earthworms can act as a transport host.
ii. Even though the gaping posture is pathognomonic, the differential diagnosis should take into account other conditions that cause respiratory distress (e.g. aspergillosis, mycoplasmosis, tracheal mite infection).
iii. It is difficult to control tracheal worm infection in birds kept on the ground in open-air enclosures/aviaries. Therefore, parasitological examination of the faeces should be performed regularly throughout the year. Benzimidazoles are the first-choice drugs and these are usually administered in the feed. (Refer to an avian/exotic animal formulary for dosage and duration of treatment.)

11 i. *Gyrodactylus* species, a monogenean parasite (skin fluke) of aquatic animals.
ii. *Gyrodactylus* flukes feed on the skin and mucus, causing irritation. Stress and injury, as a result of fish attempting to dislodge parasites by rubbing their bodies against substrate and furnishings, predispose to secondary bacterial and fungal infection.
iii. *Gyrodactylus* is viviparous/larviparous and has a direct life cycle with the potential to reach high numbers rapidly under favourable conditions.
iv. Over-the-counter remedies containing formalin and methylene blue may be successful. Other treatments include sodium chloride (1–5 g/l permanent bath, or 30–35 g/l 4–5 minute bath); mebendazole (1 mg/kg as a 24-hour bath); praziquantel (2–10 mg/l bath for up to 4 hours every 5 days for 3 treatments, or 5–12 g/kg feed q24h for 3 days). Deficiencies in water quality, husbandry and stocking density should be rectified.







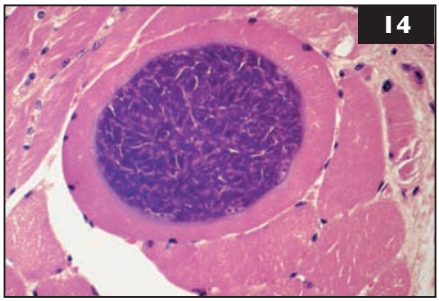
12 A 2.5-year-old Standardbred stallion is euthanized after a 2-month history of progressively worsening ataxia and weakness of all four limbs, with severity one grade worse in the hindlimbs compared with the forelimbs. There is also moderate gluteal muscle atrophy on the right side and the tail is hypotonic. The horse's appetite has decreased steadily over the past 2 weeks. The tentative clinical diagnosis is EPM. Examination of formalin-fixed spinal cord reveals grey-brown discolouration of the ventral grey and white matter in the C2 and L6 spinal cord segments (**12a**). Histopathological sections were obtained (**12b, c**). Describe the nature of the inflammatory reaction in the spinal cord if the diagnosis in this case is indeed EPM.

13 What is 'gid'?

12, 13: Answers

12 Granulomatous inflammation, with a predominance of macrophages and lesser numbers of lymphocytes and plasma cells (**12b**). Eosinophils are occasionally seen in cases of EPM. Protozoal organisms (schizonts) are rarely found in chronic lesions, but may be identified more easily in acute lesions (**12c**).

13 Coenurosis ('gid', 'sturdy') is a disease of the brain and spinal cord caused by invasion and development of *Coenurus cerebralis*, the larval stage of *Taenia multiceps*. The disease occurs in sheep and, rarely, in cattle. *C. cerebralis* causes cortical meningitis and encephalitis. Affected sheep hold their head to one side and in some cases the animal turns in circles. There may be unilateral partial blindness, pain response on pressure over the cystic area, paralysis of limbs and pressure atrophy of the brain and bones of the skull adjacent to the cyst. Dogs and other carnivores act as definitive hosts by harbouring adult tapeworms, thus serving as a continuous source of infection through discharge of eggs in the faeces. Eggs excreted from infected dogs contain hexacanth larvae. Sheep become infected via ingestion of eggs with contaminated food or water. Embryos hatch, burrow through the intestinal wall and travel to the brain and spinal cord via the blood. Once in the brain, a cyst develops within several months and grows to a size that results in the onset of clinical signs. When dogs or other canids ingest infected sheep tissue, the parasite develops into the adult tapeworm and passes mature egg-containing segments in the faeces. Fallen carcasses or slaughterhouse-disposed viscera containing mature *Coenurus* cysts pose a serious threat to dogs or other wild carnivores. Treatment ranges from administering albendazole, niclosamide or praziquantel to surgical removal if the cyst can be located. Controlling coenurosis through vaccination is still at an early stage. The frequency of coenurosis in humans is unknown, but this is a serious zoonosis and can lead to pathological conditions in affected humans.



14 A 4-year-old neutered male DSH cat was found dead. At necropsy, the heart's appearance was consistent with hypertrophic cardiomyopathy (HCM). Histopathological assessment revealed large numbers of cystic structures (**14**) in sections of skeletal muscles (neck, intercostal muscles and diaphragm) and in cardiac muscle.

i. What is the most likely diagnosis?
ii. How would you confirm the diagnosis?
iii. How did the cat get these cysts?
iv. What is the link between cardiomyopathy and these cysts?

15 A 3-year-old female owl is presented with severe dyspnoea and very poor body condition. A swab of the oropharynx reveals large numbers of inflammatory cells, but no aetiological agents. Several nematode eggs, each with a barely visible operculum and 8 blastomeres (**15**), are seen on faecal examination.

i. What is your diagnosis?
ii. How would you treat this owl?

14, 15: Answers

14 i. The cysts have morphological features consistent with sarcocysts of *Sarcocystis* species, most likely *S. felis*. Usually, cats infected with *S. felis* sarcocysts are asymptomatic and a diagnosis is made if the cat has a concomitant infection or condition, as in this case.
ii. A tentative diagnosis is based on clinical history, post-mortem and histopathological examinations and serological tests (e.g. IFA for IgG antibodies against *S. cruzi*, *S. neurona* or *Toxoplasma gondii*). Confirmation is by DNA sequencing and phylogenetic analyses. Electron microscopy will reveal ultrastructural features of the bradyzoites and wall of the sarcocystis cysts.
iii. *Sarcocystis* species have a two-host life cycle. Cats act as the definitive host by harbouring *Sarcocystis* oocysts in their intestines. They can also serve as an IH by developing sarcocysts in their muscles. Sarcocysts have been reported in skeletal and cardiac muscles of cats, where the animals were severely compromised by diseases other than sarcocystosis (e.g. pancytopenia, metastatic neoplasia, generalized lymphosarcoma, HCM). It is difficult to determine whether the cysts in this cat were derived from oocysts/sporocysts through faecal–oral autoinfection or from other carnivores. Immunosuppression has been suggested as a reason for the unusual presence of sarcocysts in cats, as indicated above. This cat was in good condition and showed no evidence of an impaired immune system.
iv. The low prevalence of sarcocysts in cardiac muscles suggests that an association between the parasite cysts and HCM is probably coincidental. HCM is a common cause of sudden death in cats and usually results in hypertrophy and stiffness of cardiac muscles. HCM mostly occurs in middle-aged animals; however, it has been reported in kittens as young as 2 months old. The condition may be due to an autosomal recessive mode of inheritance or other genetic components. The aetiology in this case remains unknown.

15 i. *Syngamus* (*Cyathostoma*) *bronchialis*. *Syngamus trachea* is also a possibility.
ii. With benzimidazoles or levamisole via the water. One week post treatment a faecal check revealed no eggs, but the owl died within 10 days following treatment.