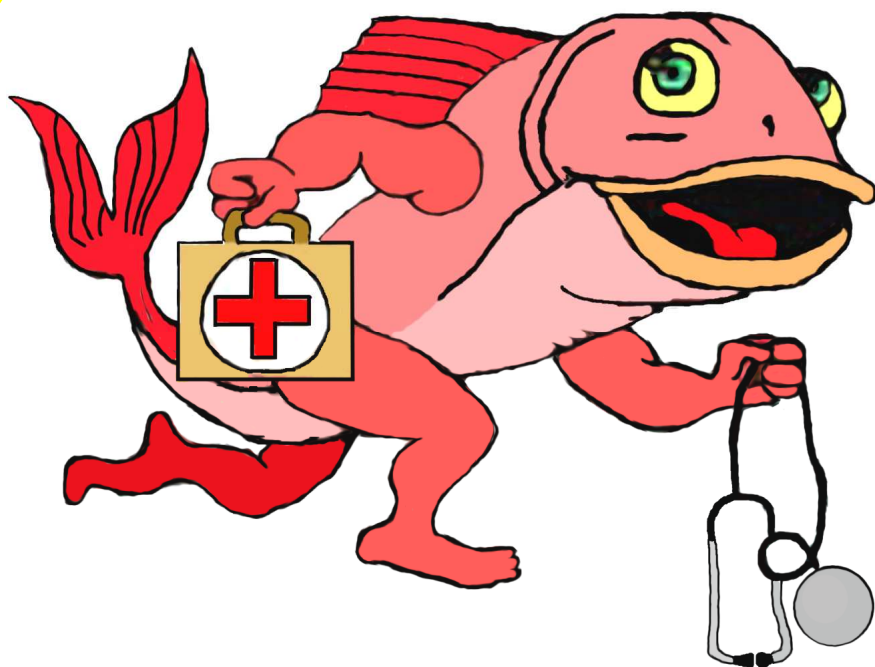


FISH VETTING ESSENTIALS



**Dr Richmond Loh
&
Dr Matt Landos**

© 2011 Richmond Loh Publishing

ISBN

This work is copyright. Apart from any use permitted under the *Copyright Act 1968*, no part may be reproduced by any process, nor may any other exclusive right be exercised, without the permission of the author. Requests and enquiries concerning reproduction and rights should be addressed to Dr Richmond Loh.

Published by:
Richmond Loh Publishing
Perth, Western Australia, Australia.

For orders
Phone: +61 (0)421 822 383
Email: thefishvet@gmail.com
Web: <http://www.thefishvet.com.au>

Preferred way to cite this publication:
Loh, R. and Landos M. (2011) ***Fish Vetting Essentials***. Richmond Loh Publishing, Perth.

Publication designed and typeset by Richmond Loh.
Proofread by John Loh and Agatha Foo.

Front cover: The Fish Vet's logo. Part fish, part vet.



FOREWORD

This is a revised version of the self-published “Australian Fish Vetting Essentials” (2007) by Drs Richmond Loh & Matt Landos. The purpose of this manual is to collate the knowledge that aquarists, aquaculturalists, public aquaria, local fish shops and veterinarians already have, and to filter out misinformation and then provide this information in a readily digestible form. The information contained in this publication has been in the process of compilation since 2001. This manual is not prescriptive, but rather, it is a collection from our combined knowledge to promote to the industry that veterinarians are best equipped to deal with aquatic animal health.

Worthy of note is that many diseases found in aquatics can be classified as emerging diseases since an “emerging disease” is one that has appeared in a population for the first time, or that may have existed previously but is rapidly increasing in incidence of geographic range.

The Authors

The Fish Vet

Dr Richmond Loh
BSc BVMS MPhil MACVSc DipPM CMAVA
+61 (0)421 822 383
thefishvet@gmail.com
<http://www.thefishvet.com.au>

Future Fisheries Veterinary Consulting

Dr Matt Landos
BVSc HonsI, MACVSc
+61 (0)437 492 863
matty.landos@gmail.com

Contributors

Dr Michael Chia
Dr Stephen Pyecroft
Dr Judith Handler
Dr Shane Raidal
Dr Fran Stephens



ABOUT THE AUTHORS

Dr Richmond Loh

Dr Loh has always been interested in animals, nature and medicine, so naturally, he studied to become a veterinarian at Murdoch University. However, his passion for all things fish was strong and so his first job was as a veterinary fish pathologist for the Tasmanian state laboratory, providing diagnostic services for the large aquaculture farms including species such as salmon, trout, ornamental fishes, abalones and oysters. At the same time, he was offering veterinary services to owners of ornamental fishes.

In 2006, he passed the examinations for Aquatic Animal Health for the Australian College of Veterinary Scientists (at this stage the highest level of specialised examinations for fish anywhere in the world). In the same year, he was awarded a Master of Philosophy degree for cancer research in Tasmanian devils. To increase his depth of knowledge in the area of diseases, he studied for and passed the examinations for Pathobiology for the Australian College of Veterinary Scientists in 2009.

So far, he has given numerous talks at seven National Veterinary Conferences and also to the Pet Industry Australia Association delegates and at the New Zealand Companion Animal Conference. He regularly writes for aquarium and pet publications. These are an initiative to generate interest within the respective professions and industry to apply scientific reasoning for the better health and management of fishes. Through his veterinary career, he has appeared on TV (Creature Features, Stateline, Catalyst, ABC news), been interviewed on radio (Curtin FM), appeared in newspapers (The Sunday Times UK, Herald Sun, The Examiner, Sunday Tasmanian, The Cairns Post, Canning Times), magazines (Australian Aquarium Magazine, Aquarium Keeper Australia, TIME Australia Magazine, Your Pet Magazine, Woman's Day, Pets – Taking Care of Your Family's Best Friend, Animals' Voice) and appears on several local and international websites (ABC Online).

He is the consultant veterinarian to AQWA (the Aquarium of WA), is an adjunct lecturer at Murdoch University and provides advice on animal welfare as it pertains to fishes to several universities and the RSPCA. His clients are diverse and range from individual pet fish owners, to retailers, farmers and exporters, locally, interstate and in Singapore.

Dr Matt Landos

Dr Landos is the Founding Director of Future Fisheries Veterinary Service, is an honorary lecturer in aquatic animal health and associate researcher at the University of Sydney, Faculty of Veterinary Science and was the 2011 president of the Aquatic Animal Health Chapter of the Australian College of Veterinary Scientists.

Dr Landos commenced his consultancy practice in aquatic animals in 2005 after a 5 year stint with the NSW DPI as the Veterinary Officer in Aquatic Animal Health. The client base is located throughout Australia, and it ranges from small native fish hatcheries to 3,000 tonne sea cage operations. He works with all aquatic species including molluscs, crustacea and finfish. He reviews emergency disease preparedness plans and develops health management plans for aquaculture industries. He has had a prominent media profile in recent years associated with investigation of the impacts of environmental pollutants on fisheries in relation to the notorious two-headed Australian bass larvae case from the Noosa River.



CONTENTS

FOREWORD.....	3
ABOUT THE AUTHORS.....	4
ANATOMY AND FUNCTION.....	15
Skin & scales	15
Body and fin shapes and gastrointestinal tracts.....	16
Gills.....	18
Kidney.....	18
Eyes.....	19
Lateral line.....	19
Reproduction.....	19
Nervous system.....	20
CATEGORIES OF FISH.....	21
Cyprinids.....	21
Goldfish.....	21
Carp.....	21
Barb.....	21
Danio.....	21
Rasbora.....	21
Miscellaneous.....	22
Characins.....	22
Tetra.....	22
Headstander.....	22
Hatchetfish.....	22
Silver dollar.....	22
Anabantoids.....	22
Gourami.....	23
Fighting fish.....	23
Paradise fish.....	23
Cichlids.....	23
Angel fish.....	23
Discus.....	23
Other cichlids.....	24
Miscellaneous.....	24
Livebearers.....	24
Guppy.....	24
Swordtail.....	24
Platy.....	24
Common disease issues: Flavobacterial infection of the mouth.....	24
Molly.....	24
Catfish.....	25
Corydoras.....	25
Loricariids.....	25
Shark catfish.....	25
Loaches.....	25
Botia.....	25
Loach.....	25



Others	26
Rainbowfish	26
Killifish	26
Eel	26
Goby	26
Archerfish	26
Lungfish	26
Saratoga	26
AQUARIUM SET-UPS.....	27
AQUARIUM EQUIPMENT.....	27
Fish tank/ aquarium	27
Heater.....	27
<i>Table. Calculating heater requirements.....</i>	28
Thermometer.....	28
Lights (incandescent, fluorescent, metal halide, other).....	28
Filter	28
Water pump.....	28
Air pump.....	28
Air stone	29
Plastic tubing, connections, valves.....	29
Cover glass	29
Gravel / shell grit / crushed coral	29
Water conditioner	29
Water test kits (ammonia, nitrite, nitrate, pH, KH, GH).....	29
Protein skimmer (marine set-ups).....	29
UV steriliser.....	30
<i>Table. UV dosages to kill fish pathogens.....</i>	30
Bacteria	30
Ozone injector	30
Carbon dioxide injector.....	31
Reverse osmosis unit	31
Denitrification filter.....	31
FILTRATION	32
AERATION vs CIRCULATION.....	32
POND SET-UP	33
Richmond’s Ultimate Pond Design	33
NITROGEN CYCLE & BIO-FILTERS.....	34
<i>Figure. The Nitrogen cycle.....</i>	34
<i>Effects of various medications on the nitrogen cycle</i>	36
WATER PARAMETERS.....	38
Temperature	38
pH	39
<i>Figure. pH levels and their consequences.[5].....</i>	40
<i>Table. Optimal pH for different species.....</i>	40
Ammonia.....	41
Nitrite.....	43
<i>Nitrite levels & their consequences</i>	43
Nitrate	44
<i>Nitrate limits for:.....</i>	44
Hardness	45
<i>Carbonate Hardness (KH) or Alkalinity.....</i>	45



<i>Table. Alkalinity supplements & their properties</i>	45
<i>General Hardness (GH)</i>	46
<i>Table. Water requirements given in fish keeping texts may use one of three kinds of descriptors for water hardness (General Hardness)</i>	46
<i>Table. Optimum GH requirements for different species.</i>	46
Salinity	47
<i>Table. Classification of water salinity expressed in different ways[5]</i>	47
<i>Table. Elements in sea-water:</i>	48
<i>Seawater – special considerations</i>	48
<i>Seawater – Using natural seawater</i>	48
<i>Seawater – Long-term studies of water chemistry of recirculating aquaria found that:</i>	49
<i>Seawater – Long-term storage guidelines for seawater:</i>	49
Oxygen	50
<i>Table. Approximate solubility of oxygen in water at different temperatures and SGs at 760mmHg</i>	50
<i>Use of Hydrogen Peroxide as an Oxygen Source</i>	51
<i>Oxygen Tablets</i>	51
Carbon Dioxide	52
<i>Table. Deriving CO₂ concentration based on the relationship between KH and pH.</i>	52
A Note on Gas Supersaturation	54
Chlorine/Chloramine	55
<i>Chlorine levels & their consequences</i>	55
Phosphate	56
Heavy Metals	57
<i>Table. Acceptable & toxic levels of heavy metals in water.</i>	57
Pollutants	59
<i>Table. Acceptable & toxic levels of pollutants in water.</i>	59
<i>WATER QUALITY PARAMETERS FOR POPULAR GROUPS OF AQUATIC ANIMALS.</i>	61
Freshwater	61
<i>Tropical community</i>	61
<i>Amazonian (soft, acid)</i>	61
<i>Africans (hard, alkaline)</i>	61
<i>Salmonids (Salmon & Trout) – Freshwater phase[13]</i>	61
<i>Axolotl</i>	62
<i>Koi</i>	62
<i>Murray cod</i>	62
<i>Silver perch</i>	62
<i>Yabby (Cherax destructor)</i>	63
Brackish	63
<i>Scats & Monos</i>	63
<i>Barramundi</i>	63
Marine	64
<i>Abalone[14]</i>	64
<i>Seahorses (Hippocampus abdominalis – Southern Knights/Pot belly)</i>	64
<i>Clownfish</i>	64
<i>Coelenterates (Ctenophora & Cnidaria)[15]</i>	65
<i>WATER SAMPLING AND PROCEDURE</i>	66
<i>Table. Method/containers for water collection for water testing.</i>	66
Parameter	66
<i>Dissolved oxygen (DO)</i>	66



<i>Biological oxygen demand (BOD)</i>	66
<i>pH</i>	66
<i>Salinity</i>	66
<i>Ammonia, nitrite, nitrate</i>	66
<i>Solids</i>	66
<i>Calcium</i>	66
<i>Metals</i>	66
<i>Pesticides, other organo-chemicals</i>	66
<i>H₂S</i>	66
<i>CO₂</i>	66
<i>Alkalinity</i>	66
<i>Faecal coliforms</i>	66
DIET AND NUTRITION	67
Storage	67
<i>Dry food</i>	67
<i>Frozen</i>	67
<i>Ideal thawing conditions</i>	67
Particle size	67
Feeding Quantity & Frequency	67
<i>Special considerations for coldwater fishes:</i>	67
Variety	68
Protein	68
Carbohydrate	68
Fat	68
Ballasts	68
Vitamins	69
Additives	69
<i>Spirulina</i>	69
<i>Carotenoids</i>	69
<i>Glucans</i>	69
<i>Oregano Essential Oil</i>	69
<i>Appetite stimulants</i>	70
Miscellaneous notes	70
<i>Table. Recipe for nutritional supplementation for sharks in public aquaria.</i>	71
FISH DISEASE INVESTIGATION	72
Taking complete history	72
<i>Living environment</i>	72
<i>Temporal epizootiology</i>	72
<i>Water Quality</i>	73
Clinical examination	73
<i>Behavioural abnormalities</i>	73
<i>Physical abnormalities/External gross pathology</i>	73
Parasitology	74
<i>Skin scrape</i>	74
<i>Gill biopsy</i>	74
Bacteriology	76
<i>Common bacteria Genus based on Gram staining properties:</i>	76
<i>Bacterial culture media</i>	76
<i>Diff Quick</i>	77



<i>Gram stain</i>	77
<i>Ziehl Neelsen stain</i>	78
<i>Modified Ziehl Neelsen stain</i>	78
Haematology & Serum Biochemistry	79
Water Chemistry	80
Algology	81
<i>Non-motile unicellular microalgae</i>	81
<i>Motile unicellular microalgae</i>	81
<i>Unbranched septate filaments</i>	82
<i>Simple branched septate filaments</i>	82
<i>Siphonous filaments</i>	82
<i>Filamentous algae</i>	82
<i>Whorls of branches</i>	82
<i>Soft or firm colonies</i>	84
<i>Sheet or blade</i>	84
<i>Cyanobacteria</i>	84
<i>Netted</i>	84
<i>Crust</i>	84
Algal Problems.....	86
Basic ways of ridding the algae.....	86
How Algal Treatments Work.....	87
<i>UV clarifiers</i>	87
<i>Flocculants</i>	87
<i>Ion-exchange Resins</i>	87
<i>Chlorine Solutions</i>	87
<i>Algicides</i>	88
<i>Coloured Pigments</i>	88
<i>Barley Straw</i>	88
<i>Biological Control</i>	88
<i>Competitive inhibition</i>	89
<i>Reduce lighting</i>	89
<i>Water exchange</i>	89
Mycology	90
Internal gross pathology	91
Histology	91
Fixatives	92
<i>10% Neutral Buffered Formalin (fish, freshwater invertebrates)</i>	92
<i>Seawater Formalin (marine shellfish and crustaceans)</i>	92
<i>Davidson's Fixative (marine shellfish and crustaceans)</i>	92
Virology	92
Molecular Biology	92
FISH DISEASES	93
Physical Injury - Fighting, Predation, Rough Handling, Parasites	94
<i>Clinical Signs</i>	94
<i>Diagnosis</i>	94
<i>Treatment</i>	94
<i>Prevention</i>	94
Carp Pox, Fish Pox	95
<i>Treatment</i>	95
Lymphocystis (Iridovirus Infection)	96
<i>Clinical Signs</i>	96
<i>Diagnosis</i>	96



<i>Treatment</i>	97
Columnaris disease, bacterial gill disease (<i>Flavobacter columnar</i>).....	98
<i>Clinical Signs</i>	98
<i>Risk Factors</i>	98
<i>Predisposing Management Problems</i>	98
<i>Diagnosis</i>	99
<i>Treatment</i>	99
<i>Prevention of columnaris disease:</i>	99
Finrot & Ulcer disease- <i>Aeromonas</i> spp., <i>Pseudomonas</i> spp., <i>Cytophaga</i> spp. (esp. <i>C. psychrophila</i>).....	100
<i>Clinical Signs</i>	100
<i>Risk Factors</i>	100
<i>Diagnosis, Treatment & Prevention</i>	101
Wasting Disease & Fish Tuberculosis (<i>Mycobacteriosis</i>)	102
<i>Clinical Signs</i>	102
<i>Diagnosis</i>	102
<i>Predisposing Factors</i>	103
<i>Treatment</i>	103
<i>Prevention</i>	103
Fungal Disease - <i>Saprolegnia</i>, <i>Achlya</i>	104
<i>Clinical signs:</i>	104
<i>Risk Factors</i>	104
<i>Diagnosis</i>	105
<i>Treatment</i>	105
White Spot Disease ('Ich')	107
<i>Clinical Signs</i>	107
<i>Transmission</i>	107
<i>Diagnosis</i>	108
<i>Treatment</i>	108
Velvet disease or coral fish disease.....	110
<i>Clinical signs:</i>	110
<i>Risk factors:</i>	110
<i>Diagnosis:</i>	111
<i>Treatment and prevention:</i>	111
<i>Chilodonella</i> (freshwater), <i>Brooklynella</i> (saltwater)	112
<i>Clinical Signs</i>	112
<i>Diagnosis</i>	112
<i>Treatment</i>	112
<i>Trichodina</i>	113
<i>Clinical signs:</i>	113
<i>Risk factors:</i>	113
<i>Diagnosis:</i>	113
<i>Treatment:</i>	114
<i>Ichthyobodo</i> (<i>Costia</i>)	115
<i>Clinical Signs</i>	115
<i>Diagnosis</i>	115
<i>Treatment</i>	116
Hole In The Head Disease.....	117
<i>Diagnosis</i>	118
<i>Treatment</i>	118
Neon Tetra Disease.....	119
<i>Clinical signs:</i>	119
<i>Diagnosis:</i>	119



<i>Treatment</i>	120
Monogenean flukes - Dactylogyrus & Gyrodactylus	121
<i>Clinical Signs</i>	121
<i>Diagnosis</i>	122
<i>Treatment:</i>	123
Digenetic trematodes flukes	124
Nematodes - Camallanus	125
<i>Clinical Signs</i>	125
<i>Diagnosis</i>	125
<i>Treatment</i>	125
<i>Prevention</i>	125
Anchor Worms (Lernaea cyprinacea And Other Spp.)	126
<i>Clinical signs</i>	126
<i>Risk factors:</i>	126
<i>Treatment and prevention:</i>	126
Fish Lice (Argulus Spp.) & Gill Maggots (Ergasilus Spp.)	128
<i>Clinical Signs</i>	128
<i>Risk Factors</i>	129
<i>Treatment and Control</i>	129
Sudden Death	130
Miscellaneous Conditions – Hikui in Koi	131
<i>Clinical signs</i>	131
<i>Risk factors:</i>	131
<i>Treatment and prevention:</i>	132
Miscellaneous Conditions – Sleeping Sickness in Koi	134
<i>Clinical signs</i>	134
<i>Diagnosis</i>	134
<i>Risk factors:</i>	134
<i>Treatment and prevention:</i>	135
MEDICAL CORNER	136
Useful conversions	136
Estimating fish body weights by length	137
Standard tank sizes & their volumes	139
Routes of administration	140
Topical	140
Parenteral	140
<i>Intramuscular (IM)</i>	140
<i>Intraperitoneal (IP)</i>	140
<i>Intravenous (IV)</i>	140
Per os	140
<i>Capsule sizes</i>	141
<i>Gastric intubation</i>	141
In-water medication	142
<i>Dip</i>	142
<i>Bath</i>	142
<i>Prolonged immersion / permanent bath</i>	142
Factors Affecting Drug Selection	143
<i>Legislation</i>	143
<i>Pathogen</i>	143
<i>Host</i>	144
<i>Environment</i>	144



<i>Other comments</i>	144
THERAPEUTIC PROTOCOLS	147
<i>New Introductions Protocol</i>	148
<i>Skin injury protocol</i>	149
<i>Bacterial infection – General information</i>	150
<i>Bacterial infection - Superficial</i>	150
<i>Bacterial infection - Abscess</i>	150
<i>Bacterial infection – Systemic</i>	150
<i>Protozoal - General</i>	152
<i>Protozoal - Flagellates</i>	153
<i>Dinoflagellates</i>	154
<i>Microsporidian</i>	154
<i>Fungal infection</i>	155
<i>Helminth - Trematodes</i>	156
<i>Helminth – Cestodes</i>	157
<i>Helminth – Nematodes</i>	157
<i>Crustacean Parasitism</i>	158
<i>Viral</i>	159
<i>Toxicities – Chloramine/Chlorine</i>	160
<i>Toxicities – Ammonia</i>	160
<i>Toxicities – Nitrite</i>	161
<i>Toxicities – Heavy metal</i>	161
<i>Environmental - Hypoxia</i>	162
<i>Immunostimulants</i>	163
<i>Breeding – Hormonal induction</i>	164
<i>Disinfectants</i>	165
<i>Adverse Drug Reactions Log</i>	166
PRACTICAL ANAESTHESIA	167
Role of anaesthesia	167
Basic Procedure	167
<i>Direct Application to the Gills</i>	167
<i>Artificially Ventilated, Pump Flow, Gill Irrigation Anaesthesia</i>	167
Drugs to dissolve in water –	168
<i>AQUI-S (iso-eugenol):</i>	168
<i>Benzocaine</i>	168
<i>Isoflurane</i>	168
<i>MS-222</i>	168
<i>Alfaxalone (Alfaxan CD RTU [Jurox])</i>	168
Injectable Anaesthesia	169
<i>Table. Stages of Anaesthesia</i>	169
In Case of Emergency	170
Pre-Surgery Considerations	170
Surgery Venue	171
SURGERY	172
Surgical Risk	172
Analgesia	172
Equipment	172
Patient Preparation	172
Procedures	173
Closure	174



Post-op Recovery.....	174
MISCELLANEOUS PROCEDURES	175
Microchipping	175
<i>Fish</i>	175
<i>Amphibia</i>	175
<i>Reptiles</i>	175
EUTHANASIA.....	176
Fish.....	176
Crustacea	176
DIAGNOSTIC IMAGING.....	177
Radiography.....	177
Ultrasonography.....	177
REPRODUCTION/BREEDING.....	179
Background	179
Handling fish	179
Broodstock Selection & Timing of the Hormonal Injection	179
Hormonal induction	180
Stripping fish.....	182
Storage of gonads	183
Fertilisation	183
Water quality	183
Hatching & feeding	184
AQUARIUM PET ADVICE FORM	185
PACKAGING DIAGNOSTIC SAMPLES	187
SUSPICION OF A NOTIFIABLE AQUATIC ANIMAL DISEASE INCURSION	
.....	189
Notify	189
<i>Local authorities</i>	189
<i>Consulting Veterinarian</i>	189
<i>Supplier</i>	189
Collect diagnostic samples	189
<i>Fish</i>	189
<i>Water and other fluids</i>	189
Waste disposal.....	189
<i>Fish</i>	189
<i>Water and other fluids</i>	189
EXOTIC DISEASE INCURSION.....	190
Ornamental Fish Diseases of Quarantine Concern	190
<i>Goldfish haematopoietic necrosis virus</i>	190
<i>Iridovirus of freshwater ornamental finfish</i>	190
<i>Spring viraemia of carp virus</i>	190
<i>Aeromonas salmonicida ('typical' strains and exotic 'atypical' strains)</i>	190
<i>Dactylogyrus vastator & D. extensus</i>	190

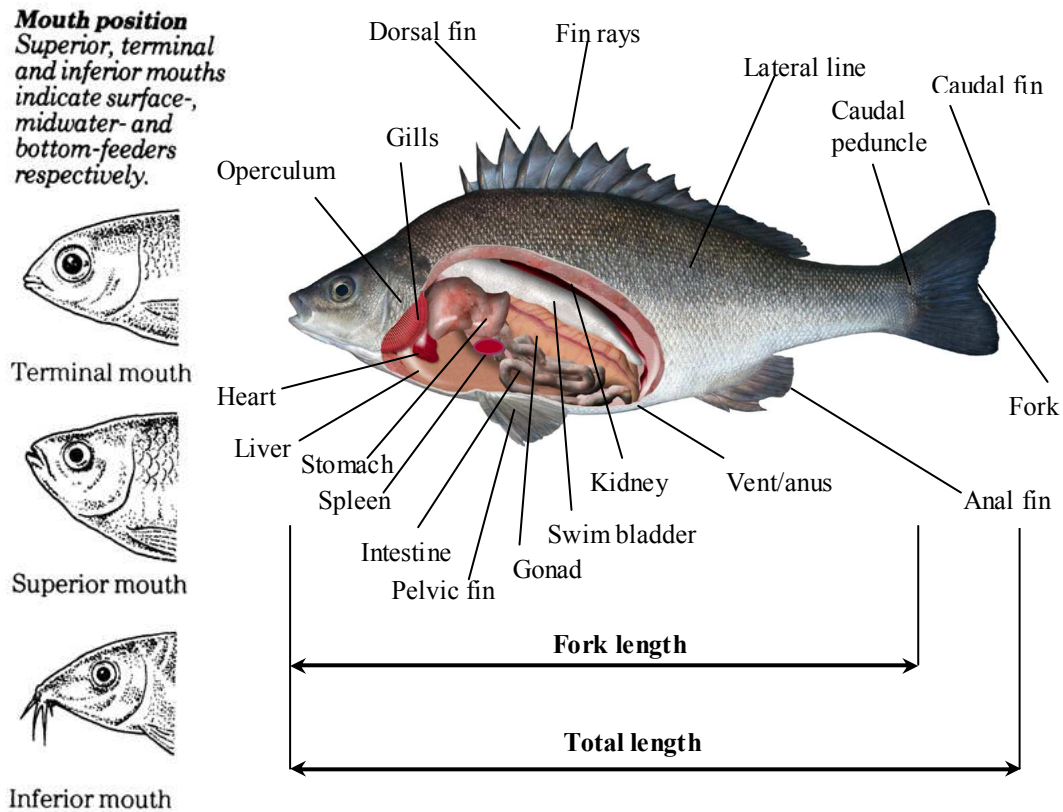


<i>Argulus foliaceus & A. coregoni</i>	190
<i>Lernaea elegans</i>	190
EXOTIC ANIMALS & THE LAW	190
IMPORTANT CONTACTS	191
Notifiable Aquatic Animal Disease	191
<i>National Emergency Disease Watch Hotline</i>	191
<i>Australian Animal Health Laboratory</i>	191
<i>Australian Capital Territory</i>	191
<i>CSIRO</i>	191
<i>New South Wales</i>	191
<i>Northern Territory</i>	191
<i>Queensland</i>	191
<i>South Australia</i>	191
<i>Tasmania</i>	191
<i>Victoria</i>	191
<i>Western Australia</i>	191
Fish Veterinarians	191
<i>The Fish Vet</i>	191
<i>Future Fisheries Veterinary Consulting</i>	191
Commonwealth & State/Territory Conservation Departments	192
<i>CSIRO's Australian Animal Health Laboratories</i>	192
<i>NSW Department of Primary Industries</i>	192
<i>Department of Primary Industries, Parks, Water & Environment– Tasmania</i>	192
<i>Northern Territory Department of Business, Industry and Resource Development – Primary Industries</i>	192
<i>Department of Primary Industries and Resources, South Australia</i>	192
<i>Queensland Department of Primary Industries and Fisheries</i>	192
<i>Victorian Department of Primary Industries</i>	193
<i>Australian Capital Territory</i>	193
<i>Department of Fisheries, Western Australia</i>	193
Miscellaneous	193
<i>Ambulance</i>	193
<i>Poisons Information Centre</i>	193
<i>Materials Safety Data Sheets</i>	193



ANATOMY AND FUNCTION

Below is a diagram of various important anatomical features of a fish, using a silver perch as the model.



Fishes vary in size (from a few millimetres to a few meters), shape, dietary preferences, water quality parameters and more. To appreciate these differences, we will be taking a dive into the watery wonders of fish folk. This section aims to explore just how much you can tell about a fish by merely looking at it.

Skin & scales

The mucus, skin and scales serve to protect fish from its external environment, functions as a sensory organ (tactile and lateral line) and have excretory, respiratory, osmoregulatory and immune functions.

The most superficial layer of the skin comprises of a mucopolysaccharide layer that contains immunoglobulins, lysozyme and free fatty acids; and together they have anti-pathogenic activities. Excessive use of astringent medications (e.g. copper sulphate, formalin, benzalkonium chloride) or excessively acidic conditions will damage the protective layer, predisposing fish to secondary infections (e.g. epizootic ulcerative syndrome). The epidermis comprises of (non-keratinised) squamous epithelial cells (still capable of replication at all levels), mucus cells, fright cells, melanocytes and various leukocytes (macrophages, lymphocytes, eosinophilic granular cells).[2] The dermis is divided into the stratum spongiosum (composed of loose collage and



CATEGORIES OF FISH

This section does not intend to classify fish into their absolute phylogenetic tree, but to familiarise the reader with the differences and commonalities between the vast variety of species available to the aquarist.[3]

Cyprinids

Origin: Europe, Asia, Africa, and North America.

Aquarium system: tropical freshwater.

Characteristics: no teeth in their jaws (possess pharyngeal teeth); egg scatterer; forked tail.

General types: Barb (Tiger, Rosy, and Golden); Danio (Pearl, Zebra, and Giant); Rasbora.

Goldfish



No barbels.

Body more rotund than common carp.

Various body morphs and colours been selected – twin tailed, telescope, celestials, oranda, pearl scale, shubunkin, etc.

Males develop white, 1mm nodules on their opercula and leading edge of their fins during breeding season (spring time - ~ Aug/Sept).

Common disease issues: swimbladder disorder (fancy varieties), mycobacteriosis, flukes.

Carp



E.g. koi carp/Japanese carp.

Have barbels;

Multi-coloured, elongated bodies.

Males are more slender than females and develop “rough” opercula and flanks during breeding season (spring time - ~ Aug/Sept).

Common disease issues: flukes, bacterial septicaemia, fish lice.

Barb



Most have barbels;

Mid to bottom dwellers;

Prefer still waters;

Tendency to nip the fins of tank mates.

Danio



Prefer fast, well-oxygenated cooler waters;

Surface dwellers and feed from the surface;

Thrive in schools of 5 or more fish.

Rasbora



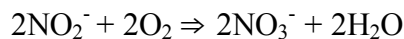
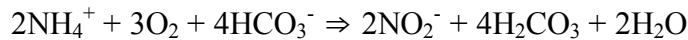
Top to mid-water.

Thrive in schools of 7 or more fish.



NITROGEN CYCLE & BIO-FILTERS

The conversion of ammonia (the major excretory product of fish) to nitrite (by *Nitrosomonas* and *Nitrosococcus*) and from nitrite to nitrate (by *Nitrobacter*, *Nitrococcus* and *Nitrospina*) is termed the “Nitrogen Cycle” and follows these equations (after ammonia is ionised):

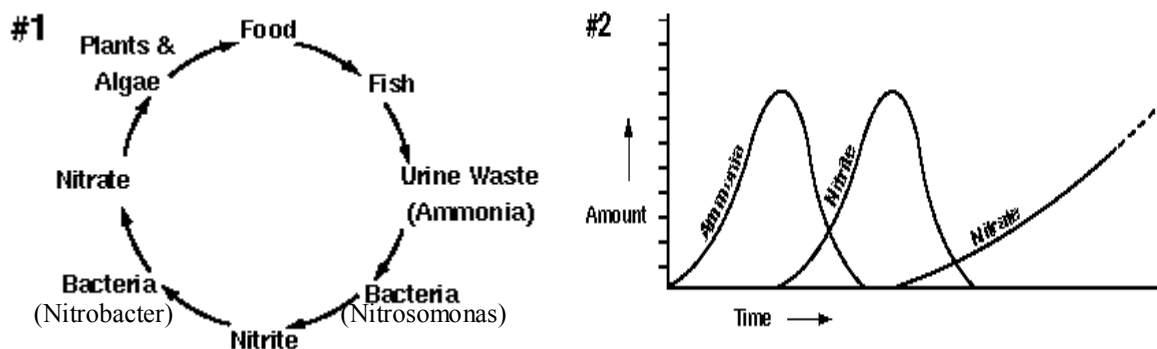


This is an oxygen-dependent process and will cease if dissolved oxygen (DO) levels fall below 2mg/L. The biological filter operates most efficiently at 28-36°C where every 4°C increase in the temperature will make the filter 50% more efficient. The temperature tolerance range for biofilters is 12 - 58°C.[4]

Nitrifying bacteria grow slowly and may take between 2-6 weeks in freshwater to develop sufficient numbers to adequately filter the water. This time is called the “conditioning period”. An established, well-balanced aquarium should have no ammonia or nitrite.

In the natural environment, the end product (nitrate) will be incorporated into plants/algae. However, in the aquarium, this will accumulate in fish tanks unless it is removed by partial water changes or by using a denitrification unit.

Figure. The Nitrogen cycle.



This “Nitrogen Cycle” takes significantly longer to establish in the marine aquaria. In fact, the time it takes may be up to double. A way to speed up the process is to set up the tank as a freshwater system (without fish or plants) and seed with ammonium chloride. Once the filter is conditioned, convert this set-up to marine by increasing the salinity by 10g/L/day until the desired SG is reached.

Some people condition the filter using fish and others use meat to supply the system with nitrogen. However, this may have unfavourable consequences if the fish carry



pathogens or the decaying meat breeds other non-desirables such as fungi and other bacteria. In a large freshwater set-up, a biological filter may be “seeded” by adding 46mg/L of NH_4Cl and 73mg/L of NaNO_2 for 20 days, maintaining the water temperature at 20-28°C.[4] Test the ammonia and nitrite levels prior to adding fish. Once the aquarium is set-up, do not increase the biomass by more than 3-4% at any one time. If need be (e.g. in a fish shop situation where you have a large order in), supplementary chemical filtration (e.g. zeolite) may be necessary.

NB: Bio-filters will also consume Ca^{+2} , Mg^{+2} , HCO_3^- and CO_3^{-2} (the latter two contribute to decrease in pH) and so partial water changes to replace the “lost” ions or buffering may be necessary from time to time.

Bio-filter requirements vary depending on species, water temperature, pH, fish size, stocking density, oxygen consumption, ammonia production, substrate type and surface area to volume ratio, filter efficiency, clogging by solids, water flow rate and feed amount, frequency and type. As a rule of thumb, the bio-filter volume should be 10-20% of tank volume.

If the bio-filter requirements need to be calculated. The following equations will be helpful[4]:

Daily feed (dry weight) may be calculated by the following equation.

$$\text{Daily feed} = (\text{body weight}) \times 0.02$$

Ammonia production rate (APR) may be calculated by the following equation.

$$\text{APR} = (\text{daily feed}) \times (\text{total fish biomass}) \div 100 \times 0.025\text{kg}$$

Bio-filter surface area requirement (BSA).

$$\text{BSA} = \text{APR} \div (\text{nitrification rate})$$

Volume of substrate required (SV).

$$\text{SV} = \text{BSA} \div (\text{specific surface area/unit volume}) \times 1.2$$

If ammonia and/or nitrite are allowed to build up considerably, fish deaths result in a condition called, “new tank syndrome” – see under Water Quality – Ammonia and Nitrite.

Some chemotherapeutants may affect the biofilter. These are tabulated below.



WATER QUALITY PARAMETERS FOR POPULAR GROUPS OF AQUATIC ANIMALS

Freshwater

Tropical community

Ammonia	<0.2mg/L
Nitrite	<0.2mg/L
Nitrate	<50mg/L (<110mg/L tolerance)
pH	6.5 - 7.5 (oviparous fish towards acidic end, viviparous fish towards basic pH)
GH	100 - 200mg/L
Specific gravity	1.000
Temperature	24 - 28°C

Amazonian (soft, acid)

Ammonia	<0.2mg/L
Nitrite	<0.2mg/L
Nitrate	<50mg/L (<110mg/L tolerance)
pH	6.8
GH	80 - 140mg/L
KH	70 - 100mg/L
Temperature	25°C

Special considerations:

- Some fish may need cover (planting, caves, and bogwood).

Africans (hard, alkaline)

Ammonia	<0.1mg/L
Nitrite	<0.2mg/L
Nitrate	<50mg/L (<110mg/L tolerance)
pH	8.0
GH	300mg/L
Temperature	25 - 29°C

Special considerations:

- Allow 10-12x cichlid lengths in diameter - A large majority of these cichlids are highly territorial (especially towards fish with similar appearance).

Salmonids (Salmon & Trout) – Freshwater phase[13]

Ammonia	<0.0125mg/L
Nitrite	<0.02mg/L
pH	5.5 - 8.5
Nitrogen	<105%
Dissolved oxygen	>6mg/L
Carbon dioxide	<10mg/L
Temperature	12 - 15°C for Atlantic salmon 14 - 18°C for rainbow trout (tolerance range: -1 - 25 °C)
Suspended solids	<80mg/L
Iron (total)	<1mg/L

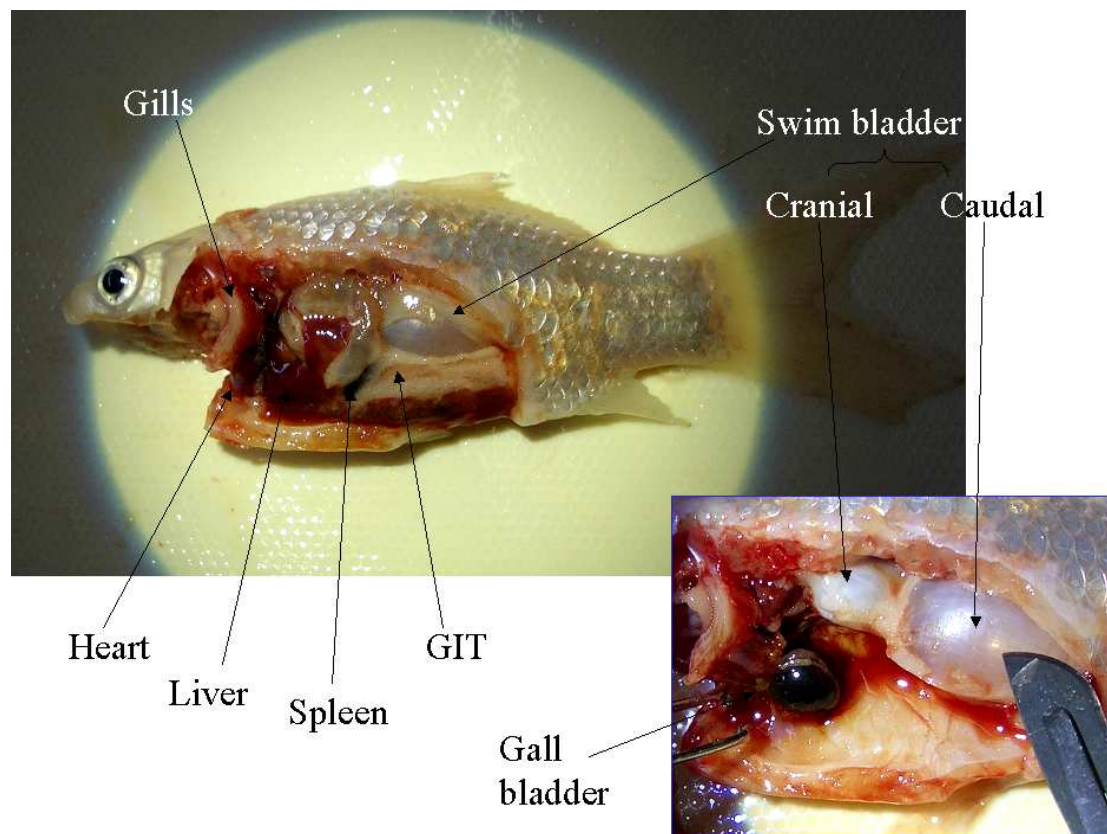


Internal gross pathology

Look for

- haemorrhage (petechiae-ecchymoses);
- ascites (exudate/transudate; clear-bloody);
- nodules/granulomas (especially in kidney, spleen and liver);
- parasites (nematodes, trematodes);
- presence of feed in gut;
- size of organs (spleen and kidney enlarge in systemic infections).

Sites for microbiology swabs: kidney, spleen, liver, heart, brain. Sterile technique must be used to access these organs to avoid contamination of the swabs.



Histology

On many occasions it is necessary to utilise more powerful diagnostic techniques. Post mortem on typically affected, freshly euthanased fish (fish that have been dead for even a few hours are often of no diagnostic value) will allow sample preservation for histopathology (using 10% formalin buffered formalin) and microbiology (transport swabs or direct plate inoculation). Wear gloves to minimise zoonotic potential of some fish pathogens (e.g. Atypical mycobacteria).

Tissues to collect for histopathology: anterior kidney, posterior kidney, swim bladder, pancreas, liver, spleen, heart, gut, brain, gill (keep entire on arch), skin (include any skin lesions with margin of “normal” tissue; take care to avoid scale detachment). It is important to use sufficient volume of formalin (1:10 tissue to formalin) to adequately preserve specimens for the lab.



Fixatives

10% Neutral Buffered Formalin (fish, freshwater invertebrates)

- Formalin (40% w/v formaldehyde) 100mL
- Sodium phosphate, monobasic monohydrate 4g
- Sodium phosphate, dibasic, anhydrous 6.5g
- Distilled water to 1L

This solution is stable for many months at room temperature. Fix small blocks of tissue (10x10x3mm) for up to 24 hours.

Seawater Formalin (marine shellfish and crustaceans)

As for 10% NBF, but fill with seawater to 1L.

Davidson's Fixative (marine shellfish and crustaceans)

- 600ml Seawater
- 600ml 95% ethanol
- 400ml 37% formaldehyde
- Add 200ml glacial acetic acid prior to use.

Virology

Preservation of tissues for viral isolation: best to send tissues fresh on ice on express courier to laboratory. Your local laboratory may be able to help with making transport media (containing antibiotics and anti-fungals). Matching samples of formalin, glutaraldehyde and 70% ethanol fixed tissues should be sent separately, to allow processing for histology, electron microscopy and molecular assays.

Molecular Biology

Material for PCR testing need to be preserved in 95% ethanol. There is also a product called "RNA Later" that can preserve genetic material, including RNA material, for long periods. It is important not to cross-contaminate samples. Remember that PCR tests only provides you with evidence for the presence or absence of that organism's DNA. A positive result does not necessarily mean there is disease per se. And a negative result could mean that you may have not selected your primers properly. Results should be interpreted in light of clinical signs and histopathology findings.



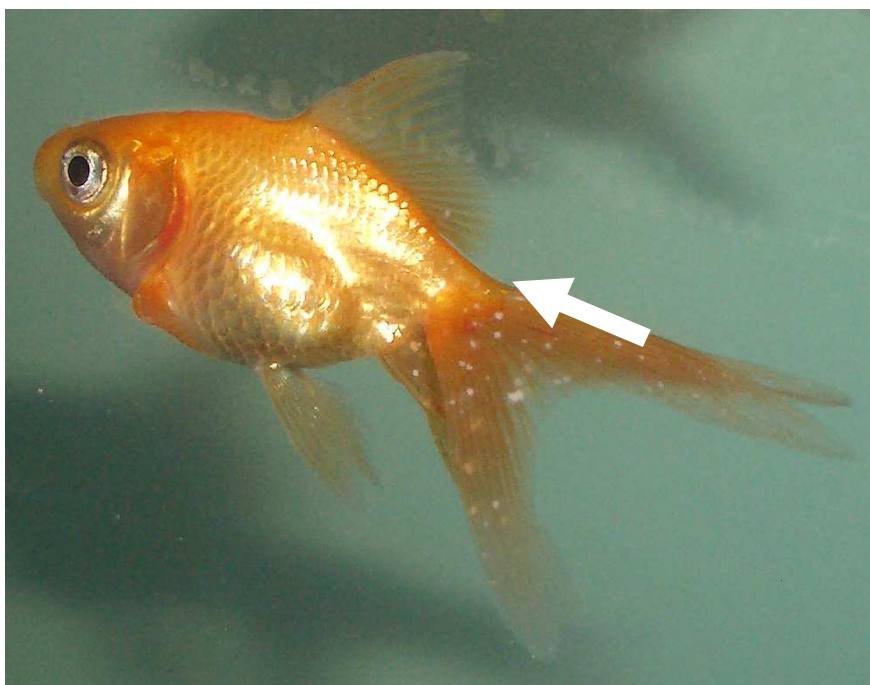
White Spot Disease ('Ich')

– *Ichthyophthirius multifiliis* (freshwater) & *Cryptocaryon irritans* (marine).

'Ich' is a very common protozoan disease of both marine and freshwater fish. The organism is a small, round, ciliate protozoan with a distinctive horse-shoe shaped nucleus that lives on the skin and gills of the fish where it produces lesions that take on the form of tiny (~1mm) white cystic nodules.

Clinical Signs

The parasitic cysts are so large that they are visible to the naked eye – affected fish will look as though they have been sprinkled with sugar and will often demonstrate irritation; scratching and rubbing against the rocks and tank. However, this may not always be present if only the “swarmer” stages are present. Thickening of the skin epithelium and increased mucus production on the skin may occur, but these may only be appreciated microscopically. The fins may also become ragged.



Since the gills are also exposed to the external aqueous environment, the organism will also parasitise the gills, causing increased mucus production as well as gill epithelial hyperplasia. This leads to respiratory embarrassment and fish will present with increased respiratory rate and flared opercula. In heavy infestations, fish will become lethargic and depressed, its respiratory rate slows and becomes shallow. Ulcers form when the encysted stages break out of the skin and the gills. In heavy infections, mortality can be high which may be in part due to electrolyte loss (in freshwater fishes) or dehydration (marine fishes) through these ulcers. In those that survive the initial insult, the ulcers would provide portals of entry for secondary infection with bacterial and fungal opportunists.

Transmission

'Ich' is a very common infection of fish in both freshwater and marine systems and that, in low numbers, it may produce little or no clinical signs. It is important therefore to always look for other pathogens (bacteria, fungi, other protozoa etc.)



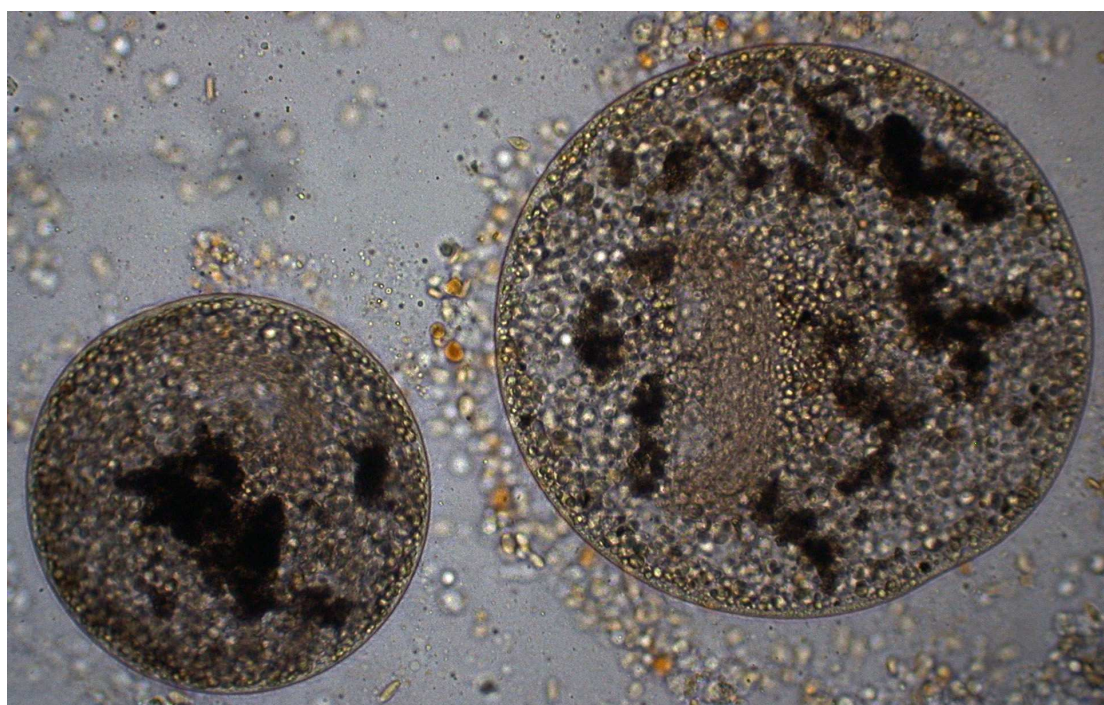
when presented with a sick fish with only a small burden of Ich, as this may be an incidental problem.

'Ich' replicates quickly and so a minor burden in one fish tank can rapidly become a serious burden to a tank full of fishes if left untreated. Mature Ich parasites that have been feeding on the host eventually fall off the host to the bottom of the tank. There they secrete a protective cyst around themselves and begin to divide, producing many hundreds of infective stages (swarmers) which swim off in search of a host.

The transmission of 'ich' is facilitated by high stocking densities of fish. Individual encysted stages on fish may go unnoticed by fish-owners and yet be a major source of infection for other fish. Temperature also plays a big role in disease transmission with the lifecycle being completed more rapidly at higher temperatures (3-4 days at 21°C vs 5 weeks at 10°C). This factor is particularly important when dealing with Cryptocaryon outbreaks as it is more temperature-governed than Ichthyophthirius.

Diagnosis

Diagnosis is made by performing a skin or gill scraping in the region of one of the white lesions and by identification of the spherical ciliate organisms, with their characteristic slow spinning motion, in a fresh wet preparation. Notice also that the parasites can be of various sizes, which is pathognomonic for "Ich" (other ciliated parasites are of uniform size and shape).



Treatment

Formalin may be used, however, because it displaces dissolved oxygen, it is not recommended if fish exhibit severe respiratory embarrassment. Malachite green + formalin combination is the most effective treatment since the mixture has a "synergistic effect" and a smaller concentration of each ingredient is used. Dip treatments and osmotic challenges will only be effective against the non-encysted stages of the parasite. Thus, this will need to be repeated every 2-3 days for 10 days.



Thermal challenge by raising the water temperature to at least 32°C for a few hours every 3 to 5 days (provided the water is well-aerated and that the fishes will tolerate it) is another method used. The high temperature interferes with the reproduction of the parasite. Since the organism is an obligate parasite, allowing the aquarium or pond to be left fish-free for at least 7 days at >20°C usually eliminates the white spot parasite.

It has been reported that some fishes that recover from the infection will develop immunity to the disease.

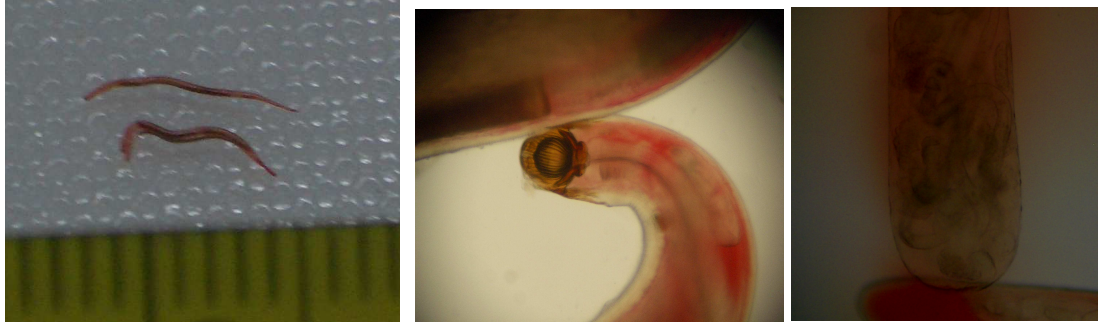
See the medication section under “*Protozoa – General*”.

<><



Nematodes - Camallanus

These are large roundworms (pictured below) that infects the gastrointestinal tract of fish, most commonly seen in livebearing fish, cichlids and other freshwater species. *Camallanus* species have indirect life cycles and are ovoviviparous - the female worms incubate the eggs which hatch into larvae within their bodies and the egg sacs containing these larvae (pictured below right) are excreted into the water with the fish's faeces. The larvae are ingested by a crustacean intermediate host in order to develop into L3s. When fish eat the infected crustacean, the larval worms mature in the gastrointestinal tract of the fish.



Clinical Signs

The worms can cause intestinal obstruction, weight loss and eventual death of the fish. The first evidence of infection is a red, worm animal protruding from the anus of the fish. They do so in order to lay their eggs (which contain larvae) into the environment.

Diagnosis

Camallanus species can be identified by their blood red colour; their location further toward the posterior of the intestinal tract and often protruding from the anus of the fish (hence “-anus”); the presence of a buccal capsule (mouth structure) that is divided into two lateral valves, giving the mouth a slit like appearance (pictured above middle - hence “*Camel*”); and, if gravid females are present, the presence of both eggs and larvae within their bodies.

Treatment

Because *Camallanus* nematodes are located within the intestinal tract, common dewormers should be effective (e.g. levamisole).

Prevention

As a copepod or other crustacean host is required to complete the life cycle, avoiding the use of copepods or related crustaceans as food items will help reduce potential for infection. Evaluation of brood stock for the presence of parasites prior to use will also aid in identifying carriers.



Routes of administration

Topical

This usually involves the application of a paste/gel onto an external lesion (e.g. applying Clonea over a fungal skin infection).

Parenteral



Intramuscular (IM)

Aim for the muscle block just ventral and caudal to the dorsal fin. Needle should be positioned between the scales and aimed to come in from a caudo-rostral angle. The most commonly used method for antibiotic injection. The medication is rapidly dispersed by the rich blood supply. Inject slowly to prevent reflux. This technique is recommended for gravid females and not recommended for small fish and fish with little muscle bulk. Additionally, the disadvantage of this method is that the injection site may discolour (aim for dark areas on the fish).

Intraperitoneal (IP)

Place the fish on its side or on its back to allow the peritoneal organs to gravitate away from the body wall. Insert needle into this space at a shallow angle to avoid penetrating the internal organs. This is a common route of administering vaccines as it is done on small fish and will not harm the flesh. It is also good for administering “painful” medications such as enrofloxacin. The disadvantage of this method is damaging peritoneal organs or injecting into the ovary where the drug will not redistribute to the rest of the body.

Intravenous (IV)

Fish must be anaesthetised. Insert needle midline and at the angle shown, just caudal to the ventral fin. Stop just short of the spine. This technique is used more commonly for drawing blood than for administering drugs.

Per os

This is a common delivery method for antibiotics on large farms for ease of medicating large numbers of fish and also minimises handling stress. However, the delivery of the correct doses to each individual fish is difficult (sick fish are usually inappetent and it is these that should actually be receiving medication). Medication is either sprayed onto the food, impregnated into the food, or prepared with gelatine with food. Depending on the drug, this medicated food may sometimes be less palatable. It is thus recommended to reduce the amount of food fed per day by 25-50%.



Skin injury protocol

1. Anaesthetise fish (*Aqui-S*, *Alfaxan*).
2. Debride/excise (only done once since repeat treatments may delay epithelialisation).
3. Make a wet prep & an impression smear (diff quick stain) to assess presence of infection.
4. Topical iodine (use *Betadine* diluted 1:10 or *F-10* diluted 1:100).
5. Topical *Panallog* cream ointment for bacterial infection; or *Clonea* cream for fungal infection (leave on skin for 30-60 seconds to allow local absorption).
6. Seal wound with dental gel (*Orabase*).
7. Anti-inflammatory (*Metacam*) – 1 drop PO.
8. Injectable antibiotic intramuscular if indicated (*enrofloxacin*).
9. Increase water temperature and aeration.
10. 3-5mg/L *NaCl* (reduce osmotic stress) and some *Vitamin C* (promote wound healing).
11. Immunostimulants may be beneficial.
12. In bath medication for 7-14 days or very clean water.
13. *Determine the primary cause of the lesions and act accordingly.
 - Check water parameters.
 - Anything causing mechanical damage?
 - Attacked by predator, other fish?
 - Rough surfaces?
 - Rough handling?
 - Any other stressors?
 - Over crowding?
 - High organic loads?



Fungal infection

Potassium permanganate

Bath: 10mg/L as a 30 minute.

PI: ~2mg/L (to maintain pink colouration for >4 hours).

Malachite green

*May be toxic to tetras, catfish, loaches & other scaleless fish.

*Not to be used on food fish.

Topical: 20mg/L (keep away from eyes & gills).

Bath: 1-2mg/L for 30-60 minutes.

Repeat alternate days for a maximum of 4 treatments.

Povidone iodine

Topical: Debride wound and topical application diluted 1:10.

F-10

(54g/L benzalkonium chloride, 4g/L polyhexamethylene biguanide hydrochloride)

Topical: Debride wound and topical application diluted 1:100 daily until lesion resolves.



EUTHANASIA

Fish

1. Overdose with fish anaesthetic (Aqui-S or Alfaxan) or if these are inaccessible, clove-oil (eugenol) or benzocaine may be used.
2. If anaesthetic is not available, stun fish by percussion.
3. Then sever the spine, followed by pithing of the brain.

*NB: Step 3 may cause involuntary muscle twitching. Let client know this may occur and that the fish is unconscious and feels no pain.

Freezing fish or leaving fish to “suffocate” out of water are not acceptable methods of euthanasia.

Crustacea

Several methods are currently acceptable:

- Injection with xylazine (70mg/kg) or pentobarbitone (250mg/kg) before placing in boiling water (Oswald 1977).
- Clove oil 0.125ml/L for one hour (Gardner 1997).
- Cooled and then deep frozen.
- Salt/ice slurry for 20 minutes before sectioning to destroy ganglia or place in boiling water.
- For terrestrial invertebrates, dry ice (CO₂) or gaseous isoflurane may be introduced into a chamber holding the animal.

ANZCCART Guidelines (under revision)

<http://www.adelaide.edu.au/ANZCCART/publications/Euthanasia.pdf>

Cooper JE, 1990. Euthanasia of invertebrates. National Federation of Zoological gardens of Great Britain and Ireland, London.

Gardner C, 1997. Options for humane immobilizing and killing crabs. *J Shellfish Res* 16:219-224.

Oswald RL, 1977. Immobilization of decapod crustacean for experimental procedures. *J Mar Biol Assoc, UK* 57:715-721.



INDEX

A

abalone 64
 acid... 18, 23, 36, 43, 45, 61,
 68, 71, 78, 92, 98, 116,
 180, 183
 acyclovir..... 159
 aeration. 53, 55, 67, 87, 144,
 149, 153, 156, 162, 170
Aeromonas 76, 100, 101,
 121, 144, 190
 air 18, 22, 28, 29, 31, 32, 41,
 51, 52, 54, 66, 67, 79, 90,
 178, 185
 air pump 28
 air stone 29
 alfaxalone 168
 algae . 17, 30, 31, 34, 39, 49,
 56, 60, 70, 81, 82, 84, 86,
 87, 88, 89, 110, 111, 154,
 185
 algology..... 81
 alkalinity 39, 45, 154
 ammonium 34, 41
 Amyloodinium 110, 111
 anaesthesia 167
 anaesthetic 76, 167, 168,
 169, 170, 172, 176, 179
 analgesia..... 168, 169, 174
 anatomy 15
anchor worm 126
 antibiotic 77, 101, 140, 143,
 149, 150, 151, 174
 anticoagulant..... 79
 appetite stimulant 70
 aqui-s 168
 artemia..... 184
 ascites..... 69, 91, 102
 axolotl 113, 116, 156

B

bacteria... 19, 30, 31, 32, 34,
 35, 41, 43, 45, 48, 49, 74,
 76, 77, 78, 88, 94, 98, 99,
 100, 106, 107, 128, 153,
 184
 bacterial culture media.... 76
 bacteriology..... 76
 ballasts..... 68
 barramundi 20, 98, 104
 bath..... 142
 behavioural abnormalities 73
 benzalkonium chloride... 15,
 144, 155
 benzocaine..... 168
 biochemistry..... 79
 biological filtration..... 39
 biological oxygen demand
 66
 bird..... 124, 173
 blood 18, 19, 39, 40, 41, 43,
 44, 54, 55, 56, 69, 71, 76,

77, 79, 80, 125, 128, 134,
 140, 172, 186, 197
 body weight.. 19, 35, 67, 68,
 136, 141, 180
 breeding 164
 brine shrimp 88, 184
 broodstock..... 179
 buoyancy..... 18, 22

C

calcium... 39, 41, 46, 48, 57,
 69, 79, 117, 165
 Camallanus..... 24, 125
 cannibalism... 103, 119, 120
 carbohydrate..... 68
 carbon..... 29, 31, 32, 39, 43,
 45, 48, 50, 52, 54, 118,
 130, 160
 Carbon dioxide..... 31, 61
 Carbonate Hardness .. 39, 45
 carotenoids 69
 carp..... 18, 21, 58, 95, 126,
 131, 134, 156, 158, 180,
 181, 190
 carp pituitary extract 164
 carp pox..... 93, 95
 catfish 16, 17, 25, 40, 58, 68,
 86, 94, 130, 144, 152,
 153, 155, 170, 181
 catheter 141, 179
 cestode 156, 157
 Chilodonella..... 93, 112
 chloramine 55
 chlorine 55, 60, 87, 160, 165
 chorulon 164
 chromatophore 16
 cichlids... 19, 24, 45, 46, 61,
 117, 125, 152, 156, 157
 ciliates 74
 clay..... 132
 clinical examination..... 73
 clove oil..... 176
 clownfish..... 64
 coelenterate 65
 columnaris 93, 98, 100, 101,
 104, 105
 conductivity 46, 47, 65
 contacts 191
 conversions 136
 copper sulphate .. 36, 57, 59,
 111, 144, 154
 coral 28, 29, 45, 110, 144
 costia 93, 113, 115
 crustacea.... 46, 68, 93, 125,
 126, 128, 176
 Crustacea..... 148
 cryptobia 23
 cryptocaryon 107, 108
 cytology 143

D

dactylogyrus....75, 121, 122,
 156, 190
 denitrification filter.....31
 diagnostic samples187
 diet.....67
 diff quick.....77, 113, 116
 diflubenzuron.....158
 digenean trematode124
 dimethyl phosphonate158
 dinoflagellate110
 dip.....142
 disinfect103, 120, 165
 diurnal variations39
 dropsy73, 186

E

egg 19, 21, 22, 69, 104, 122,
 125, 126, 128, 164, 179,
 180, 181, 183, 184
 eggs19, 20, 26, 88, 104,
 105, 121, 125, 126, 129,
 167, 173, 179, 180, 181,
 182, 183, 184
 emergency.....51, 170, 171
 enrofloxacin141, 150
 ergasilus128, 129
 erythrocytes43, 55
 erythromycin...36, 150, 151
 euthanasia80, 168, 176
 exotic disease.....190

F

faecal.....118, 182
 faecal coliforms66
 fat68, 71
 feed additives.....69
 feed thawing67
 feeding ...20, 31, 41, 43, 50,
 67, 68, 72, 86, 94, 99,
 100, 108, 121, 184
 fenbendazole156, 157
 fertilisation.....19, 181, 183
 fighting fish...16, 19, 22, 94
 filtration ..23, 28, 29, 30, 35,
 39, 41, 43, 64, 67, 72, 88,
 144, 164, 174, 184
 finrot100, 101, 102, 104,
 119
 fixatives92
 flagellate115
 flagellated protozoa110,
 115, 134
 flavobacteria24
 flocculants.....87
 florfenicol150
 fluke121, 122, 124
 formalin ..15, 36, 50, 60, 74,
 91, 92, 108, 112, 114,
 116, 118, 123, 144, 152,
 180

fungal . 25, 95, 98, 104, 105,
107, 112, 113, 115, 121,
126, 128, 140, 142, 148,
149, 184
fungi 30, 35, 74, 90, 94, 104,
107, 184

G

general hardness 45, 46
gill biopsy..... 74
gills... 18, 41, 43, 54, 57, 73,
75, 98, 104, 107, 110,
112, 113, 115, 121, 122,
128, 130, 134, 150, 155,
167, 168, 170
goldfish .. 18, 19, 38, 48, 58,
68, 95, 100, 102, 110,
126, 128, 170, 172, 173,
174, 180
gonad 172
Gram 76, 77, 98, 150
granuloma 126
granulomatous 102
gyrodactylus 121, 122

H

haematology 79
hardness.. 31, 39, 41, 45, 46,
52, 57, 86, 100, 117, 170,
172
hatching..... 184
head and lateral line erosion
..... 117
heater 27
heavy metals..... 57
helminth 123, 156, 157
herpesviral..... 95, 159
hexamita 117
hikui 131
histology..... 91
hole in the head disease. 117
hormone 143, 164, 179, 180,
181, 182
hospital 142, 165, 170
hydrometer 47
hypothermia 23
hypoxia..... 162

I

ichthyobodo.... 93, 113, 115,
116
ichthyophthirius 30, 93, 107,
108, 152
immune .. 15, 117, 132, 144,
163
immunostimulants. 132, 133
injectable 149, 169
insecticide 60
intermediate host 125
iodine..... 165
iridovirus 23
ivermectin 60, 157

K

kidney... 18, 19, 76, 91, 102,
115, 130, 143, 151, 177,
179
koi 16, 21, 38, 48, 62, 68,
95, 121, 126, 131, 132,
134, 153, 168, 170, 172,
173, 174, 179, 181, 182

L

labyrinth organ..... 22
lateral line .. 15, 19, 80, 117,
169
leech..... 134
lernaea.... 99, 121, 126, 128,
129, 190
leukocytes 79
levamisole 157, 163, 166
light.. 28, 29, 39, 74, 86, 87,
88, 89, 90, 92, 97, 104,
128, 168, 177, 179
livebearers..... 24, 40
lufenuron..... 158
lymphocystis 93, 96

M

Magnesium..... 45, 46, 48
malachite green 36, 60, 106,
108, 152, 155
methaemoglobin.. 43, 55, 73
metronidazole. 36, 148, 153,
166
microchip 175
microsporidian 119, 120,
154
milt... 19, 24, 179, 181, 182,
183
mineral 131
molecular biology 92
monogenean 121, 122
montmorillonite 132
ms222 168
MS222..... 79
murray cod 62
mycobacteria.... 76, 78, 102,
103
mycology 90

N

nematodes 91, 125
neon tetra disease..... 119
new tank syndrome 35
nitrate 29, 30, 34, 43, 44, 57,
66, 80, 87, 88, 130, 181,
184
nitrifying bacteria..... 45
nitrite 29, 30, 34, 35, 36, 41,
43, 44, 45, 55, 66, 73, 80,
130, 181, 184
nitrogen cycle..... 34, 148
nocardia..... 76, 78, 102
nutrition..... 67

O

oedema 73
old tank syndrome 44
organophosphate 156, 158
osmoregulation 18, 47
osmoregulatory stress 48,
142, 170
ovaprim..... 164
ovulation..... 164, 180
oxygen 18, 29, 31, 32, 34,
35, 38, 39, 43, 44, 50, 51,
53, 54, 55, 56, 61, 63, 64,
65, 66, 67, 87, 98, 108,
117, 130, 144, 153, 162,
168, 170
oxytetracycline..... 36, 151
ozone..... 30, 31, 185

P

pain .. 20, 167, 172, 174, 176
peroxide 51, 60, 88, 123,
144, 162
pH 39, 41, 43, 52, 57, 66
phosphate . 39, 56, 64, 65, 87
photosynthesis 28, 39, 45,
52, 54, 86, 88
physical injury 94
pigment 88
plants. 19, 23, 26, 28, 29, 34,
39, 45, 52, 56, 72, 86, 87,
88, 89, 132, 160, 162
pleistophora 119, 120
pollutants 59
potassium permanganate. 36,
60, 112, 116, 144, 148,
152, 155, 162, 165
povidone iodine 155
praziquantel ... 148, 156, 157
prolonged immersion..... 142
propolis..... 132
protein..... 29, 68, 71, 79, 80,
122, 134, 183, 185

Q

quarantine 97, 101, 111,
126, 129, 142, 148, 165

R

radiography..... 177
rancid fat 69
reproduction..... 38, 105, 109,
121
respiration 18, 38, 39, 41,
52, 54, 73
reverse osmosis unit..... 31

S

salinity 19, 34, 38, 41, 43,
47, 63, 64, 66, 70, 80,
170, 172, 185
salmonid... 80, 100, 168, 172

salts .. 18, 29, 31, 39, 47, 57, 58, 59
 sampling..... 66, 172
 saprolegnia ... 24, 30, 93, 98, 104, 105
 seahorse..... 64
 seawater..... 48, 49, 92
 sharks 40, 46, 177
 silver perch..... 62
 skin & scales 15
 skin scrape..... 74
 sleeping sickness 134
 smears 43, 55, 77, 78, 79, 102, 113, 134
 snails .. 17, 46, 88, 117, 124, 154
 sodium chloride.. 43, 62, 76, 126, 136, 142, 148, 149, 152, 156, 160, 161, 170, 183
 solids 30, 35, 46, 48, 49, 61, 72, 87
 specific gravity... 47, 50, 61, 62, 63, 64, 65
 spironucleus 117, 118
 stress. 19, 30, 41, 44, 47, 55, 70, 80, 98, 99, 104, 112, 113, 134, 135, 140, 144, 149, 169, 172, 179, 181
 stripping 179, 182
 substrate 31, 32, 35, 160, 164
 sudden death..... 130
 supersaturation 54
 surgery... 170, 171, 172, 197
 swimbladder..... 21, 76

T

TDS..... 46, 47
 teeth..... 18, 21
 temperature .. 23, 27, 28, 34, 35, 38, 41, 47, 50, 63, 64, 65, 70, 73, 80, 88, 92, 95, 98, 100, 104, 108, 109, 111, 112, 117, 129, 130, 132, 149, 156, 159, 161, 162, 167, 168, 170, 172, 179, 180, 184, 185
 temperature manipulation 159
 test.... 29, 39, 41, 42, 44, 45, 48, 52, 66, 72, 92, 130, 157, 165, 167, 174, 189
 tetra 19, 22, 40, 93, 119, 197
 thermometer 28
 thiosulphate 29, 48, 55, 160, 165, 189
 toltrazuril..... 154
 topical..... 94, 140, 149, 155, 159
 total dissolved solids..... 47
 toxicities..... 160, 161
 toxicology 130
transport . 43, 51, 55, 57, 68, 91, 92, 98, 168, 171
 trauma 95, 173, 177
 trematode 91, 123, 156
 tricaine 168
 trichlorfon 36, 156, 158
 trichodina 30, 93, 113
 trimethoprim-
 sulfamethoxazole 150
 trypanoplasma 134

tuberculosis.....93, 102

U

ulcer94, 99
 ulceration 94, 102, 104, 115, 144
 ultrasonography177
 UV sterilisers.....30

V

velvet disease.....110
 venipuncture79, 80, 197
 veterinarian191
 Virkon.....103, 148, 159, 165
 virology.....92
 virus96, 97, 131, 190
 vitamin..43, 67, 68, 69, 117, 118, 132, 133, 149, 163

W

waste disposal.....189
 wasting.....93, 102
 water conditioner29
 water quality .15, 39, 73, 98, 113, 117, 120, 130, 131, 136, 170, 181, 183
 water sampling.....66
 white spot disease....93, 107

Y

yabby63

Z

ziehl neelsen stain.....78
 zoonotic78, 91, 103

REFERENCES

1. Stoskopf, M.K., *Fish Medicine*. 1993: Saunders Company.
2. Brown, L., *Aquaculture for Veterinarians: fish husbandry and medicine*. 1993, Oxford: Pergamon Press.
3. Mills, D., *You & Your Aquarium. The complete guide to collecting and keeping your aquarium fishes*. 1986: Colour Library Books.
4. Powell, M.D., *Technology for Aquaculture, Lecture Notes, KQA 214*. 2005: University of Tasmania.
5. Claude, E.B., *Water Quality in Ponds for Aquaculture*. 1996, Alabama: Auburn University.
6. Aquarium Industries, *Technical Notes for the keeping of freshwater fishes*. 2003.
7. Kelly, L.A., *Water quality and rainbow trout farming*. *Fish Veterinary Journal.*, 1998. **May(2)**: p. 31-47.
8. *Fish Diseases*. in *Refresher Course for Veterinarians*. 1988. Stephen Roberts Lecture Theatre University of Sydney: PGF Veterinary Science.
9. Annon., *Better Management Practices (BMP) Manual for Black Tiger Shrimp (Penaeus monodon) Hatcheries in Vietnam*. 2005, NACA.
10. Reddacliff, G.L., *Diseases of Aquarium Fishes. A practical guide for the Australian Veterinarian*. Vol. 25. 1985: University of Sydney.
11. Gadd, C., *CO₂/KH/pH table*.
12. Lewbart, G.A., *Self-Assessment Colour Review of Ornamental Fish*. 1998, London: Manson Publishing.
13. Laird, L. and T. Needham, *Salmon and Trout Farming*. 1988, Chichester: Ellis Horwood Ltd.
14. Burke, C.M., et al., *Environmental requirements of abalone*. 2001, Launceston: University of Tasmania.
15. Lewbart, G.A., *Invertebrate Medicine*. 2006, Oxford: Blackwell Publishing.
16. PGF Veterinary Science, *Invertebrates in Aquaculture*. Vol. Proc No 117. 1989.
17. Chong, R.
18. Treves-Brown, K.M., *Applied Fish Pharmacology*. 2000, London: Kluwer Academic Publishers. 324.
19. Mylniczenko, N.D., et al., *Differences in hematocrit of blood samples obtained from two venipuncture sites in sharks*. *American Journal of Veterinary Research*, 2006. **67(11)**: p. 1861-1864.
20. Botanic Gardens Trust, *Australian Freshwater Algae*, Department of Environment and Conservation (NSW).
21. Gratzek, J.B. and J.R. Matthews, eds. *Aquariology: The Science of Fish Health Management*. 1992, Tetra Press: Hong Kong.
22. Pyecroft, S.B.
23. Lewbart, G.A., *Koi Medicine & Management*. Antibicrobial Therapy in Exotics. Supplement to Compendium on Continuing Education for the Practicing Veterinarian., 1998. **20(3(A))**: p. 5-12.
24. Bayer, *Off label information sheet - Masoten for veterinary use*. 2005.
25. Bayer, *Antimicrobial Therapy in Exotics. Supplement to Compendium on Continuing Education for the Practicing Veterinarian*. 1998. **20(3A)**.
26. Johnson, E.L., *Surgery in Koi*. *Koi Health and Disease*, 1997: p. 102-108.
27. PGF Veterinary Science, *Fin Fish Health*. Vol. Proceedings No. 347. 2002.
28. Ross, L.G. and B. Ross, *Anaesthetic & Sedative Techniques for Aquatic Animals*. Vol. 2nd Edition. 1999: Blackwell Science.

Disclaimer:

The information contained in these pages has been collected from many sources since 2001 and while we have tried to be accurate and complete, there may be no specific references to some items. Please help us with the referencing if you recognise where some of the information has been sourced. By all means this is not intended to be an exhaustive resource, but as a quick and useful first point of reference. To the best of our knowledge, the information contained herein is current & correct at the time of publication. Cross referencing with other texts and journal articles may be indicated in some cases. Neither the authors nor the organisations listed make any warranty, express or implied, or assume any legal responsibility for the accuracy, completeness or usefulness of any information. Drs Richmond Loh & Matt Landos.