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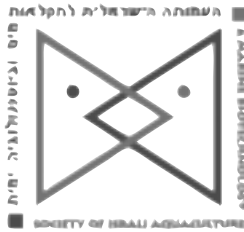


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Protozoan and Metazoan Parasites of Cultured Fish in Turkey and their Applied Treatments

Sevki Kayis¹, Tuna Ozcelep², Erol Capkin² and Ilhan Altinok^{2*}

¹ Department of Fisheries and Aquatic Sciences, Rize University, 53100 Rize, Turkey

² Faculty of Marine Sciences, Karadeniz Technical University, 61530 Sürmene, Trabzon, Turkey

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Abstract

This publication summarizes information on parasites of Turkish fishes from 2003 to 2008. The information is presented as parasite-host lists and contains 79 species of parasites, distributed among the higher taxa as follows: Protozoa (14 species), Monogenea (12), Digenea (15), Cestodes (8), Crustacea (1), Isopoda (7), Copepoda (4), Nematoda (8), Bivalvia (1), Acanthocephala (5), Hirudinea (1), and Myxosporean (3). Many records of parasites not identified to the species level are also included. The parasite-host lists are organized on a taxonomic basis and provide information for parasite species found on host species, known geographic distributions in Turkey, and published sources for each host and locality record.

Introduction

The nutritional and economic benefits of cultured aquatic organisms are considerable. However, there are many restrictive agents in the sector due to noninfectious and infectious agents. Infectious fish diseases result from fungi, viruses, bacteria, and parasites. Fish parasites are divided into two major groups, protozoan and metazoan (Tonguthai, 1997; Durborow, 2003).

Protozoans are the most common parasites encountered in fish hatcheries (Pillay, 1995). Although some authors consider them harmless, many serious fish losses are caused by proto-

* Corresponding author. Tel.: +90-462-7522805, fax: +90-462-7522158, e-mail: ialtinok@gmail.com

zoan parasites (Krier and Baker, 1987; Durborow et al., 1998; Scholz, 1999; Al-Rasheid et al., 2000). Protozoans vary in shape and size and live mainly on the gills, fins, and skin of fish. Nevertheless some, such as *Hexamita*, *Cryptobia*, and *Myxozoa*, live in the internal organs (Roberts and Shepherd, 1997). Among the protozoan parasites, *Ichthyobodo necator*, *Ichthyophthirius multifiliis*, *Trichodina* spp., *Trichophyra*, *Ambiphyra*, *Hexamita*, and *Apiosoma* are some of the most significant pathogens in aquaculture (Durborow, 2003).

Metazoan fish parasites include trematodes, cestodes, nematodes, acanthocephalans, leeches, and parasitic crustaceans (Mitchum, 1995). These parasites can cause gill infestations, damage to eyes and internal organs, starvation, inflammation of the swim bladder, and inhibited oxygen exchange across gill lamella. They provide portals of entry for bacteria in fish (Lasee, 1995).

Parasites can seriously affect cultured and wild fish populations. Control of fish parasites requires knowledge of the parasites, their hosts, and their prevalence and distribution (Mitchum, 1995). Early reviews on parasites of Turkish fishes were made by Oktener (2003) and Oktener et al. (2004). After these reviews, new parasites and hosts were reported. The objectives of this study were to determine protozoan and metazoan parasites and their host distribution in Turkey, and to report new parasites from Black Sea region. Information is also provided about procedures used to treat parasitic diseases of fish in Turkey.

Materials and Methods

This report was based on published data from 2004 to 2008 from various regions of Turkey and our own survey conducted at the Faculty of Marine Sciences, Karadeniz Technical University. Rainbow trout (*Oncorhynchus mykiss*), brook trout (*Salvelinus fontinalis*), and brown trout (*Salmo trutta fario*) ranging 1.0±0.2 to 40±0.7 g were sampled from 30 fish farms in the eastern Black Sea region of Turkey. Jewel cichlid (*Hemichromis bimaculatus*), guppy (*Poecilia reticulata*), platy fish (*Xiphophorus maculatus*), black molly (*Poecilia sphenops*), blue streak hap (*Labidochromis caeruleus*), and goldfish (*Carrasius auratus*) were collected from aquarium units of the Fisheries Faculty of Rize University between 2004 and 2008. In all, 4300 salmonids, 10 *Diplodus annularis*, and 75 aquarium fish were examined for external and internal parasites (Lom and Dykova, 1992). Parasites, if present, were identified according to methods described by Joyon and Lom (1969). Taxonomy and classification were according to Woo (2006).

Results

All identified protozoan parasites were external, except for *Hexamita salmonis* and *Pleistophora* spp.

The majority of protozoan parasites were ciliates (Table 1). Most protozoan parasites were observed in fish samples taken from the Black Sea region of Turkey while only three protozoans were from the Mediterranean (Cengizler et al., 2001; Koyuncu and Cengizler, 2002) and one from the Aegean region (Toksen, 2004). No protozoan parasites were observed in central, east, or southeast Anatolia. *Sparus aurata*, *Salvelinus fontinalis*, and *Salmo trutta fario* appeared to be new hosts for *Trichodina* spp. *Ichthyobodo necator* infestations were observed on guppy (*Poecilia reticulata*) and *Salmo trutta fario* while *Apiosoma piscicola* were observed on *Cyprinus carpio*.

A total of 60 metazoan parasites were described at species level and five at genus level from different regions of Turkey (Table 2). The majority of metazoans were trematodes and nematodes.

Discussion

The main protozoan parasites were *Trichodina* spp., *Ichthyophthirius multifiliis*, and *Ichthyobodo necator*. *Tetrahymena* spp. cause 30% mortality in aquaria and were isolated in guppy for the first time in the present study. *Hexamita salmonis* was observed in intestinal track of rainbow trout fry.

Table 1. Protozoan parasites, host and regions.

	Host	Region	Reference
Ciliates			
<i>Ambiphyra</i> spp.	<i>Poecilia reticulata</i>	Black Sea	Kayis et al., 2005
<i>Apiosoma piscicola</i>	<i>Cyprinus carpio</i>	Black Sea	Ozer and Erdem, 1998
<i>Chilodenella</i> spp.	<i>Brachydanio rerio</i>	Black Sea	Present study
<i>Ichthyophthirius multifiliis</i>	<i>Salvelinus fontinalis</i>	Black Sea	Present study
– “ –	<i>Oncorhynchus mykiss</i>	Black Sea	Present study
<i>Tetrahymena</i> spp.	<i>Poecilia reticulata</i>	Black Sea	Present study
<i>Trichodina</i> spp.	<i>Sparus aurata</i>	Aegean	Toksen, 2004
– “ –	<i>Salvelinus fontinalis</i>	Black Sea	Balta et al., 2007
– “ –	<i>Salmo trutta fario</i>	Black Sea	Balta et al., 2007
– “ –	<i>Merlangius merlangus</i>	Black Sea	Ogut and Palm, 2005
<i>Trichodina lepsii</i>	<i>Mugil cephalus</i>	Black Sea	Ozer and Ozturk, 2004
– “ –	<i>Liza aurata</i>	Black Sea	Ozer and Ozturk, 2004
<i>Trichodina modesta</i>	<i>Aphanius danfordii</i>	Black Sea	Ozer, 2007
<i>Trichodina nigra</i>	<i>Cyprinus carpio</i>	Mediterranean	Cengizler et al., 2001
– “ –	<i>Cyprinus carpio</i>	Black Sea	Ozer and Erdem, 1998
<i>Trichodina puytoraci</i>	<i>Mugil cephalus</i>	Black Sea	Ozer and Ozturk, 2004
– “ –	<i>Liza aurata</i>	Black Sea	Ozer and Ozturk, 2004
<i>Trichodinella subtilis</i>	<i>Cyprinus carpio</i>	Black Sea	Ozer and Erdem, 1998
Flagellates			
<i>Hexamita salmonis</i>	<i>Oncorhynchus mykiss</i>	Black Sea	Present study
<i>Ichthyobodo necator</i>	<i>Poecilidae</i>	Mediterranean	Koyuncu and Cengizler, 2002
– “ –	<i>Poecilia reticulata</i>	Black Sea	Kayis et al., 2005
– “ –	<i>Salmo trutta fario</i>	Black Sea	Kayis, 2006
Dinoflagellidae			
<i>Oodinium pillularis</i>	<i>Poecilidae</i>	Mediterranean	Koyuncu and Cengizler, 2002

In the present study, *Armadillidium nasatum*, an Isopoda, was isolated for the first time on *Diplodus annularis* in Turkey. Metazoan parasites that were commonly observed in the Mediterranean, Marmara, and Aegean regions were not detected in east Anatolia, possibly because of insufficient study about metazoan parasites these regions from 2004 to 2008.

Gyrodactylus salaris, a notifiable fish disease agent (OIE, 2007), was not recorded. Protozoan infestations such as *Trichodina* spp., *Tetrahymena* spp., *Ichthyophthirius multifiliis* and *Ichthyobodo necator* appeared to be the most harmful protozoan parasites identified in this review.

The applied treatments for diseases are prevention and good health management. However, copper sulfate, potassium permanganate, formalin, salt, chloramines-T, and acetic acid are commonly used to control protozoan fish parasites (Table 3). Salt, formaldehyde, and vinegar appeared to be the most effective chemicals to treat protozoan infestation (Toksen, 2000; Kayis et al., 2005; Kayis, 2006; Balta et al., 2008). Triclorphon and formalin can be used to treat metazoan parasites (Lasee, 1995; Toksen, 2006). Among the chemicals that are used to treat or prevent parasitic fish diseases in Turkey, acetic acid, betadine, chloramin-T, copper sulfate, forma-

Table 2. Metazoan parasites, hosts, and regions.

Parasite	Host	Region	Reference
Platyhelminthes			
Monogenean			
<i>Benedenia sciaenae</i>	<i>Argyrosomus regius</i>	Aegean	Toksen and Gamsiz, 2005
<i>Gyrodactylus carassii</i>	<i>Carassius carassius</i>	Marmara	Aydogdu, 2006
<i>Dactylogyrus cornoides</i>	<i>Vimba vimba</i>	Marmara	Uzunay and Soylu, 2005
<i>Dactylogyrus cornoides</i>	<i>Vimba vimba</i>	Black Sea	Ozer and Ozturk, 2004
<i>Dactylogyrus distinguendus</i>	<i>Abramis brama</i>	Marmara	Karatoy and Soylu 2006
<i>Dactylogyrus ergensi</i>	<i>Pseudophoxinus antalyae</i>	Mediterranean	Soylu and Emre, 2007
<i>Dactylogyrus phoxini</i>	<i>Cyprinus carpio</i>	Marmara	Uzunay and Soylu, 2005
<i>Lamellodiscus ignoratus</i>	<i>Diplodus puntazzo</i>	Aegean	Toksen, 2006
<i>Octosoma scombri</i>	<i>Scomber japonicus</i>	Aegean	Akmirza, 2003
<i>Octosoma scombri</i>	<i>Scomber japonicus</i>	Mediterranean	Akmirza, 2003
<i>Paradiplozoon homoion</i>	<i>Pseudophoxinus antalyae</i>	Mediterranean	Soylu and Emre, 2007
<i>Paradiplozoon homoion</i>	<i>Cyprinus carpio</i>	Mediterranean	Soylu and Emre, 2007
<i>Quadriacanthus clariadis</i>	<i>Clarias lazera</i>	Mediterranean	Soylu and Emre, 2005
<i>Skrajibillanus scardinii</i>	<i>Scardinius erythrophthalmus</i>	Marmara	Aydogdu et al., 2008
<i>Trachellobdella torquata</i>	<i>Carassius carassius</i>	Mediterranean	Ozan and Kir, 2005
Digenean			
<i>Ascocotyle</i> sp.	<i>Neogobius melanostomus</i>	Black Sea	Ozer, 2007
<i>Centrocestus formosanus</i>	<i>Xiphophorus maculatus</i>	Central Anatolia	Yildiz, 2005
– “ –	<i>Carassius auratus</i>	– “ –	– “ –
– “ –	<i>Pterophyllum scalare</i>	– “ –	– “ –
– “ –	<i>Poecilia reticulata</i>	– “ –	– “ –
<i>Dichelyne minutus</i>	<i>Neogobius melanostomus</i>	Black Sea	Ozer, 2007
<i>Ectenurus lepidus</i>	<i>Scomber japonicus</i>	Aegean	Akmirza, 2003
– “ –	– “ –	Mediterranean	– “ –
<i>Hemiuridae metacercaria</i>	<i>Solea solea</i>	Marmara	Keser et al., 2007
<i>Lecithocladium excisum</i>	<i>Scomber scombrus</i>	Marmara	Keser et al., 2007
<i>Lecithostaphylus retroflexus</i>	<i>Belone belone</i>	Marmara	Keser et al., 2007
<i>Lepidopedon elongatum</i>	<i>Scomber japonicus</i>	Aegean	Akmirza, 2003
– “ –	– “ –	Mediterranean	– “ –
<i>Monascus filiformis</i>	<i>Trachurus trachurus</i>	Marmara	Keser et al., 2007
<i>Neoechinohynchus rutilii</i>	<i>Neogobius melanostomus</i>	Black Sea	Ozer, 2007
<i>Opechona bacillaris</i>	<i>Pomatomus saltatrix</i>	Marmara	Keser et al., 2007
– “ –	<i>Scomber scombrus</i>	– “ –	– “ –
<i>Opechona ollson</i>	<i>Scomber japonicus</i>	Aegean	Akmirza, 2003
<i>Prodistomum polonii</i>	<i>Trachurus trachurus</i>	Marmara	Keser et al., 2007
<i>Grillotia</i> sp.	<i>Solea solea</i>	Marmara	Keser et al., 2007
<i>Polygonchobotrium magnum</i>	<i>Clarias lazera</i>	Mediterranean	Soylu and Emre, 2005
<i>Proteocephalus torulosus</i>	<i>Tinca tinca</i>	Central Anatolia	Ozan et al., 2006
<i>Rhapdochona denudata</i>	<i>Alburnus alburnus</i>	Marmara	Aydogdu and Selver, 2006
<i>Scolex pleuronectis</i>	<i>Solea solea</i>	Marmara	Keser et al., 2007

Parasite	Host	Region	Reference
Arthropoda			
Crustacean			
<i>Lernanthropus kroyeri</i>	<i>Dicentrarchus labrax</i>	Aegean	Toksen et al., 2008
Isopoda			
<i>Anilocra frontalis</i>	<i>Oblado melanura</i>	Mediterranean	Innal et al., 2007
– “ –	<i>Hoops boops</i>	– “ –	– “ –
– “ –	<i>Pagellus erythrinus</i>	– “ –	– “ –
– “ –	<i>Lithognathus mormyrus</i>	– “ –	– “ –
– “ –	<i>Diplodus annularis</i>	– “ –	– “ –
– “ –	<i>Sphyaena chrysotaenia</i>	– “ –	– “ –
– “ –	<i>Liza aurata</i>	– “ –	– “ –
<i>Anilocra physodes</i>	<i>Sparus aurata</i>	Marmara	Oguz and Oktener, 2007
– “ –	<i>Trachurus trachurus</i>	– “ –	– “ –
– “ –	<i>Oblado melanura</i>	Mediterranean	Innal et al., 2007
– “ –	<i>Hoops boops</i>	– “ –	– “ –
– “ –	<i>Pagellus erythrinus</i>	– “ –	– “ –
– “ –	<i>Lithognathus mormyrus</i>	– “ –	– “ –
– “ –	<i>Diplodus annularis</i>	– “ –	– “ –
– “ –	<i>Sphyaena chrysotaenia</i>	– “ –	– “ –
– “ –	<i>Liza aurata</i>	– “ –	– “ –
<i>Armadillidium nasatum</i>	<i>Diplodus annularis</i>	Black Sea	Present study
<i>Ceratothoa oestroides</i>	<i>Sardina pilchardus</i>	Marmara	Oguz and Oktener, 2007
<i>Ceratothoa steindachneri</i>	<i>Chlorophthalmus agassizi</i>	Mediterranean	Oktener et al., 2007
<i>Livoneca sinuata</i>	<i>Loligo vulgaris</i>	Aegean	Trilles and Oktener, 2004
<i>Nerocila bivittata</i>	<i>Parablennius sanguinolentus</i>	Black Sea	Alas et al., 2008
Copepoda			
<i>Caligus minimus</i>	<i>Dicentrarchus labrax</i>	Aegean	Ulukoy and Kubilay, 2005
<i>Clavellotis strumosa</i>	<i>Pagellus erythrinus</i>	Marmara	Oktener et al., 2008
<i>Ergasilus mosulensis</i>	<i>Liza abu</i>	Southeast Anatolia	Oktener et al., 2007
<i>Lernaeopoda galei</i>	<i>Mustelus mustelus</i>	Aegean	Karatug et al., 2004
Nematodes			
<i>Anguillicola crassus</i>	<i>Anguilla anguilla</i>	Mediterranean	Genc et al., 2005
<i>Anisakis simplex</i>	<i>Scomber japonicus</i>	Aegean	
		Mediterranean	Akmirza, 2003
<i>Camallanus truncates</i>	<i>Esox lucius</i>	Aegean	Kir and Ozan, 2005
<i>Contraecum</i> sp.	<i>Carassius carassius</i>	Mediterranean	Ozan and Kir, 2005
<i>Contraecum aduncum</i>	<i>Scomber japonicus</i>	Aegean	Akmirza, 2003
<i>Cucullanellus minutus</i>	<i>Platichthys flesus</i>	Marmara	Aydogdu and Ozturk, 2003
<i>Hysterothylacium aduncum</i>	<i>Trachurus trachurus</i>	Marmara	Keser et al., 2007
– “ –	<i>Sparus aurata</i>	– “ –	– “ –
– “ –	<i>Solea solea</i>	– “ –	– “ –
– “ –	<i>Engraulis encrasicolus</i>	– “ –	– “ –
– “ –	<i>Pomatomus saltatrix</i>	– “ –	– “ –
– “ –	<i>Liza saliens</i>	– “ –	– “ –
<i>Philometra lateolabracis</i>	<i>Epinephelus aeneus</i>	Mediterranean	Genc et al., 2005
Bivalvia			
<i>Glochidium</i> sp.	<i>Cyprinus carpio</i>	Marmara	Uzunay and Soylu, 2005
– “ –	<i>Vimba vimba</i>	– “ –	– “ –

Parasite	Host	Region	Reference
Acanthocephala			
<i>Solearhynchus soleae</i>	<i>Merlucciusmerluccius</i>	Marmara	Oguz and Kvach, 2006
- " -	<i>Trachurus trachurus</i>	- " -	- " -
- " -	<i>Uranoscopus scaber</i>	- " -	- " -
- " -	<i>Gobius niger</i>	- " -	- " -
- " -	<i>Gobius cobitis</i>	- " -	- " -
- " -	<i>Scorpaena scrofa</i>	- " -	- " -
- " -	<i>Eutrigla gurnardus</i>	- " -	- " -
- " -	<i>Solea vulgaris</i>	- " -	- " -
<i>Acanthocephaloides propinquus</i>	<i>Merlucciusmerluccius</i>	Marmara	Oguz and Kvach, 2006
- " -	<i>Trachurus trachurus</i>	- " -	- " -
- " -	<i>Uranoscopus scaber</i>	- " -	- " -
- " -	<i>Gobius niger</i>	- " -	- " -
- " -	<i>Gobius cobitis</i>	- " -	- " -
- " -	<i>Scorpaena scrofa</i>	- " -	- " -
- " -	<i>Eutrigla gurnardus</i>	- " -	- " -
- " -	<i>Solea vulgaris</i>	- " -	- " -
<i>Paracanthocephaloides kostylewi</i>	<i>Merlucciusmerluccius</i>	Marmara	Oguz and Kvach, 2006
- " -	<i>Trachurus trachurus</i>	- " -	- " -
- " -	<i>Uranoscopus scaber</i>	- " -	- " -
- " -	<i>Gobius niger</i>	- " -	- " -
- " -	<i>Gobius cobitis</i>	- " -	- " -
- " -	<i>Scorpaena scrofa</i>	- " -	- " -
- " -	<i>Eutrigla gurnardus</i>	- " -	- " -
- " -	<i>Solea vulgaris</i>	- " -	- " -
<i>Longicollum pagrosomi</i>	<i>Merlucciusmerluccius</i>	Marmara	Oguz and Kvach, 2006
- " -	<i>Trachurus trachurus</i>	- " -	- " -
- " -	<i>Uranoscopus scaber</i>	- " -	- " -
- " -	<i>Gobius niger</i>	- " -	- " -
- " -	<i>Gobius cobitis</i>	- " -	- " -
- " -	<i>Scorpaena scrofa</i>	- " -	- " -
- " -	<i>Eutrigla gurnardus</i>	- " -	- " -
- " -	<i>Solea vulgaris</i>	- " -	- " -
<i>Neoechinorhynchus agills</i>	<i>Liza saliens</i>	Marmara	Keser et al., 2007
Hirudinea			
<i>Trachelobdella lubrica</i>	<i>Scorpaena porcus</i>	Marmara	Celik and Aydin, 2006
Myxosporean			
<i>Myxobilatus gasterostei</i>	<i>Gasterosteus aculeatus</i>	Black Sea	Ozer, 2003
<i>Pleistophora</i> spp.	<i>Xiphophorus maenlatus</i>	Marmara	Timur et al., 2005
<i>Sphaerospora elegans</i>	<i>Gasterosteus aculeatus</i>	Black Sea	Ozer, 2003

lin, hydrogen peroxide, ivermectin, levamisol, metronidazole, potassium permanganate, and salt are authorized by the European Union by the council regulation (EEC) no. 2377/90 of the European Council.

In most countries, very few drugs and chemicals have been registered for treatment of food fish. Indeed, many biocides (e.g., malachite green) are banned from use in most countries and severe measures are taken against exporters of fish and shellfish that contain residues. Due to the carcinogenic and genotoxic potentials of malachite green, it has been prohibited for use in the production of consumer fish in the European Union by regulation no. 2377/90 of the European Council. Drugs and chemicals used to treat fish must be safe to the fish and the environment, as well as to humans.

Table 3. Control and treatment of parasitic diseases in fishes.

Chemical	Dosage; Time	Parasite	Treatment	Reference
Acetic acid*	1-2 mg/l; 1-10 min	External parasites	Dip treatment	Balta et al., 2008
Betadine*	50 mg/l; 30 min	External parasites	Bath treatment at pH 6-7	Toksen et al., 1996
Bithionol	0.2 g/kg fish	Acanthocephalans	Mixed with feed	Toksen et al., 1996
Chloramin-T*	7-15 mg/l; 1 h	Protozoan, monogenetic trematodes	Bath treatment	Balta et al., 2008
Copper sulfate*	0.5 mg/l	External parasites	Bath treatment	Toksen et al., 1996
Formaldehyde*	0.167-0.25 mg/l; 1 h			
	0.25 mg/l; indefinite	External parasites	Bath treatment	Balta et al., 2008
Hydrogen peroxide*	250-500 mg/l; 30-60 min	External parasites	Bath treatment	Lasee, 1995
Ivermectin*	2.5mg/100 kg fish; twice a week	Helminths	Mixed with feed	Toksen et al., 1996
Levamisol*	50 ml/l; 2 h	Monogenetic trematodes	Bath treatment	Timur and Timur, 2003
Mebendazole	1 mg/l; 24 h	Monogenetic trematodes	Bath treatment	Toksen et al., 1996
Metronidazole*	7 mg/l; 2 d	<i>Hexamita salmonis</i>	Bath treatment	Timur and Timur, 2003
Niclosamid	100-200 mg/kg fish; 2 d	Cestodes	Mixed with feed	Toksen et al., 1996
Potassium permanganate*	2-4 mg/l; 1 h	External parasites	Bath treatment	Lasee, 1995
Praziquantel	500 mg/100 kg fish; 2 d	<i>Eubothrium</i> <i>Diphylobothrium</i> <i>plerocercoid</i>	Mixed with feed	Timur and Timur, 2003
Salt*	3% solution; 15-30 min 0.5% solution; indefinite	External parasites	Bath treatment	Balta et al., 2008
Triclorphon	5 mg/l; 30 min	Copepods	Bath treatment	Toksen et al., 1996

* Chemicals authorized by council regulation (EEC) no. 2377/90 of the European Council.

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