



FISH
MEDICINE HANDBOOK





FISH SUPPLEMENT

FOR THE EXOTIC COMPANION MEDICINE HANDBOOK

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FISH

The information presented here has been compiled from the literature. It is intended to be used as a quick guide to selected husbandry and medical topics of fish and is not intended to replace reference material.

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Common Variations

- At least 4000 species of fish are kept as pets or in aquariums (not including morphological varieties). There are about 100 commonly kept species.
- Most pet fish fall into 5 categories:
  1. Tropical freshwater species, such as tetras, algae eaters, silver dollars, danios, mollies, swords, barbs, cichlids, and guppies. This is the most popular group of pet fishes.
  2. Temperate freshwater pond fish like goldfish and koi (ornamental carp).
  3. Native (US) freshwater species like bass, sunfish, shiners, dace, catfish, and sticklebacks. Certain species in this group may be subject to local fish and game restrictions. Not common as pets in the home.
  4. Tropical marine (saltwater) species like clown fish, damsel fish, wrasses, butterfly fish, lionfish, marine angelfish, tangs, true sharks, and stingrays.
  5. Native (US) marine species like sculpins, flounder, drum, and herring. Fish in this group are uncommonly kept in the home aquarium and may be subject to local fish and game restrictions.

Popular Freshwater Ornamental Fish

- Some good community aquarium varieties: Mollies, guppies, swordtails, gouramis, silver dollars, tetras, corydoras catfish, small plecostomus species, danios, loaches, koi (primarily for the pond), goldfish (there are numerous varieties available).
- Some aggressive aquarium species: Oscars, Jack Dempseys, red devil cichlids, jewel cichlids, convicts, large plecostomus species, green terrors, piranhas (illegal in some states), carnivorous catfish.
- Single pet aquarium species: Goldfish, any of the above aggressive species, pacu, large catfish.

THE TETRAS: FAMILY CHARACIDAE

- Several hundred different species; bright colors (many silver, black, red).
- Small fish (1-2 inches [2.5-5 cm]). Have swim bladders and adipose fins (small fleshy fin behind the dorsal fin).
- Active swimmers, coexist well with other fish.
- Egg-layers; may be difficult to breed.
- **Common Tetra Species and Variations:**

Black neon tetra	*Hyphessobrycon herbertaxelrodi*
Black phantom tetra	*Megalamphodus megalopterus*

Black phantom tetra	*Gymnocorymbus ternetzi*
Bleeding heart tetra	*Hyphessobrycon erythrostigma*
Blind cave tetra	*Astyanax fasciatus mexicanus*
Blood fin tetra	*Aphyocharax anisitsi*
Buenos Aires tetra	*Hemigrammus caudovittatus*
Cardinal tetra	*Paracheirodon axelrodi*
Glowlight tetra	*Hemigrammus erythrozonus*
Hatchet	*Gasteropelecus sternicla*
Lemon tetra	*Hyphessobrycon pulchripinnis*
Neon tetra	*Paracheirodon innesi*
Serpae tetra	*Hyphessobrycon serpae*
Red pacu	*Piaractus brachypomum*
Silver dollar	*Metynnis argenteus*
Red-bellied piranha	*Pygocentrus nattereri*
Rummy-nosed tetra	*Hemigrammus bleheri*

THE CARPS AND BARBS: FAMILY CYPRINIDAE

- Similar to tetras, less colorful (silver, gold, black/red).
- Some have barbs (small fleshy whiskers on lower jaw). Most lack an adipose fin. Have swim bladders.
- Active swimmers.
- Egg layers (in fine-leaved plants), easy to breed.
- Barbs, danios and rasboras.
- Goldfish:
  * Over 100 varieties — see www.petstation.com/goldfish-varieties.html
  * Not tropical fish, don't keep with warmer water species.
  * Males often have raised tubercles on the gill plate and leading rays of the pectoral fins during breeding season. Spring breeders. Chasing is not reliable in determining sex. Females spawn in plants. Chasing precedes spawning (cover rough edges of pond decorations/substrate to reduce risk of injury).
- Koi:
  * Strong, hardy, tolerate temperature variation.
  * Grow to fit size of their habitat (up to 30 inches [76 cm] long).
  * At 1 inch (2.54 cm) long, most are black or gray; change color as they grow, but general pattern is established when they reach 5 inches (12.7 cm) in length.
- **Common Carps and Barb Species and Variations:**

Goldfish	*Carassius auratus*
Koi	*Cyprinus carpio*
Clown barb	*Barbus everetti*
Zebra danio	*Brachydanio rerio*
Rosy barb	*Barbus conchonius*

Tiger barb	*Barbus tetrazona*
Cherry barb	*Barbus titteya*
Tinfoil barb	*Barbonymus schwanenfeldii*

THE CATFISH

- Belong to 37 different families, mostly freshwater; more than 2000 different species.
- Colors: brown, black and white.
- All have barbels (whiskers). Have swim bladder. Some have bony plates that look like scales.
- Size 1 inch to 5 feet (2.5 cm to 1.5 m), although most are 2-6 inches (5-15 cm).
- Bottom fish, actively search for food using the whiskers. Some are nocturnal. Many catfish are piscivorous (fish eaters). If the mouth is large and/or points forward, it is predatory (eg, angelicus catfish can eat fish larger than itself).
- Often sold as scavengers for community tanks, but require feeding (use sinking food).
- **Common Catfish Species and Variations:**

Aeneus/bronze cory	*Corydoras aeneus*
Arcuatus/skunk/arched cory	*Corydoras arcuatus*
Banjo catfish	*Bunocephalus coracoideus*
Blue-eyed plecostomus	*Panaque suttoni*
Chaca chaca catfish	*Chaca bankanensis*
Glass catfish	*Kryptopterus bicirrhis*
Otocinclus	*Otocinclus vittatus*
Pictus/angelicus catfish	*Pimelodus pictus*
Pleco/plecostomus	*Hypostomus plecostomus*
Red-tailed catfish	*Phractocephalus hemioliopterus*
Spotted talking/ Raphael catfish	*Agamyxis pectinifrons*
Striped talking/ Raphael catfish	*Platydoras costatus*
Upside-down catfish	*Synodontis nigriventris*
Zebra pleco	*Hypancistrus zebra*

THE LOACHES: FAMILY COBITIDAE

- Similar to catfish, but longer and more rounded; some have worm or eel shape (eg, kuhli loach). Swim bladders present.
- Same colors as the catfish, with some brightly colored.
- Many are secretive, coming out only to feed at night. May show amusing antics (eg, clown loaches may roll over and play dead).

- **Common Loaches Species and Variations:**

Algae eater loach	*Gyrinocheilus aymonieri*
Clown loach	*Botia macracanthus*
Dojo loach	*Misgurnus anguillicaudatus*
Flying fox	*Epalzeorhynchos kalopterus*
Harlequin rasbora	*Trigonostigma heteromorpha*
Kuhli/coolie loach	*Acanthophthalmus kuhlii*
Pakistan loach	*Botia almorhae/lohachata*
Red-tail black shark	*Epalzeorhynchos bicolor*
Red-tail botia or orange-finned loach	*Botia modesta*
Silver/bala shark	*Balanteocheilus melanopterus*
Zebra loach	*Botia striata*

THE LIVEBEARERS: FAMILY POECILIIDAE

- Many live in brackish waters. They appreciate, and some species require, a small amount of salt added to their water.
- Small (1-3 inches [2.5-7.5 cm]); the male is often smaller and more colorful than the female.
- Wide variety of color strains with different kinds of finnage.
- Many have enlarged dorsal fin. Young fish and females have fan-shaped anal fins; at about 2 months, males' anal fin becomes narrow and tube shaped. Swim bladders present.
- Give birth to live young.
- Will reproduce in a community tank, but parents may eat fry.
- Carnivorous, feeding on insect larvae in the wild (used in mosquito control programs). Exception: mollies need vegetable matter. Can feed flake food.
- **Common Livebearer Species and Variations:**

Guppy/millions fish	*Poecilia reticulata*
Platy/moon	*Xiphophorus maculatus*
Swordtail	*Xiphophorus helleri*
Sailfin molly	*Poecilia latipinna*

THE CICHLIDS: FAMILY CICHLIDAE

- Includes fish with special water requirements; less tolerant of laxity in water quality than other tropicals.
- Size 1-10 inches (2.5-25.5 cm). Have a classical "fish shape" with prominent fins; many colors. Have swim bladders.
- Very intelligent.
- Carnivorous; can be aggressive fish eaters.
- Angelfish:
  * Schooling fish.
  * Grow to 9 inches tall (23 cm), need large (>20 gal) aquarium.

* Other species such as barbs may attack angels.
* Angels will eat smaller fish and their own fry.

- **Common Cichlids Species and Variations:**

Angelfish	*Pterophyllum scalare*
Black-belt cichlid	*Thorichthys marculicauda*
Blue acara	*Aequidens pulcher*
Convict cichlid	*Cryptoheros nigrofasciatus*
Discus	*Symphysodon aequifasciatus*
Eartheater/jurupari cichlid	*Geophagus jurupari*
Firemouth	*Thorichthys meeki*
Green terror	*Aequidens rivulatus*
Jack Dempsey	*Nandopsis octofasciatum*
Jewel cichlid	*Hemichromis bimaculatus*
Kennyi	*Pseudotropheus lombardoi*
Krib/kribensis	*Pelvicachromis pulcher*
Malawi eye-biter	*Dimidichromis compressiceps*
Oscar	*Astronotus ocellatus*
Pike cichlid	*Crenicichla* sp.
Powder blue/pindani	*Pseudotropheus socolofi*
Ram dwarf cichlid	*Microgeophagus ramirezi*
Rainbow cichlid	*Herotilapia multispinosa*
Red devil	*Cichlasoma citrinellum*
Severum	*Heros severus*
Tilapia	*Oreochromis* hybrid
Zebra cichlid	*Pseudotropheus zebra*

THE LABYRINTH FISH: FAMILY ANABANTOIDEA

- All possess a labyrinth or pseudo-lung, which facilitates the breathing of atmospheric air.
- Size generally 2-4 inches (5-10 cm), laterally compressed.
- Swim bladders present.
- Brightly colored (some females are less colorful than males).
- Prefer the top portion of the tank; require floating food. Enjoy floating plants.
- Males build nest at water surface using bubbles of air and saliva. Fish spawn under the nest, then male places the eggs in the nest, guarding and caring for them (and sometimes the new fry) while they develop.
- **Common Labyrinth Species and Variations:**

Blue/three-spot gourami	*Trichogaster trichopterus*
Croaking gourami	*Trichopsis pumilus*
Dwarf gourami	*Colisa lalia*
Giant gourami	*Osphronemus goramy*
Kissing gourami	*Helostoma temminkii*

Moonlight gourami	*Trichogaster microlepis*
Paradise fish	*Macropodus opercularis*
Pearl gourami	*Trichogaster leeri*
Siamese fighting fish/betta	*Betta splendens*

Popular Pond Fish

THE CARPS: FAMILY CYPRINIDAE

- Koi (Nishikigoi)
- Carp
- Goldfish
- Tench

Popular Marine Tropical Fish

THE DAMSELFISH: FAMILY POMACENTRIDAE

- Hardy, colorful, easy to care for, small.
- Chromis: Most are delicate, must be kept in schools (eg, yellowtail blue damsel).
- *Pseudochromis* sp. (dottybacks): Hardy, size to 3 inches (7.5 cm).
- Clownfish:
  * Gender-neutral fish, with one developing into a female (becoming largest).
  * Tank size recommended: ≥20 gal.
  * Larger species are hardy. Size up to 4 inches (10 cm) (eg, tomato, fire, and sebae clown).
  * Do not require an anemone to live in.
  * Not territorially aggressive.
  * Common (percula) clown is less hardy.
- **Common Damselfish Species and Variations:**

Bicolor damsel	*Stegastes partitus*
Blue devil	*Chrysiptera cyanea*
Clark's clownfish	*Amphiprion clarkii*
Domino/threespot damsel	*Dascyllus trimaculatus*
Dottybacks	*Pseudochromids* sp.
False clownfish	*Amphiprion ocellaris*
Fire clownfish	*Amphiprion ephippium*
Green chromis	*Chromis viridis*
Maroon clownfish	*Premnas biaculeatus*
Percula/true clownfish	*Amphiprion percula*
Pink (skunk) clownfish	*Amphiprion perideraion*
Sebae clownfish	*Amphiprion sebae*
Skunk clownfish	*Amphiprion perideraion*
Tomato clownfish	*Amphiprion frenatus*
Yellow-tailed blue damsel	*Glyphidodontops hemicyaneus*

THE CARDINALFISH: FAMILY APOGONIDAE

- Hardy, grow to 3 inches (7.5 cm).
- Nocturnal, require hiding places. Turn off lights when introducing fish to tank to avoid shock. Not aggressive.
- **Common Cardinalfish Species and Variations:**

Banggai cardinal	*Pterapogon kauderni*
Flamefish cardinal	*Apogon maculatus*
(Gold) striped cardinal	*Apogon cyanosoma*
Pajama cardinal	*Sphaeramia nematoptera*
Red cardinal (15 spp.)	*Apogon quadrisquamatus*

THE BLENNIES: FAMILY BLENNIIDAE

- Lack a swim bladder and most swim at tank bottom.
- Hardy, size to 4 inches (10 cm). Large "canine" teeth.
- Good personality but not colorful.
- **Common Blenny Species and Variations:**

Bicolor blenny	*Ecsenius bicolor*
Forktail blenny	*Meiacanthus atrodorsalis*
Golden/lyretail blenny	*Escenius midas*
Lawnmower blenny	*Salarias fasciatus*
Mimic blenny	*Ecsenius gravieri*
Molly miller blenny	*Scartella cristata*
Redlip blenny	*Ophioblennius atlanticus*
Rockskipper blenny	*Istiblennius zebra*

THE HAWKFISH (ROCKHOPPERS): FAMILY CIRRHITIDAE

- Bottom swimmers, no swim bladder. Normally live in deep water; difficult to acclimate to the confines of an aquarium.
- A lot of personality and color.
- **Common Hawkfish Species and Variations:**

Flame hawkfish	*Neocirrhites armatus*
Longnose hawkfish	*Oxycirrhites typus*
Redspotted hawkfish	*Amblycirrhitus pinos*

THE PUFFERS: FAMILY TETRAODONTIDAE

- Do not keep with invertebrates.
- Up to 12 inches (30.5 cm) long.
- Slow swimming.
- **Common Puffer Species and Variations:**

Burrfish/striped puffer	*Chilomycterus schoepfi*
Dwarf/pygmy puffer	*Carinotetraodon travancoricus*
Spotted puffer	*Tetraodon nigrifilis*
Whitespotted puffer	*Arothron hispidus*

THE GOBIES: FAMILY GOBIDAE

- Small, up to 3 inches (7.5 cm). No swim bladder.
- Spend a lot of time resting on tank floor.
- **Common Goby Species and Variations:**

(Atlantic) neon goby	*Gobiosoma oceanops*
Bumblebee goby	*Hypogymnogobius xanthozona*
Gold head sleeper	*Valenciennea strigata*
Yellow shrimp goby	*Cryptocentrus cinctu*

THE TRIGGERFISH: FAMILY BALISTIDAE

- Require large aquarium.
- Intelligent, aggressive.
- **Common Triggerfish Species and Variations:**

Clown trigger	*Balistoides conspicillum*
Huma/Picasso trigger	*Rhinecanthus aculeatus*
Niger trigger	*Odonus niger*
Redtooth trigger	*Odonus niger*
Undulate trigger	*Balistapus undulatus*

THE SERRANIDS (GROUPERS): FAMILY SERRANIDAE

- Carnivorous.
- Basslets are compatible with most other fish.
- True groupers are large; best kept with triggers, lionfish and moray eels.
- **Common Serranid Species and Variations:**

Panther grouper	*Cromilepetes altivelis*
Swalesi basslet	*Liopropoma swalesi*

THE TANGS AND SURGEON FISH: FAMILY ACANTHURIDAE

- Reef-dwellers, up to 10 inches (25 cm), very colorful, have sharp caudal peduncle spines.
- **Common Tang and Surgeon Species and Variations:**

Brown tang	*Acanthurus nigrofuscus*
Goldrimmed surgeon	*Acanthurus nigricans*
Naso tang	*Naso lituratus*
Purple surgeon	*Acanthurus xanthopterus*
Purple tang	*Zebrasoma xanthurus*
Sailfin tang	*Zebrasoma veliferum*
Yellow tang	*Zebrasoma flavescens*
Yellow-tailed surgeon	*Prionurus laticlavius*

Popular Aquarium Non-fish Species

- Aquarium snails: *Lymnaea* (can be intermediate host for trema-

todes, which require a bird to complete life cycle in most cases).
- Crayfish.

MARINE TANKS
- Shrimps (cleaner, candycane, blood, coral-banded).
- Crabs (anemone, hermit, arrow).
- Sea stars.
- Sea urchins.

Laws and Permits

- Few laws govern the keeping of pet fish.
- Restrictions may apply to species that could survive in the wild (eg, piranhas and stingrays in Florida and Texas) or to C.I.T.E.S. listed species (very few). Most laws affect breeders and commercial aquariums.
- Contact the U.S. Fish and Wildlife Service (www.fws.gov/permits), state wildlife or conservation offices or international wildlife organization for details.
- Consult EPA for regulations regarding runoff of pond water that has been treated.

Housing

TANK ESSENTIALS
- Size: Small tanks are generally more difficult to keep since water quality can change faster.
- Light: Artificial light is easier to control than sunlight. Do not use blue or white fluorescent tubes ("warm"); need red spectrum as well to bring out fish color and enhance plant growth. Incandescent bulbs are not recommended because they give off heat.
- Cover: Many fish will jump so a tight-fitting hood or cover is essential.
- Filter: Filters remove ammonia (nitrogenous waste), debris, and toxins. Water conditioners remove chlorine but not ammonia. Larger tanks may require biological filter and outside-tank filter. Filter types:
  * Adsorption: activated charcoal (limited capacity). Remove during medical treatment of water.
  * Nitrification: Undergravel or wet/dry biological filter. Wet/dry (ammonia tower or trickle) for large volumes. Allow several weeks for biological filter development before adding a full complement of fish.
  * Ultraviolet
  * Ozone

  * Diatom
  * Mechanical: Will not remove ammonia, nitrite, particles <3 microns
- Gravel: Enough to form a 2-3 inch (5-8 cm) layer over undergravel filter (if applicable).
- Submersible heater: Maintain ideal water temperature (monitor with thermometer). Cold fish will huddle at bottom of tank; warm fish may pip at the surface for oxygen.
  * Recommended heater size: 4 watts/gallon (15 watts/L)
  * Marine tropicals: 78-84°F (25-29°C)
  * Freshwater tropicals: 75-80°F (24-26°C)
  * Guppies: 68-84°F (20-29°C)
  * Goldfish, koi thrive at room temp (68-72°F [20-22°C]), can live in outdoor ponds year-round (even when pond freezes over as long as there is running water and an opening in the ice).
- Air pump (with tubing, airstones): Maintain dissolved oxygen at 5-10 ppm.
  * Decrease in dissolved oxygen results from salinity, decreased atmospheric pressure, and increased temperature (cool-water fishes require more oxygen than warm-water fish). Hypoxia develops in outdoor, shallow, heavily planted ponds, warm weather. Test at dawn when oxygen levels are lowest.
- Plants: Provide a place for fish to hide. Plastic plants are usually not eaten by fish, do not transmit disease (unless transferred from another tank). Live plants can carry disease (acting as fomites for pathogens) and don't do well with undergravel filters or some species of fish.
- Tank maintenance equipment (eg, sponge, siphon hose, bucket)
- Net

Water Chemistry Reference Ranges

	Freshwater	Saltwater
Oxygen	5-8 ppm	5-8 ppm
pH	6.5-7.5	8.0-8.5
Specific gravity	1.0	1.020-1.023
Nitrite	<0.5 ppm	N/A*
Nitrate	<30 ppm	<30 ppm
Ammonia	<1.0 ppm	<0.5 ppm
Copper (as a treatment only)	0	<0.2 ppm
Calcium		400-500 ppm

*Detectible nitrite levels may indicate a problem with the filter. Nitrite is rarely toxic to marine fish because chloride competes with nitrite for uptake at the gill epithelium.

Water Quality: Chemical Imbalances and Treatments

ACIDITY, ALKALINITY, AND PH

- Abrupt changes are more disruptive than a specific stable pH level.
- Alkalinity = buffering capacity (not the same as alkaline). Freshwater alkalinity 50-100 mg/L. Measure dissolved cations in water for indirect alkalinity measurement.
- Carbonate (as $CaCO_3$, $MgCO_3$) is the primary buffer in water. Soft water has low total alkalinity; add buffers: crushed coral, dolomite (1 lb per 10 gallon [453 g per 37.8 L] of water) or commercial products from pet stores.
- Over time, water organic acids increase, and ammonia is oxidized to nitrate, lowering pH. Prevent acidity with 10% water change q10d.
- Emergency acidic water treatment:
  * Aerate water vigorously to expel CO_2.
  * Gradually change 25-50% of the water q48h until normal; and/or increase pH with sodium bicarbonate (baking soda).
- Alkaline water treatment:
  * Filter water through peat.
  * Decrease pH with sodium biphosphate or HCl.
  * Use commercial products.

WATER HARDNESS

- Total cations, expressed as mg/L calcium carbonate.
- Soft water (0-60 mg/L) has poor buffering capacity; hard water (>180 mg/L) is a good buffer. Not true when alkalinity is low.
- Water hardness and pH can affect toxicity of some medications.
- Reduce hardness by adding peat.

CALCIUM

- Measure in saltwater tanks; 400-450 ppm recommended.
- If using artificial sea salt, usually Ca is sufficient.

SPECIFIC GRAVITY

- Measure with refractometer or hydrometer.
- Freshwater specific gravity may increase to 1.003 when salt is being used as a treatment.

AMMONIA

- Any detectable ammonia indicates a filter deficiency, too many fish, or overfeeding.
- NH_3 is toxic, un-ionized ammonia.
- NH_4+ is non-toxic, ionized ammonia.

- NH_3: NH_4+ ratio depends on temperature, pressure, salinity, and pH.
- High pH increases toxic, un-ionized ammonia:
  * 3.0 ppm total ammonia at pH 8.5 is deadly.
  * 3.0 ppm total ammonia at pH 6.0 is nontoxic in short-term, but stressful.
- Reverse high ammonia (>1.0 ppm) with a 30-50% water change using dechlorinated water q12-24h.

NITRITE NO_2

- Harmful if >0.5 ppm; in marine systems it is less of a problem since sea water contains much chloride, which competes with nitrite for uptake at the gill membrane.
- Nitrites increase methemoglobin, causing respiratory compromise; known as "brown blood disease."
- Reverse with 30-50% water change + 0.1% salt, or move fish to clean pond or aquarium.
- Biological filters contain bacteria that oxidize ammonia to nitrite and nitrite to nitrate.
- Susceptibility of pond fish to nitrite toxicity (from most sensitive to least): trout and cool water fish; catfish, tilapia and striped bass; goldfish and fathead minnows; large/small mouth bass, bluegill and green sunfish.

NITRATE NO_3

- Levels >40 ppm stressful, <30 recommended.
- Reduce with regular water changes.

CHLORINE/CHLORAMINE TOXICITY

- Chlorinity = amount of Cl, Br, and I dissolved in 1 kg (2.2 lbs) of sea water.
- City water may contain harmful chlorine (0.5-2.0 mg/L) and chloramines (chlorine + ammonia).
- Treatment for chlorine/chloramines toxicity (piping +/- gill necrosis):
  * Bubble 100% O_2 into water.
  * Lower water temperature with ice packs to increase dissolved oxygen. Tropical fishes to 70°F (21°C), goldfish and koi to 55°F (13°C).
  * Add artificial sea salt 1-2 g/L to fresh water.
  * Dexamethasone 2 mg/kg ICe or IV q24h for 3 days.
  * 7 g sodium thiosulfate (water conditioner) removes Cl up to 2.0 ppm from 1000 L; also neutralizes chloramines, but not ammonia.

COPPER
- More toxic at lower total alkalinity; very toxic to invertebrates (crabs, clams, corals, snails, sea urchins).
- Remove with copper filter.
- Look for copper pipes, city water as source.

Tank and Water Tips

NEW TANK CONSIDERATIONS
- Test and balance water chemistry.
- If using a biological filter, allow several weeks for bacterial establishment.
- Add only a few fish at one time.
- Always quarantine new fish for 4 weeks before adding to main tank.
- Number of fish: old rule of thumb "1 inch of fish per gallon of water (2.54 cm per 3.78 L)" (numbers affected by many environmental parameters including water temperature, species of fish, filtration, nutrition).

ESTABLISHED TANK TIPS
- Tanks that are "topped up" repeatedly and not receiving true water changes may accumulate toxic substances, eg, copper.
- Film on tank surface:
  * White film: lime (calcium carbonate), the result of frequent low water levels.
  * Green spots: green algae growing on pits in the aquarium glass. Remove with a razor blade, or wash tank with dilute bleach (thoroughly rinse and re-establish proper water quality).

FRESH WATER TIPS
- When moving fish, mix old and new water to allow acclimatization (0.5 pH/hr). A pH difference of 0.5 or less is not usually harmful.

TIPS FOR PONDS
- Protect fish from birds, cats, rats, snakes, other wildlife.
- Rough estimate for number of fish: Maximum 4-8 koi, 8-13 inches (20-33 cm) long, per 1000 gallons (3785 L).
- Have one deep spot to keep water cool in summer; in winter if pond freezes, must have running water and a hole in the ice (fountain, or a heater, to keep an open spot).
- Goldfish can live through winter, hibernating and living on fat storage (requires ample feeding through autumn).
- High nitrite levels more frequent in fall and spring with

temperature fluctuations, cloudy weather. Check nitrite q2-3wk, or total ammonia nitrogen (NO_2 precursor) weekly (total ammonia nitrogen = NH_3 + NH_4+). Keep chloride: nitrite ratio at least 6:1. Maintain 25-50 ppm Cl in pond, using salt:
* 6 x pond [NO_2] - pond [Cl] = ppm Cl
(if <0, no addition needed).
* NaCl is approximately 60% Cl.

Calculating area and volume of ponds and tanks

- Calculate surface area with a transit, measuring tape, or pacing.
  * Rectangles or squares: area = length x width.
  * Circles: Area = 3.14 x radius^2.
  * Triangles: Area = ½ length x width.
- Volume = length x width x depth; circular tank volume = 3.14 x depth x radius^2.
- Calculate average depth of ponds by taking several depth measurements (from boat with weighted cord) in a grid pattern.
- Cubic inches x 0.000579 = cubic feet.
- Cubic inches x 0.00433 = gallons.
- See www.nettam.com/convert.html for an online conversion calculator for any unit of measure.
- See Southern Regional Aquaculture Center's "Calculating Treatments for Ponds and Tanks" and "Calculating Area and Volume of Ponds and Tanks" for detailed instructions and conversion tables.

SALT WATER TIPS

- Ocean water contains a good balance of elements. Artificial mixes simulate sea water.
- Salinity (specific gravity) 1.022 (use hydrometer). Salinity rises with evaporation. Replace evaporative loss with dechlorinated fresh water. When replacing salt water, use commercial prep (mix before adding) or sea water, not table salt.
- Light: Marine fishes and invertebrates (eg, anemones) require more light than freshwater species. Leave lights on for 6-12 hr/day.
- Substrate: Crushed coral or dolomite, >2mm.
- Reef systems have more stringent light and water flow requirements than pure fish-only aquaria.

Common Measurement Conversion Table

	Cooper Sulfate ($CuSO_4$) Snow	Cooper Sulfate ($CuSO_4$) Powder
1/4 tsp	1.6 g	1 g
1/2 tsp	3.2 g	2 g
1 tsp	6.4 g	4 g
1 Tbsp	19.2 g	12 g
1/4 cup	76.8 g	48 g
1/2 cup	153.6 g	96 g
1 cup	307.2 g	192 g
	Paracide-F (37% Formaldehyde)	**Potassium Permanganate ($KMnO_4$)**
1/4 tsp	1.3 g	2 g
1/2 tsp	2.6 g	4 g
1 tsp	5.3 g	8 g
1 Tbsp	15.8 g	24 g
1/4 cup	63.2 g	96 g
1/2 cup	126.4 g	192 g
1 cup	252.8 g	384 g
	Coarse-grain Salt (NaCl)	**Potassium Permanganate ($KMnO_4$)**
1/4 tsp	1.2 g	1.6 g
1/2 tsp	2.4 g	3.3 g
1 tsp	4.8 g	6.5 g
1 Tbsp	14.4 g	19.5 g
1/4 cup	57.6 g	78 g
1/2 cup	115.2 g	156 g
1 cup	230.4 g	312 g
	Vinegar	**HTH (65% Chlorine)**
1/4 tsp	1.2 g	1.25 g
1/2 tsp	2.5 g	2.5 g
1 tsp	5 g	5 g
1 Tbsp	15 g	15 g
1/4 cup	60 g	60 g
1/2 cup	120 g	120 g
1 cup	240 g	240 g

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Salt Calculations for Common Volumes of Water

Salt (NaCl-sodium chloride). Coarse-grain, meat-curing grade is given with volumes for common table salt in parentheses. Approved (FDA-GRAS declaration) for use on food fish as an osmoregulatory enhancer. Salt by its osmoregulatory action causes fish to release large amounts of mucus from their skin and gills. The release of mucus removes and/or kills (at high salt concentrations) some external parasites on the fish. At low concentrations salt reduces osmotic stress during handling, holding and hauling Ounces in the table refer to weight, NOT FLUID OUNCES. Level all spoon and cup measurements.

Concentration and Duration of Treatment		Volume of water to which salt is added							
		10 gal		100 gal		10 ft³		100 ft³	
10,000-30,000 ppm as a prolonged treatment (30 minutes or until the fish show signs of stress)	g	1,400		11,400					
	kg	1.14		11.4					
	lb	2½		25					
	cups	5 (3⅔)		50 (36⅔)					
		Min	Max	Min	Max	Min	Max	Min	Max
10,000-30,000 ppm as a prolonged treatment (30 min or until the fish show signs of stress)	g	380	1,140	3,800	11,400	—	—	—	—
	kg	.38	1.14	3.8	11.4	2.83	8.49	28.3	84.9
	lb	¾	2½	8⅓	25	6¼	18¾	62⅖	187⅕
	cups	1⅔ (1¼)	5 (3⅔)	—	—	—	—		—
1,000-2,000 ppm (0.1-0.2%) in hauling tanks as an indefinite treatment	g	38	76	380	760	283	566	—	—
	kg	—	—	—	—	—	—	2.8	5.6
	lb	—	—	⅘	1⅔	⅔	1¼	—	—
	Tbsp	2⅔ (2)	5¼ (4)	—	—	—	—	—	—
	cups	—	—	1⅔ (1¼)	3⅓ (2½)	1¼ (1)	2½ (1¾)	—	—
200-500 ppm as an indefinite treatment to relieve stress	g	7.6	19	76	190	56.6	141.5	—	—
	kg	—	—	—	—	—	—	0.57	1.4
	oz	—	—	2⅔	6⅔	2	5	20	50
	tsp	1½ (1⅛)	4 (3)	—	—	—	—	—	—
	Tbsp	—		5¼ (4)	13¼ (9¾)	4 (3)	9¾ (7¼)	—	—
	cups	—		—	—		—	2½	6

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Diet

NUTRIENT REQUIREMENTS AND FEED INGREDIENTS

- Most fish are omnivores. Carbohydrates are not required by many fish (although goldfish and koi use hindgut fermentation to digest complex carbohydrates; other fishes excrete plant matter undigested).
- Most energy is from dietary fat (not more than 15% of the daily intake to avoid hepatic lipidosis).
- Most commercial diets list protein as the largest % of dry matter in the feed. Excess protein breaks down into toxic ammonia, nitrite. Animal proteins are most desirable as they contain the 10 essential amino acids.
- Form: Flakes, floating pellets, sinking pellets, sinking wafers, freeze-dried, frozen, live. Store flakes, pellets in cool (39°F [4°C]), dry, dark areas; replace every 6-8 months.
- Nutrient leaching: Water-soluble vitamins are lost in water from some flake diets within 30 seconds. Pelleted or granular feeds lose less by leaching.
- Provide variety to avoid malnutrition, even with commercial diets.
- Add fresh vegetables.
- Avoid live fish as food—risk of disease/parasite transmission.
- Brine shrimp is fairly nutritious when alive, but does not provide enough protein when frozen and then thawed. Don't use as the only feed.

AMOUNT

- Feed once daily, no more than fish can eat in 3-5 minutes.
- Juvenile fish may require multiple daily feedings.
- Warm water ornamentals (eg, neon tetras, zebra danios, cichlids, gouramis) require 1.0-2.5% of their body weight in food per day.
- Goldfish maintained at 68°F (20°C) require 0.3% of their body weight per day in food.
- "Neighbor syndrome:" neighbors over-feed fish while owners are away, causing rising ammonia levels. Avoid by not feeding when gone; most fish can readily survive 7-10 days without supplemental food.
- Another option is to prepackage food into daily meals.

Preventive Care: Vaccines

- Commercially available vaccines for over 20 viral and bacterial diseases. Mostly used in the commercial food fish industry.
- Some examples:

* Vibrio: a disease of marine fish (*Vibrio* spp.)
* Enteric redmouth disease (*Yersinia ruckeri*)
* Furunculosis (koi ulcerative disease): a killed bacterin for *Aeromonas salmonicida* is available for koi.

Sexing (cichlids only)

- Age 2-24 months before sexually mature.
- Females tend to be larger, have a slightly rounder abdomen, shorter dorsal and anal fins, lack ray extensions on any of the fins, and are less colorful. Males may have elongated fins or extended rays, on the fins.
- Many species differences.

Physiological Quick Facts

Life span:	Freshwater tropical fish: several years, some up to 20 years
Body temperature:	Equal to water temperature
Heart rate:	30-100 beats/min, variable with species
Respiratory rate:	40-80 breaths/min, variable with species

Breeding & Raising Young

- Livebearers easier for beginners (eg, guppies, mollies, platies); livebearing fish must be 3-4 months old before breeding.
- Pregnancy lasts 20-30 days; isolate the breeders from all other fish, including members of their species.
- Supply spawning material (eg, plants, pieces of clay pot, slate).
- Once eggs are laid, remove parents, change >50% of the water to remove any waste products that might decompose and harm the eggs.
- Some species' eggs require darkness, are sensitive to light.

CARE OF EGGS AND FRY

- Use filtration that will not harm eggs or hatching fry.
- Eggs hatch over 1-2 days; earlier hatching fry are larger, may eat others.
- When livebearers are born they sink to the tank bottom briefly before swimming. One brood can include hundreds of fry.
- Move eggs or fry to separate tank to avoid cannibalism by adults.
- Fry survival in ponds is poor; water beetles or beetle larvae may eat fish fry in ponds. Move fish to tank for breeding.
- Need special food for larvae (small enough). Infusorians are microorganism eaten by fry. May also use newly hatched brine

shrimp (purchase eggs).
- Egg-borne fry do not eat for 1-2 days, using yolk sac for nutrition.
- Split the spawn into smaller, more manageable groups as they grow.
- Livebearers can eat when born; move to tank with other fish once they grow too big to be consumed by other fish.
- Goldfish grow to 1 inch (2.5 cm) in 1 month.

Restraint

- Wear latex gloves with talc removed to avoid scale/epidermal damage.
- Keep fish on smooth, moist surface.
- Can restrain fish by placing in plastic bag with a little water.
- Anesthesia or sedation may be required.
- Cover eyes to calm fish, or dim lights.

Examination

FIRST VISIT/ANNUAL EXAMINATION PROTOCOL

- Fish brought to clinic: use a covered container filled only 1/3 with water. Have client bring in any medication being used and food being fed.
- Take history:
  * How long has fish been kept?
  * How long has problem been noticed?
  * Where did the fish come from?
  * What about other fish (number, type, illness)?
  * What size is the tank, and what type and number of filters are used?
  * What are the results of your most recent water test (if done)?
  * What and how often are fish fed?
  * Is tank-mate aggression observed?
  * Has the fish changed color (an early sign of many different diseases)?
- Rule out water quality problems first; test water.
- Examine ophthalmic, neurologic, and dermatologic systems.

SICK FISH EXAM

- Rule out parasites/bacteria: take skin scraping, fin clip, and/or gill snip for wet mount. Take specimens from more than one fish if possible. Continue to look after finding one parasite, could be more.
- Biopsy (eg, skin, fin, gills) or necropsy.
- Evaluation of feces: do not collect from bottom of tank as

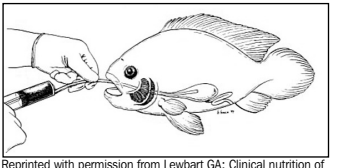
opportunistic organisms may confuse a diagnosis. Isolate fish in clean bucket or plastic bag and wait for fecal production. Place fish in anesthetic solution; fish will frequently defecate as it relaxes. Can also perform a saline rectal wash.

EMERGENCY THERAPY/FIRST AID

- Take history; test water.
- Physical examination.
- Biopsy (skin, fin, gills) or necropsy.
- Take blood sample.
- Radiograph.
- Fluid therapy for marine fish: Use 20 ml/kg/day LRS ICe or PO. Freshwater fish don't drink, are hyperosmotic, don't usually need fluids.
- Dexamethasone injectable for shock 1-2 mg/kg IM or ICe.
- Epinephrine (for shock/cardiac arrest 0.2-0.5 ml IM or ICe of 1:1000).

TUBE FEEDING

- Add water to regular feed, or use high calorie cat/dog canned food or Emeraid II (dietary supplement for tube feeding).
- Most bony fish (eg, cichlids) possess a sacular stomach. Use small volumes for goldfish, koi (lack reservoir stomach).



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- Use flexible, blunt-tipped, feeding tube, can use lubricating jelly.
- Avoid branchial arches when inserting tube into pharynx.

Blood and Sample Collection

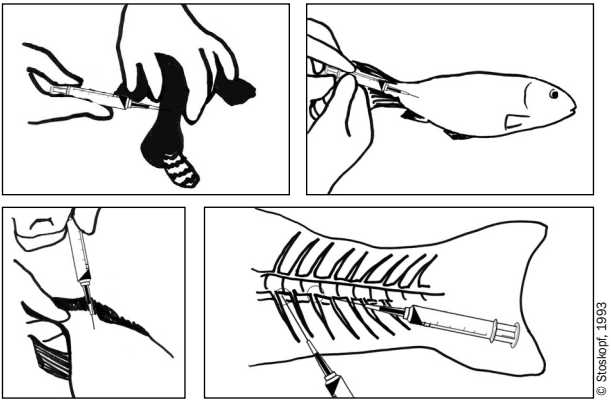
- Require immediate microscopic examination (have slides ready with clean drops of water) and laboratory analysis.
- Take specimens for fresh evaluation (squash prep of any organ, skin scraping, gill or fin snip) and formalin fixation.
- SKIN: Draw a coverslip over area of concern to collect mucus and epidermal tissue.
- FIN/GILL BIOPSY: Cut fin biopsy or 1-2 mm of gill tissue with fine scissors (+/- anesthesia for restraint). Place on slide with drops of water for immediate analysis. Diagnose environmental problems (ammonia, bacterial gill hyperplasia) with gill biopsy.

- BACTERIAL CULTURE: Use blood (fish >10 cm long) or kidney tissue (small fish). Kidneys are ventral to the spinal column along length of body in most species.

BLOOD COLLECTION

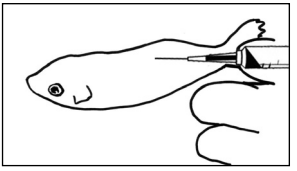
- Use heparinized syringe and needle.
- Technique #1: Direct needle at 90° to the ventral margin of the thin lateral line caudal to the vent and cranial to the tail/caudal peduncle. Insert until resistance from the spinal column is felt, then "walk" ventrally until needle slips into the venous sinus just ventral to the spine.
- Technique #2: Place fish in dorsal recumbency, use a midventral approach, and insert the needle at a point midway between the anal fin and tail. Insert until resistance from the vertebral body is felt, then withdraw needle slightly to caudal venous sinus.
- Technique #3: Fish less than 3 inches (7.5 cm) long—euthanize for diagnosis, remove tail at base, collect blood with capillary tube.

Venipuncture

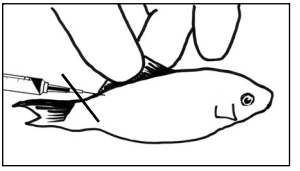


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IM Injection
(epaxial musculature)



IM Injection
Base of the caudal dorsal fin (line)



Diagnostic Testing

- Visualize parasites, fungi, bacteria from skin, fin, or gills.
- Gram stain blood (blood smear may reveal sepsis) or kidney (Note: Gram-negative bacteria normal in skin, gills, water).
- Bacterial diagnosis/culture from blood or kidney.
- Preserve tissue samples in formalin for laboratory analysis (use a laboratory familiar with fish diseases and microbiology).

Hematology

- Higher water temperature, stress, and disease affect hematologic values.
- Manual analysis methods (hemacytometer, refractometer, centrifuge) are required due to cell size and nucleation (RBCs and thrombocytes) that skew automated counts.
- Thrombocytes are the most abundant non-erythroid blood cell in carp and goldfish.
- Red blood cells are oval, nucleated, and larger than mammalian RBCs. PCV lower than 20% indicates anemia.
- White blood cells: Slide-estimate total WBC counts (using the avian white blood cell slide estimate method, which relies on ratios of RBCs to WBCs) are lower than values obtained using a hemacytometer. Pacu RBCs (and likely other fishes too) are present at 50-90% of the concentration observed in birds, so the avian method should be adjusted ([Mean WBC/10 HPF x 2000] + 6300).

HEMATOLOGY REFERENCE RANGES FOR SELECTED FISH*

PARAMETER	GOLDFISH	KOI	RED PACU*	TILAPIA	SANDBAR SHARK*
PCV (%)	26 +/- 1	35 (24-43)	26 (22-32)	33 (27-37)	22.8 (21-23)
RBC ($10^6/\mu l$)	1.5 +/- 0.1	1.67 +/- 0.08	1.7 (1.2-2.9)		
Hgb (g/dl)	9.1 +/- 0.4	6.9 +/- 1.6		2.31 (1.91-2.83)	
MCV (fl)		178.2 +/- 31.7		135.7 (115-183)	
MCH (pg)		40.2 +/- 6.5		34.9 (28.3-42.3)	
MCHC (g/dl)		21.6 +/- 3.3		25.7 (22-29)	
WBC ($10^3/\mu l$)		24 +/- 5.6	33.5 (13.6-52.3)	75.7 (21.6-154.7)	
Heterophils (%)	29 +/- 3		5.2 (0.3-36.7)		5.2 (0.3-36.7)
Lymphocytes (%)	70 +/- 5	79.1 +/- 12.4	84 (53-96)		50 (40-55)
Monocytes (%)	1 +/- 0.1	2.9 +/- 1.3	4 (0.8-11.2)	2.0	3 (2-6)
Eosinophils (%)			0.3 (0.3-0.7)	0.44	0.3 (0.3-0.7)
Basophils (%)		4.6 +/- 2.6			
Neutrophils (%)		10.9 +/- 7.7		2.38	46 (40-58)
Small lymphocytes (%)				80.8	
Large lymphocytes (%)				14.2	
Thrombocytes ($10^3/\mu l$)				52.7 (25.1-85.2)	

PCV (%): Striped bass = 42 (34-48); Southern stingray* = 22 (15-25); Bonnethead shark* = 24 (17-28)

BLOOD CHEMISTRY REFERENCE RANGES FOR FISH			
PARAMETER	**GOLDFISH**	**KOI***	**STRIPED BASS**
AP (IU/L)	—	—	—
ALT (IU/L)	106 +/- 9	—	—
Anion gap (mmol/L)	—	17 (14-23)	24 +/- 1
Bicarbonate (mmol/L)	—	6 (3-8)	—
AST (IU/L)	908 +/- 102	121 (40-381)	45 +/- 21
Calcium (mg/dL)	—	8.7 (7.8-11.4)	11.1 +/- 0.2
Chloride	—	114 (108-119)	144 +/- 2
Cholesterol (mg/dL)	—	—	—
Cortisol (μg/dl)	—	23.7	—
Creatine kinase (IU/L)	—	4123 (80-9014)	—
Creatinine (mg/dL)	—	—	0.3 +/- 0.0
Glucose (mg/dL)	73 +/- 9	37 (22-65)	118 +/- 10
LDH (IU/L)	—	359 (41-1675)	164 +/- 54
Magnesium (mEq/L)	—	—	—
Osmolality (mOsm/kg)	—	—	356 +/- 2
Phosphorus (mg/dL)	—	6.1 (3.5-7.7)	9.8 +/- 0.2
Potassium (mEq/L)	—	3.4 (2.7-4.3)	3.3 +/- 0.2
Protein, total (g/dL)	—	2.0 (1.4-2.7)	4.6 +/- 0.1
Albumin (g/dL)	—	0.9 (0.6-1.1)	1.3 +/- 0.0
Globulin (g/dL)	—	1.1 (0.8-1.6)	—
A:G (ratio)	—	—	0.4 +/- 0.0
Sodium (mEq/L)	—	134 (112-141)	174 +/- 2
Total CO_2 (mmol/L)	—	—	10.7 +/- 0.9
Urea nitrogen (mmol/L)	10 +/- 0	—	—

*Values listed are means except for the red pacu hematology, koi chemistry and elasmobranch data, which are medians. The ranges listed for the southern stingray are 10^{th}/90^{th} percentiles. In some cases the data is not based on a large sample size. These values are only meant to be guidelines. Age of fish, time of year, and water temperature may all affect "normal" clinical pathological data.

References are listed on page 54.

BLOOD CHEMISTRY REFERENCE RANGES FOR FISH		
PARAMETER	**RED PACU**	**TILAPIA***
AP (IU/L)	—	22 (15-39)
ALT (IU/L)	—	—
Anion gap (mmol/L)	6.9 (1.2-12.5)	—
Bicarbonate (mmol/L)	49 (0-125)	—
AST (IU/L)	—	26 (9-102)
Calcium (mg/dL)	10.8 (9.5-12.5)	31 (13.6-69.4)*
Chloride	138 (146-159)	136 (128-142)
Cholesterol (mg/dL)	—	189 (110-318)
Cortisol (μg/dl)	—	—
Creatine kinase (IU/L)	—	—
Creatinine (mg/dL)	0.3 (0.2-0.4)	0.2 (0.1-0.5)
Glucose (mg/dL)	—	46 (30-69)
LDH (IU/L)	238 (65-692)	—
Magnesium (mEq/L)	—	2.5 (1.9-3.5)
Osmolality (mOsm/kg)	—	—
Phosphorus (mg/dL)	7.3 (4.1-8.9)	9.1 (5.5-22.1)*
Potassium (mEq/L)	3.9 (2.7-5.0)	4.3 (3.5-5.4)
Protein, total (g/dL)	—	3.0 (2.9-6.6)*
Albumin (g/dL)	0.9 (0.5-1.0)	1.8 (1.3-2.6)
Globulin (g/dL)	—	2.1 (1.6-4.2)
A:G (ratio)	—	—
Sodium (mEq/L)	150 (146-159)	151 (139-160)
Total CO_2 (mmol/L)	7.5 (6-10)	—
Urea nitrogen (mmol/L)	—	—

*Levels lower for tilapia raised in a low-density system.

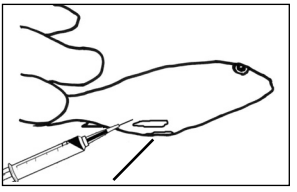
BLOOD CHEMISTRY REFERENCE RANGES FOR FISH		
PARAMETER	**SOUTHERN STINGRAY***	**BONNETHEAD SHARK***
AP (IU/L)	—	—
ALT (IU/L)	—	—
Anion gap	—	-5.8 (-15.7- -7.5)
Bicarbonate (mmol/L)	—	3 (0-5)
AST (IU/L)	14.5 (3.6-61.2)	42 (15-132)
Calcium (mg/dL)	16.5 (12.1-19.3)	16.8 (15.8-18.2)
Chloride	342 (301-362)	290 (277-304)
Cholesterol (mg/dL)	—	—
Creatine kinase (IU/L)	80.5 (11.7-296.5)	82 (18-725)
Creatinine (mg/dL)	---	—
Glucose (mg/dL)	30.5 (16.9-42.4)	184 (155-218)
Lactate (mmol/L)	3.1 (<2.0-6.2)	<5 (<5-11)
LDH (IU/L)	—	—
Magnesium (mEq/L)	—	—
Osmolality (mOsm/kg)	1065 (1008-1144)	1094 (1056-1139)
Phosphorus (mg/dL)	4.7 (3.0-6.4)	8.8 (5.9-12.7)
Potassium (mEq/L)	5.0 (3.2-6.4)	7.3 (5.7-9.2)
Protein, total (g/dL)	2.6 (1.6-3.2)	2.9 (2.2-4.3)
Total solids (g/dL)	5.6 (4.2-6.0)	—
Albumin (g/dL)	—	0.4 (0.3-0.5)
Globulin (g/dL)	—	2.6 (1.9-3.8)
A:G (ratio)	—	0.1 (0.1-0.2)
Sodium (mEq/L)	315 (296-326)	282 (273-292)
Total CO_2 (mmol/L)	—	—
Urea nitrogen (mmol/L)	444 (423-462)	1004 (944-1068)

*Values listed are means except for the red pacu hematology, koi chemistry and elasmobranch data, which are medians. The ranges listed for the southern stingray are 10^{th}/90^{th} percentiles. In some cases the data is not based on a large sample size. These values are only meant to be guidelines. Age of fish, time of year, and water temperature may all affect "normal" clinical pathological data.

References are listed on page 54.

Routes of Drug Administration

INJECTABLE: Subcutaneous, intramuscular, intravenous and intracoelomic. Place fish in plastic bag, drain water, inject through bag. Alternatively, fish can be sedated prior to injection.



Intracoelomic (ICe) Injection: Either caudo ventral abdomen (needle) or just caudal to the base of the pelvic fin — a few mm from the bone (line)

ORAL: Mixed with food or placed in a chunk of food and then fed or force-fed. Avoid with anorexic fish.

- Manufactured gel food (can mix in medications): Mazuri® Aquatic Gel Diet.
- Recipe for gelatinized medicated food (modified from recipe of Dr. John Gratzek, College of Veterinary Medicine, University of Georgia):
  * Boil 500 ml tap water
  * Add 21-35 g powdered unflavored gelatin (3-5 7-g packets), stir to dissolve, cool (do not set)

  Mix in blender:
  * 250 g flake food
  * 500 ml tap water
  * 25 ml cod liver oil + 25 ml vegetable oil (optional)
  * Can of sardines, tuna, or baby food spinach (optional)
  * Add medications and mix.
  * Mix medicated food with gelatin, stir, refrigerate or freeze
  * Use cheese grater to make bite-sized pieces

TOPICAL: Medication applied directly to the lesion or parasite.

WATER TREATMENTS: ***Discontinue chemical (charcoal) filtration and water flow through biological filter, but continue aeration.*** Use hospital tank, not regular tank, if possible.

- Bath: Less desirable than injectable or oral. Drug is dissolved in the water in which the fish are swimming. Lasts 15 minutes to 24 hours. Dosage based on water volume.
- Dip: Fish is submerged in a solution for 1 second to 15 minutes.
- Flush or flow through: Constant water flow, used in raceways or narrow vats. Medicant is added to inflow area. Fish may not have to be removed from their normal holding area.
- Indefinite bath: Medication added to tank or pond with no water change or immediate re-treatment.

Radiography

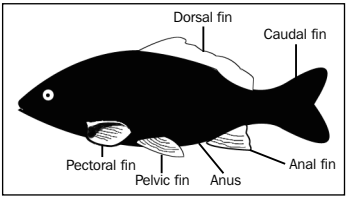
- Use to diagnose swim bladder disorders, GI impactions, foreign bodies, skeletal abnormalities.
- Take radiographs of normal fish to establish technique and obtain normal views.
- May be done without anesthesia, fish in lateral recumbency on plate protected with plastic bag. Some fish can be placed directly on the protected plate, others can be restrained by placing in plastic bag with a little water.
- Large catfish, koi, cichlids may require sedation.
- Dim room lights to reduce photophobia.
- Obtain DV or VD views by rotating radiograph machine for a horizontal beam.
- Grid is unnecessary; high-detail intensifying screens and detail film are recommended.

Necropsy

- Dead fish autolyze rapidly. Instruct owner to remove fish (preferably when moribund) and bring in ASAP. For fresh-dead fish have owner place in plastic bag and refrigerate. Bring water sample in separate container.
- Euthanize with tricaine methanesulfonate (>400 mg/L 15 minutes) or cut at base of cervical spine, or both.
- Remove operculum to expose gills and then body wall to reveal internal organs.
- Take specimens for fresh evaluation (squash prep) and formalin fixation.

NORMAL FISH ANATOMY

- Heart is two-chambered (one ventricle and one atrium). There is also a sinous venosus and bulbus arteriosis.
- Kidneys can be a long single organ (trout) or divided into two regions (anterior and posterior, in catfish, koi, goldfish). The kidneys are fused and lie retroperitoneally, dorsal to the swim bladder and ventral to the spine in most species.
- Bony fish (most pet fish, except sharks and rays) have a swim bladder that regulates buoyancy.
- Swim bladder has either a single chamber (cichlids) or two chambers connected by an isthmus (carp, goldfish, tetras).



- Sensory lateral line system along body and head mediates responses through CNS. Seen as a line of dots or pits along scales.

Anesthesia and Sedation

TRICAINE METHANESULFONATE (FINQUEL®, MS-222)

- Make stock solution with 10 g/L of dechlorinated, deionized water, (using special filter or distilled water) buffered to pH 7.0 with 5-10 g/L sodium bicarbonate.
- Store away from light at room temperature, lasts 30 days.
- Concentration of 100-150 mg/L will anesthetize fish in 3-5 minutes (100 for most fish, 150 for larger cichlids, koi).
- Higher doses take effect more quickly; lower doses are appropriate for maintenance or long term.

CLOVE OIL (EUGENOL)

- Available at pharmacies.
- Dilute in 95% ethanol at 1:9 ratio to make 100 mg/ml (1 g drug in 1 ml clove oil).
- Concentration of 25-120 mg/L will anesthetize fish; recovery more prolonged than with MS-222.

ANESTHESIA TIPS

- Anesthesia stages: excitatory, sedation, loss of equilibrium and loss of any reactivity.
- Anesthesia is adequate if fish has only mild opercular movements.
- Obtain longer-term anesthesia using a recirculating anesthesia machine, ensuring gills are bathed with anesthetic water (90-160 mg/L, 3 L/minute).
- Reverse or reduce anesthetic level by reducing anesthetic concentration or placing fish in fresh clean water.
- After anesthesia and procedures are complete, place fish in aerated recovery tank.

Surgery

MAIN INDICATIONS FOR SURGERY

- Correction of swim bladder abnormalities.
- Removal of growths (neoplastic or parasitic).
- Enucleation.
- Endoscopic exam for sexing or diagnosis.
- Implanting telemetry devices.

PREPARATION OF FISH

- Pre-op: evaluate with radiology and/or ultrasonography.
- Anesthetize, then place on wet foam pad with "V" cut out to support fish.
- Keep fish moist with regular basting.
- Remove scales from surgical area with forceps.
- Wipe incision area with a small amount of saline, dilute povidone iodine (1:20), or chlorhexidine (1:40).
- Routine pre-operative antibiotics may reduce secondary bacterial infection (enrofloxacin 10 mg/kg ICe or oxytetracycline 10 mg/kg IM).
- Clear plastic drapes retain moisture and provide sterile field.

SURGICAL TIPS

- Bipolar cautery helps control hemorrhage (caution in small patients to avoid damaging adjacent tissues).
- Use small animal instruments and/or ocular or microsurgical pack and head loupe magnification.
- When removing growths, strive for wide margins over complete primary closure.
- Swim bladder is fragile and can collapse if torn.
- "Absorbable" sutures may not be absorbed in fish; use monofilament to avoid bacterial colonization. Healing time is shortest and skin reaction is least using polydioxanone suture. Cyanoacrylate irritates; avoid.
- Use cutting tip needle. Suture pattern: simple continuous, simple interrupted, or Ford interlocking pattern on skin, with single or 2-layer closure.
- Aspirate air from abdomen with suction when closing muscular layer.
- Control pain with butorphanol.
- Lack of mobile skin makes defects difficult to close; second-intention healing is common. Reduce osmotic gradient to enhance healing: add salt to pond/tank at 1-3 g/L for freshwater patients.
- Apply povidone iodine ointment to closed incision before returning fish to recovery water.
- Remove skin sutures upon healing (10-14 days).

Common Medical Conditions

FATTY LIVER DISEASE

- Fish fed methyltestosterone to enhance color; history of slowly fading color, gradual wasting 1-2 months after purchase.
- Fish fed high-fat diet.

- Differential diagnosis for color fading: liver disease, stress, cold shock, hypoxia; young goldfish frequently lose black markings.
- Treatment: change diet; poor prognosis.

NEOPLASIA

- Diagnosis: enlarged abdomen and/or growth; radiography.
- Many tumors in wild fish are skin tumors. Most common tumors: benign epidermal hyperplasia (may be viral origin); papillomas; sarcomas.
- Surgical removal is possible.

BUOYANCY PROBLEMS, SWIM BLADDER "DISEASE"

- Affects fish with swim bladders.
- Causes: supersaturation of water with air, infection/rupture of swim bladder, inner ear disease, GI disease (obstruction of pneumocystic duct by food); congenital deformation.
- Treatment: treat inciting cause; aspirate air and/or surgical correction; ignore (some can eat upside down).
- Feed 1-2 green peas per day (unknown mechanism).
- Prevent by avoiding feeding dry food, or soak flakes/pellets before feeding (reduces air gulping).

SUPERFICIAL WOUNDS

- Caused by parasites, protozoa, trauma, aggression, or pre-spawning chase in ponds or tanks with rough rocks.
- Secondary bacterial infection may occur.
- Internal tissues of freshwater fish are hyperosmotic; internal tissues of saltwater fish are hypo-osomtic. Surface wounds disturb osmotic balance, may result in loss of fluid balance and circulatory collapse.

SIGNS ASSOCIATED WITH WATER QUALITY PROBLEMS

- Stress of poor water quality can predispose to any disease.
- Excess mucus production, skin inflammation, gill erosion, hemorrhage: Acidosis.
- Pale gills, skin erosions, gill necrosis (noted at necropsy): Alkalosis.
- Piping (gasping for air at water surface) indicates oxygen deprivation: Increase aeration. Note: This can be normal behavior for air breathers (eg, lungfish, eels); surface-dwelling fish (eg, leaf fish); bubble-nesters (fish that build nest for their eggs from bubbles they produce).
- Gas under skin, visible bubbles in various tissues; sudden death: Gas bubble disease. Caused by supersaturation,

moving fish from cold to warm water, defective pumps. Reduce aeration.
- Hypoxia following inappropriate transport: Place fish in bag 1/3 filled with water, inflate bag with 100% O_2.
- Ponds: runoff or acid rain pollution.

HEAD AND LATERAL LINE EROSION SYNDROME (HLLE) OF MARINE FISH
- Superficial erosions of head, face, progressing down lateral flank to and including the lateral line.
- Etiology unknown; some cases respond to vitamin C supplementation, removal of charcoal filter.
- Encouraging results with topical application of Regranex®, α human platelet growth factor.

VITAMIN E DEFICIENCY
- Fraying and deterioration of tail and fins, secondary infections, death.

VITAMIN A DEFICIENCY
- Poor growth, retinal atrophy.

CONSTIPATION
- Signs: Failure to defecate; anorexia.
- Cause: Using dry pelleted foods, especially in ponds.
- Treatment: add 0.3% magnesium sulfate salt to the diet. Laxatives: chopped earthworms, spinach, other vegetables.

ABNORMAL BEHAVIOR
- Bottom-sitting (normal in sedentary/sleeping fish).
- Circling: damage to one eye or one fin.
- Hovering (normal in angel fish, hatchet fish, Siamese fighting fish, some fancy goldfish).
- Aggression.

Zoonotic Potential
- Mycobacteriosis of aquarium fish is caused by *Mycobacterium* spp., which can cause skin lesions and allergic dermatitis in humans.
- Edwardsiellosis.
- Shigellosis.
- Vibriosis.
- Salmonellosis.

RULE-OUT CHART BASED ON CLINICAL SIGNS

CLINICAL SIGNS	DIFFERENTIAL DIAGNOSIS	DIAGNOSTIC OPTIONS
Erratic swimming	Chlorine toxicity, sepsis, trauma	Water quality test, physical examination
Exophthalmos	Bacterial infection; neoplasia, gas bubble disease, sepsis	Blood/kidney culture, necropsy/biopsy, ophthalmic examination
Flashing, rubbing, itching	Ectoparasites	Skin scraping / wet mount
Gill necrosis	Koi herpes viral disease, chlorine toxicity, bacterial gill disease	Water quality test, history, necropsy
Piping	Temp. too high; nitrite or chloramine toxicity, hypoxia	Water quality testing
Skin, gill, or fin lesions	Ectoparasites, protozoa, fungi, bacteria, tank-mate aggression, HLLE of marine fish	Skin/gill scraping, microscopic evaluation, C&S
Sudden death	Gas bubble disease, chlorine toxicity, acidosis, bacterial (esp. *Aeromonas*) infection, new tank syndrome, tank-mate aggression	Blood/kidney culture, water quality test, examine gill biopsies for intravascular air emboli
Swelling/ascites “dropsy”	Bacterial infection, renal/hepatic/cardiac failure	Blood/kidney culture, biopsy, necropsy
Tail walking (swimming vertically)	Protozoal infection, gas bubble disease, sepsis, encephalitis/ meningitis	Physical examination, necropsy

DISEASES OF FISH

DISEASE	CLINICAL SIGNS	DIAGNOSTIC OPTIONS	SPECIES AFFECTED	POSSIBLE THERAPY
VIRAL				
"Carp pox," a herpesvirus	"Melted candlewax" lesions on head, fins, and body.	Biopsy and histology	Koi and carp	No treatment known, may be self-limiting
Koi herpesvirus	Severe mortality; acute gill necrosis	Electron microscopy/virus isolation; PCR testing	Koi	No proven treatment; quarantine new fish for one month
Lymphocystis (an iridovirus)	Hypertrophy; white granular lesions on skin, fins	Skin scraping: cells enlarged, circular, clusters	Marine; brackish water (*Scatophagus*, *Monodactylus, Changa*); green terror (*Aequidens rivulatus*)	Self-limiting; surgical removal of growths +/- antibiotics
BACTERIAL				
Aeromonas hydrophila Motile Aeromonad Disease (MAD)	Petechiae, ecchymosis, hemorrhagic septicemia, inflammation of GI, kidney, spleen, muscle, exophthalmia, abdominal distension, vent swelling, skin/fin necrosis	Opportunistic pathogen (stress, poor nutrition). View motile aeromonads in tissue samples	Many freshwater species	Antibiotic based on C&S
Aeromonas salmonicida infection (ulcer disease)	Deep ulcers, exophthalmia, ecchymosis, distended abdomen, death	Blood/kidney C&S using heart-enriched 5% blood agar	Goldfish, koi	Injectable antibiotic in affected fish, oral treatment of others

DISEASES OF FISH				
DISEASE	**CLINICAL SIGNS**	**DIAGNOSTIC OPTIONS**	**SPECIES AFFECTED**	**POSSIBLE THERAPY**
Bacterial skin infection secondary to wounds, stress	Hemorrhage, ulcers, erosions	Skin cultures not usually rewarding. *Aeromonas, Pseudomonas, Vibrio* (marine)	Many species	Topical antibiotic and/or antibiotic PO, IM, ICe. Identify cause
Flavobacterium columnaris ("Columnaris disease" in freshwater fish)	Primary pathogen; blanched necrotic skin lesions, saddle-like marking behind dorsal fin; whitish split areas of fins, tail, face.	Wet mount of tissue to visualize "haystacking" bacteria	Many freshwater species. mollies, platies esp. sensitive	Antibiotics via immersion or topically; potassium permanganate bath
Mycobacteriosis	Emaciation, skin/fin ulceration; internal granulomas, anorexia, general unthriftiness	Identification of acid-fast organisms in impression smear or histologic section; culture; PCR analysis	Many freshwater and marine species. This disease should always be on the differential list when fish are debilitated.	Some anecdotal success treating with antibiotics such as enrofloxacin and rifampin. Clinician must consider the contagious nature of this disease and the zoonotic potential.
Pseudomonas and other Gram-negative bacteria	Necrosis of skin, fins; death	Skin scraping C&S; blood or kidney culture	Many freshwater species	Antibiotic based on C&S
Vibriosis	Systemic hemorrhagic disease	C&S	Marine fish	Antibiotic based on C&S

DISEASES OF FISH

DISEASE	CLINICAL SIGNS	DIAGNOSTIC OPTIONS	SPECIES AFFECTED	POSSIBLE THERAPY
FUNGAL				
Ichthyophonus (sandpaper disease)	Skin discoloration, multiple white papules, subcutaneous granulomas	Wet mount; round/elliptic cysts	Marine fish	Eliminate fresh fish from diet
Saprolegnia or *Fusarium*	Infects wounds, stressed fish; white cotton-like random growths, anorexia, lethargy	Microscopically view fungal hyphae, microconidia for *Fusarium*	*Saprolegnia* freshwater only. *Fusarium* more common in marine fish.	Self-limiting; formaldehyde, salt. Manual removal + topical antimicrobial or povidone iodine.
PARASITIC (PROTOZOAN) - See drug formulary for doses				
Brooklynella	See *Chilodonella* below. Skin: small discolored foci, epithelial slough, death	Skin scraping wet mount: bean to heart-shaped ciliates with oval macronucleus	Marine; clownfish, seahorses	Formaldehyde + malachite green, antimicrobials for secondary infection
Chilodonella	Skin/gills, respiratory distress, excess mucus, death	Skin scraping, wet mount; heart-shaped ciliate, slow circular motion, dies quickly	Freshwater tropicals, fish farms	Formaldehyde, malachite green, salt

DISEASES OF FISH

DISEASE	CLINICAL SIGNS	DIAGNOSTIC OPTIONS	SPECIES AFFECTED	POSSIBLE THERAPY
Cryptocaryon (Saltwater "Ich," white spot disease)	Skin irritation, whitish-gray nodules, excess mucus production, increased respiration	Skin scraping	Marine (optimum growth at 30°C, 31 ppt salinity)	Copper sulfate as prophylaxis. Formaldehyde. Increase water temp 2-3°C q5-7d; move fish to clean water q7d to limit reinfection. Hyposalinity
Epistylis (Heteropolaria)	Pale white tuft-like lesions resemble fungus. Normal tank inhabitant, stressed or debilitated fish, look for *Aeromonas*	Wet mount prep: Ciliated crown atop long stalk, bell-shaped	Freshwater, goldfish, bottom dwelling eg, plecostomus catfish	Formaldehyde; topical iodine; clean tank regularly to reduce organic matter buildup
Henneguya	White cysts on dorsal fins, gills; not harmful	Wet mount prep	*Leporinus*	Remove by scalpel scraping
Hexamita (Spironucleus)	GI disease; normal GI inhabitant	Wet mount prep of feces or intestine	Many, esp. freshwater angelfish	Metronidazole
Ichthyobodo (Costia)	Normal and diseased skin	Small, 5-10 micron, rapidly moving, sickle shaped	Freshwater, some marine	Formaldehyde
Ichthyophthirius "Ich"	Skin, gills, whitish gray nodules	Skin scraping; largest protozoa of fish, to 1.0 mm	Freshwater	Formaldehyde; increase water temp 2-3°C q5-7d; move fish to clean water q7d to limit reinfection

DISEASES OF FISH

DISEASE	CLINICAL SIGNS	DIAGNOSTIC OPTIONS	SPECIES AFFECTED	POSSIBLE THERAPY
Plistophora "Neon tetra disease"	White pale muscle; death; tail-walking; pale epaxial musculature	Microsporidian spores in muscles	Neon tetras and others	Remove diseased fish
Tetrahymena "Guppy killer"	Normal tank inhabitant. Deep skin infection, necrosis surrounded by hemorrhage +/- exophthalmus, death	Pear-shaped protozoa viewed on wet mount	Guppies and species in crowded aquaria	Cull affected fish, maintain proper hygiene
Trichodina	Skin, gills, fins	Disc-shaped protozoa, radial symmetry, denticular ring	Freshwater and marine species, esp. crowded goldfish	Formaldehyde
Uronema	See *Tetrahymena*	Pear-shaped protozoa viewed on wet mount	Marine	Treatment usually ineffective

DISEASES OF FISH

DISEASE	CLINICAL SIGNS	DIAGNOSTIC OPTIONS	SPECIES AFFECTED	POSSIBLE THERAPY
PARASITIC (METAZOAN) - See drug formulary for doses				
Amyloodinium/Oodinium (Dinoflagellate; velvet disease, coral fish disease, rust)	Fine dusty gold appearance of skin, gills; ulceration, itching, "flashing"	Wet mount skin scraping, gill biopsy; pear-shaped cysts attached to underlying tissues	Marine (*Amyloodinium*) and freshwater fish	Copper sulfate
Argulus (fish louse)	Skin irritation, ulceration with secondary bacterial or fungal infection	Visible (transparent); Skin scraping	Freshwater, esp. goldfish and koi	Manual removal. Organophosphates, glacial acetic acid dips (to remove juveniles), saltwater dips, chitin inhibitors (diffubenzuron & lufenuron)
Cestodes (tapeworms)	GI-related; weight loss	Fecal exam or observe proglottids	Many	Praziquantel
Digenean flukes "salt & pepper disease" and "Grub"	Primarily aesthetic. Severe gill infestations can cause problems.	Metacercaria in & under skin; 5-mm worms (Grub)	Silver dollar fish, red hooks, pond-reared livebearers	Praziquantel
"Hole in the head"* disease	Head & lateral line erosions	Physical examination	Oscars, other New World cichlids	Metronidazole may be of some benefit
Isopods (*Livoneca*)	Look like "pill bugs" on fish	Visual examination	Primarily marine, some freshwater	Manual removal

*Syndrome has been partially attributed to *Hexamita (Spironucleus)* but many clinical cases don't reveal these parasites.

DISEASES OF FISH

DISEASE	CLINICAL SIGNS	DIAGNOSTIC OPTIONS	SPECIES AFFECTED	POSSIBLE THERAPY
Lernaea sp. (anchorworm, a crustacean)	Localized irritation, hemorrhage	Visible 2 cm worm anchored to skin/muscle	Freshwater, esp. goldfish and koi	Manual removal. Organophosphates, glacial acetic acid dips (to remove juveniles), saltwater dips, chitin inhibitors (diffubenzuron & lufenuron)
Monogenean trematodes (*Dactylogyrus* = gill flukes, *Gyrodactylus* = skin flukes)	Gills: Hyperplasia, asphyxiation. Skin: Localized hemorrhage, ulcers, mucus, ragged tail. Flashing, rubbing, inactivity, death.	Microscopic: 0.1 - 0.8 mm worm with hold-fast hooks (haptor)	Overcrowded koi; fresh and marine	Fresh or salt water baths. Salt; glacial acetic acid or H_2O_2 dips; praziquantel.
Nematodes (many species)	GI worms, skin/muscle cysts	Fecal exam; visualize cysts	Esp. in wild-caught animals.	Surgically remove large cysts; fenbendazole or piperazine in food; levamisole bath
Philometra ("red worm" disease)	Swollen abdomen	See worms protruding from anus	Guppies	Nematodicides
Trypanosomes	Blood parasite	Blood smears	Wild fishes, esp. loricarid catfishes	None known

Formulary

- No drugs are FDA-approved for ornamental pet fish.
- Use caution (attention to runoff onto plants, into other water sources) when disposing of treated water or when changing water in outdoor ponds.
- Systemic bacterial infections usually secondary to stress, poor water quality, parasites/fungi/protozoa.
- *A. salmonicida* is an obligatory pathogen.
- Adding antibiotics to tank can be deleterious to natural, beneficial bacteria; preferable to use dips. Treat based on culture and sensitivity results.
- The FDA is currently examining the wide availability of prescription drugs, especially antibiotics (for more information on the FDA and the use of drugs in aquaculture, consult the following web address: www.fda.gov/cvm. With the recent passing of the Minor Use and Minor Species (MUMS) Animal Health Act, we are likely to see some dramatic changes in the availability of drugs for use in fish (it is likely that these changes will mean more "approved" drugs). Such measures will necessitate sound pharmacokinetics, efficacy, and safety studies to support clinical use of antimicrobials and other chemotherapeutants in fishes. Relatively little research related to pharmacology has been reported in aquarium fishes. What little information exists is based on clinical efficacy and in vitro trials using a number of different antimicrobials. An on-line database (www.aapsj.org/view.asp?art=aapsj070230) contains valuable information on pharmacokinetics in fish (Reimschuessel, et al, 2005).

DOSING ROUTES:

- Before using any drug in the water, discontinue chemical (eg, carbon) filtration during treatment as this will inactivate the drug. Adequate aeration is also important during any water treatment.
- Due to their aquatic nature, generally small size, and frequently large numbers, a variety of atypical methods are utilized to deliver antibiotics to pet fish. Standard parenteral methods can and commonly are used to dose aquarium fish with antibiotics, but the clinician must also be familiar with the terminology applied to water borne treatments (below):

ROUTES OF ANTIBIOTIC ADMINISTRATION FOR ORNAMENTAL FISH:

- **Bath:** Usually refers to a treatment in which the drug is dissolved in the water in which the fish are swimming. The

treatment lasts at least 15 minutes and less than 24 hours. Dosage is normally based on volume of water and not on fish biomass.*

- **Dip:** Refers to a treatment in which the fish is submerged in a particular solution for between 1 second and 15 minutes. Water volumes are usually smaller than those of bath treatments and drug concentrations are frequently higher.
- **Flush or Flow Through:** Requires constant water flow. Most frequently used in raceways or narrow vats. The chemotherapeutant is added to inflow area and fish are exposed to the drug as it passes over them with the water current. Similar to dip procedure except fish may not have to be removed from their normal holding area.
- **Indefinite Bath:** Medication is added to aquarium and usually there is no water change or immediate retreatment.
- **Injection:** The antibiotic is given by injection with the aid of a hypodermic needle and syringe. Routes may be subcutaneous, intradermal, intramuscular, intravenous, and intracoelomic (intraperitoneal).
- **Oral:** Medication is mixed with the food in order to treat the fish. Usually done by incorporating the drug into a gelatinized food mixture. For larger fish patients, medication can be placed in a chunk of food and then fed or force-fed to the patient.
- **Topical:** The medication is applied directly to the lesion.

*When antibiotics are used as bath treatments, ideally they should be used daily for 5-7 days. Water changes (at least 50%) should take place between treatments. This protocol is much easier to follow in a home or hospital aquarium than in a pet store or wholesale facility.

DRUGS AND DOSAGES:

- The majority of the current information on chemotherapeutics used in aquarium fish has been extrapolated from the aquaculture literature. There are a number of reasons for this, most of which revolve around funding for sound pharmacokinetic research. An article summarizes the literature on this subject (Stoffregen, et al, 1996). There are currently only three antibiotics approved for use in fish intended for human consumption (Romet-30R, Terramycin for Fish®, and, as of October, 2005, Aquaflor® – florfenicol). Much of the literature dealing with antibiotic usage in aquarium fish is empirical and anecdotal. Fortunately, the veterinarian treating aquarium fish can apply current extra label drug use regulations when selecting and initiating antibiotic therapy.

The formulary is not meant to be a complete listing of all drugs available to treat fishes nor has the information provided been proven to be safe and effective on all species. The formulary is a quick reference of drugs and dosages for the treatment of pet fishes by a licensed veterinarian.

FISH FORMULARY

DRUG	ROUTE	DOSAGE	USE
Amikacin sulfate (Amiglyde-V®)	IM	5 mg/kg then 2.5 mg/kg q72h x 5 treatments	Antibiotic
Butorphanol	IM	0.1-0.4 mg/kg	Pain control
Ceftazidime (Fortaz®)	IM or SC	20 mg/kg q72h	*Pseudomonas*
Copper sulfate	Bath, dip	Bath: 0.18-0.22 mg/L x14-21d (marine fish only; monitor levels daily and add more as necessary to maintain 0.18-0.22 mg/L) Caution: toxic to elasmobranchs and invertebrates	External protozoans
Dexamethasone injectable	ICe, IV or IM	2 mg/kg ICe or IV q24h x3d; for shock: 1-2 mg/kg IM or intracoelomically	Chlorine / chloramine toxicity; shock
Dimethyl phosphonate; trichlorfon (liquid form for cattle grubs)	Bath	0.25-0.5 mg/L q10d x 3, with 20-30% water change 24-48 hr post-treatment	Parasitic crustaceans (fish lice, anchorworm)
Diflubenzuron (Dimilin®) (anecdotal evidence for lufenuron efficacy as well)	Bath	0.01 mg/L q48h x 7d x 3 treatments, 7d apart (very effective but may kill desirable invertebrates). May require an EPA license to administer. Anecdotal reports lufenuron (Program®) at a similar dose with good success.	Parasitic crustaceans (fish lice, anchorworm)
Enrofloxacin (Baytril®) 22.7 mg/ml injectable or tablets	IM, ICe, PO, bath	5-10 mg/kg IM, ICe q48h x7-21d (dilute 1:1 with sterile saline to reduce irritation); or 5 mg/kg PO 10-14d, or 0.1% in food 10-14d; or 2.5 mg/L x 5 hr bath q24h x5-7d, with 50-75% water change between treatments; Recent work indicates 10 mg/kg ICe x5d for koi at 20°C.	Antibiotic
Epinephrine	IM or ICe	0.2-0.5 ml of 1:1000	Shock / cardiac arrest

FISH FORMULARY

DRUG	ROUTE	DOSAGE	USE
Erythromycin (water-soluble phosphate form)	Bath or PO	Bath: 200 mg/10 gal for 6-12 hr q24h; PO 100 mg/kg/d x14-21d. Watch for resistance.	Antibiotic
Eugenol (clove oil) 1:10 with 95% ethanol (stock approx. 100 mg/ml)	Bath	25-120 mg/L are effective in freshwater and marine species and results are comparable to MS-222, except that recovery may be prolonged	Anesthesia; alternative to MS-222
Fenbendazole (Panacur®)	In gel food or PO	In gel food at 0.2% (200 mg/100 g food) x3d, repeat in 2 wks, or 50-100 mg/kg PO, repeat in 2 wks	Intestinal nematodes
Florfenicol	IM	10-30 mg/kg q24h	Antibiotic
Formaldehyde 37% (100% formalin)	Bath or dip	Bath: 20-25 mg/L (ppm) (1.0 ml of 100% formalin [37% formaldehyde] in 10 gal [38 L] water) x 12-24 hr, then 50% water change, every other day x 3 treatments. Encysted parasites like "Ich" and *Cryptocaryon* require several treatments. Or, dip 100-250 ppm 30-60 min. Effective for some ecto-parasites in koi as a 10-min dip at 100-150 mg/L. Caution: carcinogen; may compromise biological filter; removes O_2 from water (increase aeration). Formalin is the only parasiticide approved for use in food fish. Monitor fish closely for signs of distress. Always change water between treatments.	Protozoa; fungal disease
Glacial acetic acid	Dip	2 ml/L 30-45 sec (test 1 fish for sensitivity)	Trematodes in goldfish; parasitic crustaceans (fish lice, anchorworm)
Hydrogen peroxide 3%	Dip	70 mg/gal x 4 minutes	Protozoa

FISH FORMULARY			
DRUG	**ROUTE**	**DOSAGE**	**USE**
Levamisole phosphate (Ripercol®)	Bath	2 mg/L q12-24h	Internal nematodes
Lidocaine 2%			Local anesthesia
Malachite green (zinc-free)	Bath	0.1 - 0.15 ppm for 12-24 hr +/- 20 ppm formaldehyde; 30% water change, then repeat. Repeat as long as parasites are present. **Caution:** carcinogen - wear gloves. Toxic to scaleless fish.	"Ich;" fungal disease
Metronidazole (Flagyl®)	Bath or in gel food	Bath: 10 mg/L q24h x3d, 25-50% water changes between treatments.; or gel food 0.2% (200 mg/100 g food) x10d	External/internal flagellates
Tricane methanesulfonate, Finquel®, MS-222 (10 mg/ml buffered stock solution)	Bath	100-150 mg/L, effective in 3-5 min, 1 L of stock solution should be buffered with 3-5 g of sodium bicarbonate (baking soda)	Anesthesia
Nalidixic acid	Bath	500 mg/10 gal for 1-4 hr for Gram-negative bacteria; can be toxic.	Antibiotic
Nitrofurazone	Bath	20 mg/L as 5 hr bath q24h, repeat daily x5-7d	Antibiotic
Oxytetracycline	PO, IM, ICe or bath	10-70 mg/kg q24h	Antibiotic
Panalog® ointment	Topical	q12h for 30-60 sec with fish out of water, gills submerged	Wounds
Povidone iodine solution and ointment	Topical solution	1:10 dilution	Wounds

FISH FORMULARY

DRUG	ROUTE	DOSAGE	USE
Praziquantel (Droncit®) tablets and injectable solution	IM, ICe or PO	5-8 mg/kg fish PO in food, repeat in 2 wks; or bath 5-10 mg/L x 3-6 hr, repeat in 7d; Inexpensive over-the-counter preparations are available for use in ornamental fish.	Internal cestodes or internal digenean trematodes (flukes)
Praziquantel	Bath	5-10 mg/L x 3-6 hr, repeat in 7d; move to new aquarium	Ectoparasitic monogenean trematodes (flukes); internal cestodes or internal digenean trematodes (flukes)
Quinine hydrochloride	Bath	10-20 ppm indefinitely	*Oodinium*, "Ich"
Salt (sea salt, artificial sea salt, kosher salt, solar salt). Avoid salts with anti-caking agents or other additives	Add to tank	Freshwater species: 4-5 min in 30-35 g/L seawater, or add salt to tank or pond at 1-3 g/L (1-3 parts per thousand)	Protozoa, used as a general tonic for stress, and control of external parasites
		Freshwater tropicals: salt @ 1 g/L indefinitely (as preventive, reduces stress) 2-3 g/L will usually kill protozoa)	
		Goldfish, koi: salt @ 3-5 g/L for up to 1 mo as needed	
		Caution: salt may be stressful to wild-caught discus, corydoras catfish, dwarf cichlids. Freshwater plants harmed at salt >0.5 g/L.	
Silver sulfadiazine cream (Silvadene®)		q12h for 30-60 sec with fish out of water, gills submerged	Wounds

FISH FORMULARY			
DRUG	**ROUTE**	**DOSAGE**	**USE**
Tetracycline (frequent resistance)	Bath or PO	Bath: 250-500 mg/10 gal 3-6 hr, or PO (commercially prepared diet)	Antibiotic
Trichlorfon (Neguvon® and Malthion®)	Bath	0.5 mg/L, treatment is usually repeated several times with 25-30% water changes between treatments. A biotest is strongly recommended when using these compounds.	Effective in controlling crustacean ectoparasites
Trimethoprim sulfadiazine (Tribrissen®)	IM, ICe, in food or bath	30 mg/kg IM, ICe q24h x7-10d; or 30 mg/kg PO q24h x10-14d; or 0.2% in food x10-14 d, or bath 20 mg/L x 5 hr q24h	A good broad-spectrum antibiotic.
Triple antibiotic ointment	Bath	q12h for 30-60 sec with fish out of water, gills submerged	Wounds
Water	Dip or bath	Many freshwater species will tolerate a 4-5 min dip in full strength (30-35 g/L) seawater. Marine fishes can be placed in a freshwater dip for 4-5 min. Aerate well and monitor very closely. Certain smaller fishes may not survive this treatment. If possible, test treatment on one fish first.	Ectoparasitic protozoans

Although every effort has been made to ensure the accuracy of the information presented herein (particularly doses), in all cases the clinician is responsible for the use of any pharmaceuticals. Most drugs used in exotic companion species are considered extra-label, and few pharmacokinetic studies have been conducted; therefore, the clinician must critically evaluate the information provided and stay informed of recommendations in the literature.

Equipment and Supplies

HUSBANDRY

- Air pumps
- Air tubing
- Assorted plastic totes/sweater boxes
- Assorted glass aquaria
- Assorted sizes of plastic fish bags
- Assorted nets
- Commercial dechlorinator
- Rubberbands
- Sea salt
- Sponge filters
- Water test kit
- Water sample bottles (plastic, 250 ml)
- 5-gallon bucket(s)

MEDICAL

- Centrifuge
- Complete dissecting kit
- Compound microscope
- Eugenol (clove oil) 1:9 with 95% ethanol (stock approx. 100 mg/ml)
- Fish anesthesia machine
- Gram scale (to 1 kg)
- Kg scale (to 10 kg)
- MS-222 (10 mg/ml buffered stock solution)
- Oxygen tank with regulator
- Plastic surgical drapes
- Refractometer
- Sterile surgical pack(s)

DRUGS AND OTHER COMPOUNDS

- Amikacin
- Assorted scalpel blades
- Atropine
- Calcium gluconate
- Ceftazidime
- Commercial dechlorinator
- Dexamethasone injectable
- Diflubenzuron
- Emeraid II
- Enrofloxacin 22.7 mg/ml injectable
- Enrofloxacin 22.7 mg tablets
- Epinephrine

- Eugenol (clove oil) 1:9 with 95% ethanol (stock approx. 100 mg/ml)
- Euthanasia solution
- Fenbendazole
- Furosemide
- Heparin 1000 u
- High energy/protein dog food (1 small can)
- Lidocaine 2%
- Lubricating jelly
- Lufenuron
- Metronidazole
- MS-222 (10 mg/ml buffered stock solution)
- 10% Neutral buffered formalin
- Nexaband® adhesive
- Nitrofurazone
- Nolvasan® (dilute and nondilute)
- Panalog® ointment
- Povidone iodine ointment
- Praziquantel tablets and injectable solution
- Sea salt (5 lbs [2.25 kg])
- Silver sulfadiazine cream
- Sterile water
- Trichlorfon 8%
- Trimethoprim/sulfamethoxazole tablets 960 mg

DIAGNOSTIC MATERIALS

- Assorted needles: 18g, 20g, 22g, 23g, 25g, 26g
- Assorted red rubber catheters 5 French-12 French
- Assorted suture materials
- Assorted syringes: 1 cc, 3 cc, 6 cc, 12 cc, 35 cc, 60 cc with lure or eccentric tip
- 2.5 ml blood collection tubes
  - red top (clot tube)
  - green (heparin)
  - yellow (sodium chloride)
- Bullet tubes (eppendorf) 1.5 ml
- Coverslips
- Culturettes
  - minitip
  - portacult
  - regular
  - ARD bottle
- Fluorescence strips
- Glass slides

- Kimwipes®
- Microcentrifuge with putty
- Microhematocrit tubes
- Microcontainer tubes (serum separator)
- Nonsterile 2x2 and 4x4 pads
- Nonsterile gloves
- Paper towels
- Plastic pipettes
- Tongue depressors

Material Resources

PRODUCTS AND SERVICES

- Heaters:
  * (Visi-Therm®) Aquarium Systems
    8141 Tyler Blvd
    Mentor, OH 44060
  * (Heetmaster®) EG Danner Mfg, Inc
    160 Oval Drive
    Central Islip, NY 11722
- Air pumps:
  * (Second Nature®) Willinger Bros, Inc
    Wright Way
    Oakland, NJ 07436-3121
- Undergravel filters:
  * Power Filters (Dynaflo®, Aquaclear®)
    Hagen Corp
    Vansfield, MA 02048
  * Penn Plax, Inc., Garden City, NY 11530
- Ultraviolet filtration:
  * Rainbow Plastics
    3242 Meeker Ave
    PO Box 4127, El Monte, CA 91734
- Diatom filters:
  * Vortex Innerspace Products
    PO Box 168, Hwy 90 West
    Ponce De Leon, FL 32455
- Water test kits:
  * Hach Company
    PO Box 389
    Loveland CO 80539
    800-227-4224
    www.hach.com

* Gilford Instrument Lab, Inc/CIBA
  132 Artino St
  Oberlin, OH 44074
  216-774-1041
  800-445-3673
* La Motte Chemicals
  PO Box 329
  Chestertown MD 21260
  800-344-3100
  www.lamotte.com
* PondRx
  www.pondrx.com

FISH DRUG DISTRIBUTORS

- Any local pet store, pet supply retailer, or veterinary drug supplier
- Argent Chemical Laboratories
  8702 152nd Ave NE
  Redmond WA 98052
  www.argent-labs.com
- Chem Aqua
  PO Box 2457
  Oxnard CA 93033
  www.chemaqua.com
- Dyna-Pet, Inc
  1110 Florence Way
  Campbell CA 95008

Other Informational Resources

NATIONAL ORGANIZATIONS

- International Association for Aquatic Animal Medicine (IAAAM): www.iaaam.org
- American Fisheries Society: www.fisheries.org

INDUSTRY RESOURCES:

- American Cichlid Association. www.cichlid.org
- American Pet Products Manufacturers Association, Inc. www.appma.org
- Associated Koi Clubs of America. www.akca.org
- Florida Tropical Fish Farmers Association (FTFFA). www.ftffa.com
- National Ornamental Goldfish Growers Association (NOGGA). 6916 Black's Mill Rd, Thurmont, MD 21788 PH: (301)271-7475
- Ornamental Fish International (OFI). www.ofish.org

- Pet Industry Joint Advisory Council (PIJAC). www.pijac.org
- University of Florida Tropical Aquaculture Laboratory. www.fishweb.ifas.ufl.edu/Facilities/RuskinLabPics/RuskinLab.htm

COURSES IN PET FISH MEDICINE

- University of Florida: 2 week course on warm water fish diseases.
- North Carolina State University: 3 day course on pet fish medicine.
- Aquavet (University of Pennsylvania & Cornell University), AquaMed (Louisiana State University).
- University of Georgia: 3-day course on koi medicine

POPULAR MAGAZINES

- Tropical Fish Hobbyist
  One TFH Plaza
  Neptune City NJ 07753
  908-988-8400
  www.tfhmagazine.com
- Freshwater and Marine Aquarium
  PO Box 487
  Sierra Madre CA 91025
  818-355-1476
  www.famamagazine.com
- Aquarium Fish
  PO Box 57900
  Los Angeles CA 90057
  213-385-2222
  www.aquariumfish.com
- Koi USA Magazine
  PO Box 469070
  Escondido, CA 92046
  888-660-2073
  www.koiusa.com

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