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Parasite Surveys of Aquarium Fish

By Diana Walstad (March 2018)

Before I began this article, I had never thought much about parasites except for a nasty encounter with nematodes.[1] However in 2017, an unexplained illness in my guppies prompted me to start digging into the scientific literature. I wanted to know what were the most common diseases in aquarium fish.

Aquarium Fish [3] require knowledge and effort to keep them healthy.

Eventually, I found eleven surveys from around the world- Sri Lanka, Pakistan, Iran, Australia, Brazil, etc. All were quantitative. Surveyed fish came from rivers, pet shops, fish farms, export holding facilities, etc. Survey results depended on how the investigators examined the fish, the anomolies of parasite infections, farm management practices, etc. For this reason, I looked at as many surveys as I could find. Surprisingly—in view of so many variables—there was general agreement on the dominating prevalence of MONOs (i.e., flukes).

I found no comparable American surveys. However, since many of the fish offered for sale in America are imported, I would not discount foreign surveys. The parasites found in Pakistani pet stores may not be that different than those in American stores. People from all over the world love aquarium fish!

Understanding the Surveys

Table 1 lists the surveyed fish referred to in this article.

Table 2 organizes the surveyed parasites. I categorized parasites based on their size and whether they are found on the outside of the fish (skin or gills) or inside the fish (gut). The table only lists parasites reported in the surveys. This automatically eliminates parasites that are not of general concern to the ornamental freshwater fish industry or aquarium hobbyists.

I've called attention to parasites associated with ponds. For example, copepods (lice) and leeches are usually found only on Goldfish. Some pond parasites require birds, snails, or copepods from the natural world to spread, so these parasites (e.g., TREMs) become less of a problem once in holding tanks and/or aquariums.

I included the efficacy of treating fish with salt in Table 2 because of its importance as an all-purpose remedy for many common fish diseases. Salt also kills several other external parasites plus gill pathogens like Columnaris bacteria [1]. One fish disease expert [2] credits 3 ppt salt with the gradual clearance of several parasite pathogens (e.g., ICH, CHIL, TRIC, etc). And a four-day, 9 ppt salt treatment helped me diagnose and cure some very sick Guppies.[2] Indeed, the table shows that salt will

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[1] My article 'Treating Fish for Camallanus and Other Nematodes' is available at: http://dianawalstad.com

[2] Guppies were later diagnosed with GYROs (sub-category of MONOs), the subject of a future article.

work on a variety of parasites. A "Yes" in Table 2 does not mean that salt is the only treatment or the optimal treatment, just that it will work. A "Yes/No" means there are caveats such as salt-resistant species.

The final column in Table 2 provides one authority's subjective ranking of parasites in terms of prevalence [1].

The remaining tables deal with quantitative surveys of parasite prevalence in freshwater tropical aquarium fish. *Parasite Prevalence* is the percentage of sampled fish found to be infected with a designated parasite. In general, I put the most prevalent parasites in the top rows; less prevalent parasites went to the bottom.

Tables 3 and 4 (three surveys) showcase tropical fish from South America, from which many wild-caught fish—not farmed fish—are exported. Table 5 (two surveys) pertains to farmed fish in Sri Lanka and Iran. Two additional surveys—from Korea and Turkey—contain useful data on farmed fish, but it was difficult to tabulate properly. Thus, I have described their key findings within the text. Table 6 (one survey) provides information on parasite prevalence on fish imported into Australia.

Tables 7 and 8 include surveys from Sweden, Australia, and Pakistan where the investigators chose sick fish from pet shops.

Table 8 (data from the Pakistani survey) provides an additional measure (i.e., Mean Intensity) of the parasite burden carried by sick fish. *Mean Intensity* is the average number of a specified parasite found on the fishes infected by that parasite. A certain parasite may have a high prevalence in a fish population, but if it is present on infected fishes only in small numbers (i.e., has a low Mean Intensity), the parasite's impact on fish health may be neglible. For example in lab experiments with Guppies [4], if the Mean Intensity of *Gyrodactylus turnbulli* (a GYRO) was ~3, fish were okay; once it reached 16, mortality resulted.

Table 1. Surveyed Fish

COMMON NAME	SCIENTIFIC NAME
Angelfish	*Pterophyllum scalare*
Bala Shark	*Balantinocheilos melanopterus*
Betta	*Betta splendens*
Black Tetra	*Gymnocorymbus ternetzi*
Bodó	*Ancistrus hoplogenys*
Cardinal Tetra	*Paracheirodon axelrodi*
Chinese Algae Eater	*Gyrinocheilus aymonieri*
Flagtail Catfish	*Dianema urostriatum*
Goldfish	*Carassius auratus*
Gourami, Blue	*Trichogaster trichopteris*
Gourami, Dwarf	*Colisa lalia*
Gourami, Three Spot	*Trichogaster tricopterus*
Guppy	*Poecilia reticulata*
Hatchetfish (Bl.)	*Carnegiella martae*
Hatchetfish (Mar.)	*Carnegiella strigata*
Molly	*Poecilia sphenops*
Mosquitofish	*Gambusia affinis*
Neon Tetra	*Paracheirodon innesi*
Oscar	*Astronotus ocellatus*
Paradise Fish	*Macropodus opercularis*
Pencilfish (Brown)	*Nannostomus eques*
Pencilfish (Oneline)	*Nannostomus unifasciatus*
Platy	*Xiphophorus maculatus*
Rainbow Shark	*Epalzeorhynchos frenatum*
Rosy Barb	*Puntius conchonius*
Rosy Tetra	*Hyphessobrycon copelandi*
Sumatra Barb	*Puntitus tetrazona*
Swordtail	*Xiphophorus helleri*

Data Handling

Many studies lumped GYRO and DACT flukes together under a MONO heading, while other studies reported on them separately. To avoid any potential data inaccuracies, I recorded fluke prevalence under the headings chosen by the investigators. Explanation: If I were to simply add GYRO and DACT percentages together and report the total as a MONO percentage, I would be assuming incorrectly that no individual fish carried both GYRO and DACT parasites.

Table 2. Categorization of Surveyed Parasites

	Parasite Type	Parasite (Abbr.)	Representative Species	Salt Work? [1;2]	Prev-alence? [1]
External:	Protozoa	EPIS	*Epistylus* sp., *Apiosoma* sp., *Riboscyphidia* sp.	Yes	1
		CHIL	*Chilodonella piscicola*	Yes	1
		COST	*Ichthyobodo nectar*	Yes/No	2
		CRYP	*Cryptobia branchialis*	No	3
		ICH	*Ichthyophthirius multifiliis*	Yes	1
		MYXO*	*Myxobolus argenteus*	No	2
		OOD	*Piscinoodinium pillulare*	Yes	2
		TETR	*Tetrahymena corlissi*	Yes	3
		TRIC	*Trichodinella epizootica*	Yes/No	1
	Metazoan (flukes)	MONO	GYROs *(Gyrodacytylus* sp.) DACTs (*Dactylogyrus* sp.), *Urocleidoides* sp.	Yes	1
		TREM*	*Centrocestus formosanus*, *Ascocotyle* sp., *Cryptocotyle* sp.	No	2L & 4A**
	Copepods (lice)	ARGU*	*Argulus foliaceus*	No	3
		ERGA*	*Ergasilus* sp.	No	2
		LERN*	*Lernaea cyprinacea*	No	2
	Leeches	LEEC*	*Myzobdella lugubris*	Yes	4
Internal:	Hexamita protozoa	HEXA	*Hexamita salmonis, Spironucleus* sp.	n.a.	2
	Protozoa	OPAL	*Protopalina* sp.	n.a.	-
	Round Worms	NEMA	*Camallanus* sp., *Capillaria* sp.	n.a.	2L & 3A**
	Spore-forming protozoa	SPOR	*Pseudoloma neurophilia, Pleistophora hyphessobryconis, Cryptosporidium* sp.	n.a.	4
	Tape worms	CEST*	*Bothriocephalus acheilognathi*	n.a.	4L & 3A**

Parasite prevalence ratings [1]--specified for *cultured* freshwater fish kept at temperatures warmer than 20°C (68°F) --are as follows: (1) very common; (2) common; (3) uncommon; and (4) rare.

* Parasites associated with outdoor ponds

** Parasite prevalence ratings divided into larva and adults (L= Larva; A= Adults)

Similarly, I could not pin down the exact % prevalence for the 'SPOR' category in an Australian survey (Table 7), because the investigators reported results for Coccidia (16.7%), *Cryptosporidium* (1.9%) and Microsporidia (18.5%), which are all subcategories of my large SPOR category. Thus, I was forced to report the SPOR as a range (18.5% to 37%). Explanation: If these 3 parasites were *always* found together on the same fish, the SPOR prevalence would match the parasite with the highest prevalence, that is, the Microsporidia with 18.5%. Only if the 3 parasites occurred on separate fish could I report them as a 37% total (16.7% + 1.9% + 18.5% = 37%). Since mixed infections are common in fish, the exact SPOR value could not be determined from the reported survey data.

Overall, I tried to present the survey data extracted from the 11 surveys as accurately as possible.

Captured Fish Surveys

Table 3 gives us an idea of how the parasite prevalence changes after wild fish are captured and enter the aquarium trade.

For the 'Rio Negro' survey in Column 1, Brazilian investigators [5] examined 223 wild fish from a major collection site in the Rio Negro. The purpose of the Rio Negro study was to provide a "Before" picture of parasitism. Explanation: Fish captured for export are often kept for 7-10 days in the field and on collection boats under very stressful conditions. Perhaps parasitism increased during the collection time?

Of the 223 fish examined (representing the 8 fish species shown in Table 4), 64% carried one or more parasite species. The table shows the prevalence of various parasites in these fish. MONOs, with a 37% presence, were the most common parasites, followed by ICH at 21%.

Table 3. Brazilian Surveys

Percentages represent 'Parasite Prevalence' within fish gills.

PARASITES	Rio Negro [5]	Manaus [6]	S. Brazil [7]
MONO	37%	32%	15%
ICH	21%	5.5%	3.7%
TRIC	4.0%	2.7%	4.7%
NEMA	0.4%	21%	2.6%
OOD	1.3%	2.3%	6.9%
TREM	n.r.	4.6%	15%
LERN	n.r.	n.r.	2.1%
TETR	0.9%	n.r.	n.r.
CEST	n.r.	n.r.	2.6%
CHIL	n.r.	n.r.	0.5%
LEEC	n.r.	0.4%	n.r.
MYXO	n.r.	0.4%	n.r.

See Table 2 for parasite abbreviations; n.r. = not reported

The 'Manaus' survey [6] of Table 3—the "After" picture—encompassed 218 wild fish originating from the same Amazon basin and sampled at a Manaus holding facility. (The 5 fish species represented are shown in Table 4.) During the hold time, which could last up to a year, farm managers treated fish prophylactically with formalin, tetracycline and Ivermectin. Water quality was carefully monitored and found to be within an acceptable range. Parasites were found in 61% of the fish. However, the investigators found no significant difference ($p < 0.05$) in the condition and health of parasitized fish v. non-parasitized fish.

The Rio Negro and Manaus studies were conducted by the same investigative team on fish originating from the wild. Both studies showed an overall parasitism of about 60%, with MONOs the most dominate parasite. Notably, investigators sampled fish gills only for MONOs, thereby missing MONO skin flukes and possibly underestimating the true MONO presence. The Rio Negro fish had more ICH than the Manaus fish (21% v. 5.5%), but less NEMA (0.4% v. 21%). That said, the investigators concluded that overall parasitism was not that different in the two groups of surveyed fish [5].

The third column ('S. Brazil') in Table 3 represents an unrelated Brazilian survey [7]. Piazza (2006) examined 189 fish from a holding facilitity located in southern Brazil. Fish included: 88 Platies, 27 Swordtails, 20 Mollies, 20 Paradise Fish, etc. This commercial fish supplier apparently employed few prophylactic measures to limit parasitism, which could explain the high TREM (15%). Overall, 34% of the 189 fish carried at least one parasite. Parasite prevalence ranged from 0% in Paradise Fish to 67% in Goldfish. NEMA, identified as *Camallanus maculatus*, was found only in Mollies and Platies.

Platies were infected by all 9 surveyed parasites. For these fish, TREM infestation was the worst. TREM larvas were present in 22% of Platies with a high Mean Intensity of 335 (range 1-1,070). Investigators recommended measures that the fish manager could use to reduce fish mortality.

Table 4 compares data for major parasites MONO, ICH, and TRIC in individual fish species from the Rio Negro [5] and Manaus [6] surveys shown in Table 3. The 'Rio Negro' wild-caught Cardinal Tetras had notably fewer parasites than those in the Manaus holding facility. In contrast, parasitism of the Rosy Tetra was not that different. The 'Manaus' results show that the *Apistogramma* sp. carried a much lighter parasite burden that the other fish.

Table 4. Parasites of Amazonian Fish

Percentages represent 'Parasite Prevalence' in fish gills only.

STUDY	FISH	# Fish Examined	MONO	ICH	TRIC
Rio Negro [5]	Angelfish	13	92%	23%	0
	Bodó	27	30%	0	0
	Cardinal Tetra	27	7.4%	0	0
	Hatchetfish, BW	26	65%	54%	7.9%
	Hatchetfish, M.	28	7.1%	64%	14%
	Pencilfish, Br.	31	48%	6.4%	9.7%
	Pencilfish, One.	38	47%	7.9%	0
	Rosy Tetra	33	21%	21%	0
Manaus [6]	*Apistogramma*	33	3.0%	0	0
	Cardinal Tetra	89	43%	7.9%	3.4%
	Flagtail Catfish	30	40%	6.7%	0
	Otocinclus	32	34%	0	19%
	Rosy Tetra	34	23%	8.8%	0

See Table 2 for parasite abbreviations.

Farmed Fish Surveys

Table 5. The two surveys represented in this table are of farmed fish. Investigators also divided the big MONO group into GYROs and DACTs.

Sri Lankan investigators [8] sampled 1,520 fish representing 13 different fish species from 26 export farms in Sri Lanka. Parasites were present in 23 of the farms and 45% of the fish. Infected farms showed a significant variation ($p < 0.01$) in prevalences of different parasites. The table shows the results for Guppies (n=590), Goldfish (n=153), Bettas (n=84) and Barbs (n=95).

The investigators stated that MONOs, which were found in all infected farms, "were the most common parasites in ornamental fish species prepared for export from Sri Lanka." They attributed this to the MONOs' high reproductive rates, short life cycle, and no requirement for an intermediate host. At least 9 MONO species were identified. Both DACTs and GYROs were found in 11 of 12 fish species surveyed. Guppies were infected with *Dactylogyrus cf. vastator* and *Gyrodactylus turnbulli*.

NEMAs, identified as a *Capillaria*, had the lowest presence of all the parasites and were found only in Guppies and Angelfish. The investigators reported a significantly ($p < 0.01$) higher prevalence of TETR in the Guppies (8.5%)—as compared to other fish. They hypothesized that this resulted from

Guppy breeding that focused on color and finnage, not resistance to pathogens. [TETR (*Tetrahymena*) is considered an opportunistic pathogen.]

The 26 farms participating in this survey were licensed by the Sri Lankan government to export their fish. At the time, their fish represented over 95% of the country's ornamental fish exports. Farm managers employed a variety of disease control measures. Caretakers culled sick fish, treated fish routinely with anti-parasitic compounds (e.g., salt, formalin, acriflavin, methylene blue and malachite green), kept birds and snail hosts out of the ponds, and cleaned ponds after each production cycle. To prevent cross contamination, most ponds had an independent water supply.

In a separate survey, Iranian investigators [9] examined 400 healthy-appearing fish from 5 fish species (Goldfish, Guppies, Angelfish, Discus, and Sailfin Mollies) obtained from 5 different fish farms in northern Iran. The table shows the results obtained for all 5 fish species. NEMAs from Angelfish, Guppies and Mollies were identified as a *Capallaria* sp.

Although 95% of the 400 fish carried at least one parasite, mean intensities were low. For example, despite the high (73%) GYRO prevalence in Goldfish, the number of GYRO flukes on infected Goldfish ranged from 1 to 8; for Guppies, only 1 to 2. The authors cautioned that although parasite mean intensities were low and the fish on these farms were healthy, if environmental conditions deteriorated, the parasites that they were carrying could create problems. So true!

Table 5. Surveys of Asian Fish Farms Percentages represent 'Parasite Prevalence.'

PARASITE	SRI LANKA [8]				IRAN [9]				
	Guppies	Goldfish	Betta	Barbs	Guppies	Goldfish	Angelfish	Discus	Mollies
MONO (DACTs)	15%	31%	18%	12%	18%	29%	35%	7.5%	16%
MONO (GYROs)	11%	23%	4.8%	7.4%	21%	73%	5.0%	14%	29%
TRIC	7.1%	4.6%	7.1%	13%	15%	20%	25%	6.3%	13%
ICH	0	0	7.1%	7.4%	6.3%	88%	15%	10%	13%
TETR	8.5%	2.0%	0	1.1%	n.r.	n.r.	n.r.	n.r.	n.r.
NEMA	0.7%	0	0	0	2.5%	0	23%	0	1.3%
OOD	0	5.9%	4.8%	0	n.r.	n.r.	n.r.	n.r.	n.r.
LERN	0	4.6%	0	0	1.3%	30%	0	0	5%
TREM	0	7.8%	0	0	n.r.	n.r.	n.r.	n.r.	n.r.
ERGA	2.4%	1.3%	0	0	n.r.	n.r.	n.r.	n.r.	n.r.
ARGU	0	2.6%	0	0	n.r.	n.r.	n.r.	n.r.	n.r.
COST	2.2%	0	0	3.2%	n.r.	n.r.	n.r.	n.r.	n.r.

See Table 2 for parasite abbreviations; n.r. = not reported

Non-tabulated Surveys: Korean investigators [10] surveyed 351 fish from 8 different farms in South Korea to determine the cause of recent fish mortalities. Farm managers believed that infected fish brought in from Southeast Asia—typically without quarantine—were responsible, so the study's fish were sampled soon after importation. The survey covered 15 species of aquarium fish. Livebearers and Guppies predominated (n=226); no Goldfish examined.

Investigators found parasites on 7 of the 15 fish species. Only 2 of the 51 Cichlids (6 species) had parasites. Amazingly and out of 351 fish, only three (2 Oscars and 1 Platy) had MONO parasites. The most parasitized fish were: (1) Guppies infected with TETR (7.2% prevalence) and/or NEMA (14%

prevalence of *Camallanus cotti*); and (2) Sumatra Barbs infected with both ICH (100% prevalence) and TRIC (100% prevalence). ICH and TRIC had caused massive mortalities of the Sumatra Barb at one farm. Farmers considered ICH and TETR to be the most serious pathogens in Korea.

In a separate survey, Turkish investigators [11] examined fish from two ornamental fish farms monthly over a 4 year period for a total of 759 fish. Of the 6 fish groups examined, Goldfish, Guppies, and Mollies had the greatest parasite prevalence—63%, 58%, and 50%, respectively. Discus, other Cichlids, and Platies had the least—32%, 24%, and 20%, respectively. MONOs (12.5% prevalence) consisted solely of *Gyrodactylus bullatarudis* parasitizing Guppies (11% prevalence) and *Dactylogyrus extensus* parasitizing Goldfish (1.5% prevalence). Goldfish were parasitized by several different parasites, and they alone carried the copepods LERN and AGRU. In contrast, Discus were only infected with NEMAs—in the form of a *Capillaria* sp. (prevalence 1.5%)—and TRIC (~30% prevalence).

Table 6. Australian investigators [12] sampled shipments of imported fish immediately after they were released from Australia's 1- 3 week(s) mandatory quarantine. Each shipment—from 4 different exporting companies from Southeast Asia—contained thousands of fish. The 37 shipments consisted of 6-8 shipments each of either Guppies, Neon Tetras, Cardinal Tetras, Chinese Algae Eaters, or Platies. About 9-10 fish from each shipment were examined for parasites for a grand total of 361 fish.

The investigators found parasites in 27 of the 37 shipments. The table shows how many shipments for each fish species were infected by each parasite type. The investigators expressed the parasite prevalence as an average for the infected shipments. For example, 3 of the 8 Guppy shipments contained fish infected with NEMA. While the NEMA prevalence within each of those 3 shipments probably varied, the average was 48%. That is, about half of the ~30 fish from those 3 infected shipments (~10 fish sampled per shipment X 3 shipments = 30 fish) were infected with NEMA. Investigators identified the NEMA in Guppies as *Camallanus cotti*; in Cardinal Tetras, it was unspecified larva. The MONO in Guppies and Platies was identified as *Urocleidoides reticulatus*. The 8 Neon Tetra shipments, all of which were infected with HEXA, came from 4 different exporting companies based in either Singapore (2), Hong Kong (1), or Indonesia (1). The investigators hypothesized that the Neons originated from a common source and that they had not not treated for parasites prior to export.

Table 6. Australian Survey of Fish Imports [12]

Percentages represent average Parasite Prevalence in infected shipment(s). (*See* Text)

Parasite	Fish	Infected/Total Shipments	Preva-lence
TETR	Guppy	2/8	65%
MONO	Guppy	1/8	33%
	Platy	1/7	70%
TREM	Guppy	1/8	45%
	Platy	1/7	100%
CEST	Guppy	1/8	36%
	Platy	1/7	10%
NEMA	Guppy	3/8	48%
	Cardinals	7/8	51%
HEXA	Neons	8/8	76%
	Cardinals	1/8	100%
CHIL	Neons	1/8	100%
CRYP	Algae Eater	6/6	66%
MYXO	Algae Eater	4/6	22%

See Table 2 for parasite abbreviations

Diseased Fish Surveys

Table 7. This 2009 Swedish health survey [13] was the first dealing exclusively with retail store fish. The investigators collected 30 sick-looking fish from each of 24 randomly chosen stores—12 pet shops and 12 aquarium stores for a total of 720 fish. Whenever possible, they took one fish from each tank. They selected a wide variety of pet fish—livebearers, Goldfish, Koi, Gouramis, Bettas, Cichlids, Catfish, Tetras, etc.

This survey screened fish for viral and bacterial diseases, not just parasites. Investigators found little evidence of the Koi Herpes Virus among the 720 fish screened via genetic testing.

Of the 720 fish collected, the investigators selected 24 fish to represent each of the following designated fish groups: Livebearers, Cyprinids, Labyrinths, Cichlids, and Miscellaneous (Cardinal Tetras, Corydoras, Rainbowfish). These 120 fish (5 X 24 = 120), which were examined more thoroughly, represent the 'MIX' results shown in Table 7. (Neon tetras were not part of the fish 'MIX'.) Mycobacteriosis ("Fish TB") was the most common bacterial disease; it was found in 23% of the 120 fish—and 22% of the 23 Neon Tetras examined separately. The investigators noted that some tanks with diseased fish were found to have high levels of nitrite, ammonia, and copper.

Table 7. *Diseased* Fish in Stores

Percentages represent 'Parasite Prevalence.'

PARASITE	SWEDEN [13]		AUSTRA-LIA [14]
	MIX	Neons	MIX
MONO	64%	0	19%
CRYP	13%	61%	n.r.
SPOR	0.8%	39%	19-37%*
ICH	5.0%	5.6%	2.8%
HEXA	7.5%	28%	n.r.
COST	5.8%	0	13%
TRIC	4.2%	0	0.9%
NEMA	11%	0	n.r.
OOD	2.5%	0	4.6%
MYXO	3.3%	0	15%
CHIL	4.2%	0	2.8%
TREM	5.8%	0	n.r.
TETR	1.7%	0	n.r.
CEST	0.8%	0	n.r.
OPAL	0.8%	0	n.r.
EPIS	0.8%	0	n.r.

See Table 2 for parasite abbreviations; n.r. = not reported
*See Text for explanation of why I had to use a range.

MONOs, with a 64% prevalence in the 120 fish, far and away dominated all viral, bacterial, and parasitic pathogens. Of the MONO-infected fish, 45 fish (38%) had DACT and 32 fish (27%) had GYRO.

Neon Tetras shown in the table as 'Neons' were examined separately from the other 120 fish. The parasites found on them differ markedly from those on other aquarium fish. They had no MONO, but plenty of CRYP, SPOR, and HEXA. The SPOR identified was *Pleistophora hyphessobryconis*, the parasite responsible for 'Neon Tetra Disease'.

The Australian fish 'Mix' in Table 7 consists of 108 sick fish from 24 Australian pet shops surveyed for viruses, bacteria, and parasites [14]. Investigators selected fish that were not eating, lying on the bottom, had poor body condition, poor skin color and lesions, were housed in tanks under treatment and/or with dead tank mates, etc. Fish included 62 Goldfish, 11 livebearers, 15 Dwarf Gouramis, 4 Neon Tetras, etc. Investigators found that parasites were the main problem; the prevalences of viruses, bacteria, and parasites within the 108 fish were 5.6%, 15%, and 61%, respectively. Mycobacteriosis, at 7.4% prevalence, was the single most common bacterial disease. Mixed infections were common, with 27% of infected fish carrying 2 pathogens and 18% carrying 3 to 5.

This survey focused on histological examination of internal tissues rather than wet mounts of the fish's skin, fins, and gills. Thus, it probably underestimated the MONOs. These parasites are loosely attached and can "fall off" the fish during handling prior to examination. Indeed, the investigators themselves pointed out this potential artifact in order to explain why they found several fish with severe gill inflammation, but no causative pathogen.

Table 8 Pakistani investigators [15] surveyed 178 sick fish bagged up from local pet shops in Lahore, Pakistan. In contrast to the Australian study [14], this study focused on wet mounts and external parasites on skin, fins, and gills. The investigators actually counted the number and type of parasites on infected fish.

Table 8 Pakistani Survey [15] of *Diseased* Fish in Stores

Percentages represent 'Parasite Prevalence' followed by 'Mean Intensity' (in paranthesis), which is the average number of parasites found on infected fish.

PARASITE	Goldfish	Guppy	Molly	Platy	Swordtail
ALL PARASITES	75% (31)	75% (16)	52% (25)	67% (22)	65% (17)
MONO (DACTs)	70% (14)	43% (11)	20% (18)	40% (10)	35% (7)
MONO (GYROs)	33% (11)	38% (8)	40% (10)	50% (5)	43% (7)
TRIC	75% (10)	25% (4)	36% (1)	33% (4)	22% (4)
TREM	0	38% (8)	28% (17)	30% (22)	43% (9)
ICH	25% (4)	0	0	0	0
CHIL	0	7.5% (2)	0	0	0
LERN	1.7% (2)	0	0	0	0
ARGU	42% (3)	0	0	0	0
EPIS	0	0	0	17% (4)	0
OOD	0	0	0	0	13% (5)
TETR	0	0	0	0	8.7% (3)

See Table 2 for parasite abbreviations

Surveyed fish were 60 Goldfish, 40 Guppies, 25 Mollies, 30 Platies, and 23 Swordtails that had been originally imported from Southeast Asia. Parasite prevalence for the entire 178 surveyed fish was 69%. The table shows the parasitism for each fish type in terms of both parasite prevalence and mean intensity. For example in the 'All Parasites' row, 45 (i.e., 75%) of the 60 Goldfish were parasitized and the average number of parasites on the 45 infected Goldfish was 31. The 75% prevalence of TRIC in the Goldfish indicates that all infected Goldfish must have been carrying TRIC. DACT, with a 70% prevalence, was a close second to TRIC.

Overall, MONO parasitism dominated, followed by TRIC and TREM. The GYRO in the four livebearers was *G. turnbulli*; the one in the Goldfish was an undefined *Gyrodactylus* sp. The DACT found in all 5 groups was *Dactylogyrus extensus*. The TREMs were identified as a *Cryptocotyle* species, which causes 'Black Spot Disease' in fish.

The mean intensity data better gauges the seriousness of the parasite infection. The 60 Goldfish (average body weight of 15 grams and average length of 10 cm) were much bigger than the 25 Mollies (2.8 grams and 4.2 cm). The table shows that the average number of DACTs on infected Goldfish was 14; for Mollies, it was 18. One can speculate that the Mollies, being smaller, probably suffered more from their *D. extensus* fluke infestation than the Goldfish.

Discussion

The combined 11 surveys, in my opinion, represent a more realistic picture of the overall disease landscape than a single survey based on sick fish brought into a veterinary clinic for diagnosis. For example, one veterinarian's ranking of parasite prevalence (Table 2) shows EPIS, CHIL, and MONO parasites as all being "very common." However, the surveys displayed in this report reveal an overwhelming prevalence of MONOs and almost nothing about the other two parasites.

Two surveys [13, 14] reported parasites as being far more prevalent than bacterial infections. And that among parasites, MONOs are far and away the most common parasite in aquarium fish. The one exception was the Neon Tetra, which carries a different bunch of parasites (Table 7).

Parasites are by no means restricted to farmed fish. The results of the Rio Negro study [5] show a high parasite prevalence in wild fish. Unsurprisingly, multiple surveys of native and game fish in the USA provide a long list of parasites found on sampled fish [16, 17]. As parasites are a part of the natural world, wild fish would be expected to carry them. Over the course of evolution, parasites have "learned" to feed off fish populations long-term, not destroy their food source. Under normal circumstances, fish resistance prevents parasites from multiplying to numbers where they cause disease. However, when fish are stressed by capture, rough handling, and overcrowding, a few attached parasites can multiply and cause problems.

Goldfish seemed to be the most parasitized fish (Tables 5 and 8).

The effect of parasitism will always be worse where there is a continuous influx of new fish such as in retail stores or in hobbyist tanks where new fish are continually added. Fish in established tanks build up resistance, but newly introduced fish are often immunologically "naïve." The new fish stimulates multiplication of the parasite population, thereby threatening the entire tank.

The studies suggest that efforts to eradicate parasites from aquaculture farms may be quite difficult. The Sri Lankan farms, carefully regulated by the government, probably set a high standard. Parasites were not detected in 3 of the 26 surveyed farms.

Keeping popular "beginner" fish like Platies, Guppies, Bettas and Angelfish has become harder over the years. In the past, local shopkeepers often sold fish raised by themselves and/or local breeders. Now, many of the popular fish are imported from fish farms from all over the world. Globalization promotes the spread of new parasites, plus fish are stressed by the shipping and handling procedure.

The result is that inexpensive "beginner fish" from aquarium stores and pet shops are not always the easiest fish to keep. Buying fish directly from the breeder, such as at aquarium society auctions, is a prudent first step. However, parasites are so prevalent in fish—whether wild-caught or farmed—that one should not take these pests for granted.

The information from these 11 surveys has increased my confidence in keeping aquarium fish healthy. It seems parasites, especially the MONOs, are the most common cause of disease in aquarium fish. Hopefully, this information will be of use to other fish keepers.

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Diana Walstad is the author of *Ecology of the Planted Aquarium* (2013). For more information about her books, see: http://dianawalstad.com.