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Invasion of *Schyzocotyle acheilognathi* (Yamaguti, 1934) (Cestoda: Bothriocephalidea) in Turkey

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Abstract: Introduction of *Schyzocotyle acheilognathi* (Yamaguti, 1934) with the grass carp and common carp, has been documented in Asia, Europe and some parts of North America. It is known that it parazites more than one hundred fishes, principally cyprinids. One of the major negative effects of fish introductions in Turkey is the wide spread distribution of *S. acheilognathi*. It is a highly pathogenic cestode that infects 26 fish species from seven families in Turkey. This study presents the current geographical distribution and host range of *S. acheilognathi* in inland waters of Turkey.

Keywords: *Schyzocotyle acheilognathi*, *Ctenopharyngodon idella*, *Cyprinus carpio*, Invasion, Host range, Turkey.

Introduction

The grass carp (*Ctenopharyngodon idella*) is an agent of some parasites and diseases (Coad, 1996). Among them, *Schyzocotyle acheilognathi* (Bothriocephalus acheilognathi) (Yamaguti, 1934) is a parasite species with a great capacity for natural dispersal, invasion and capable of colonizing. It is known that it parazites more than one hundred fishes, principally cyprinids. *Schyzocotyle acheilognathi* can cause massive fish kills in cultivated fish and serious damage in fry and small fish at high infection levels. Potential negative impacts include: loss and separation of intestinal microvilli and enterocytes, blockage and perforation in innards, emaciation and anemia in chronic infections, decrease in hepatic and pancreatic enzymes, reduction in growth and reproductive capacity, muscular problems, decrease in hemoglobin content, weakened swimming capacity and secondary bacterial infection (Salgado-Maldonado and Pineda-Lopez, 2003).

The natural host and geographical origin of this tapeworm is the grass carp of the Amur River (Paperna, 1996). The pathogenic cestode *S. acheilognathi* is considered to have been introduced from China initially to East Europe and thence to the other parts of the world (Hoole, 1994). Introduction of the infected Asian carps into Europe also exposed *S. acheilognathi* to native European fishes.

The impact of *S. acheilognathi* on biodiversity of Turkey is still largely unknown. This study presents the current geographical distribution and host range of *S. acheilognathi* in inland waters of Turkey.

Materials and Methods

The data, given in this study, were presented by documenting the scientific researches, carried out in the inland waters of Turkey. Fish names and their distributions were updated according to FishBase (Froese and Pauly, 2015).

Results

Geographical distribution and host range of *S. acheilognathi* infection are given in Table 1. Host record numbers of *S. acheilognathi* in Turkey is given in Table 2. The distribution of *S. acheilognathi* in the inland waters of Turkey is given on the map below (Fig. 1).

Schyzocotyle acheilognathi has firstly been reported from İznik Lake in inland waters of Turkey (Türkmen, 1990). From this time on, this cestode has actively invaded

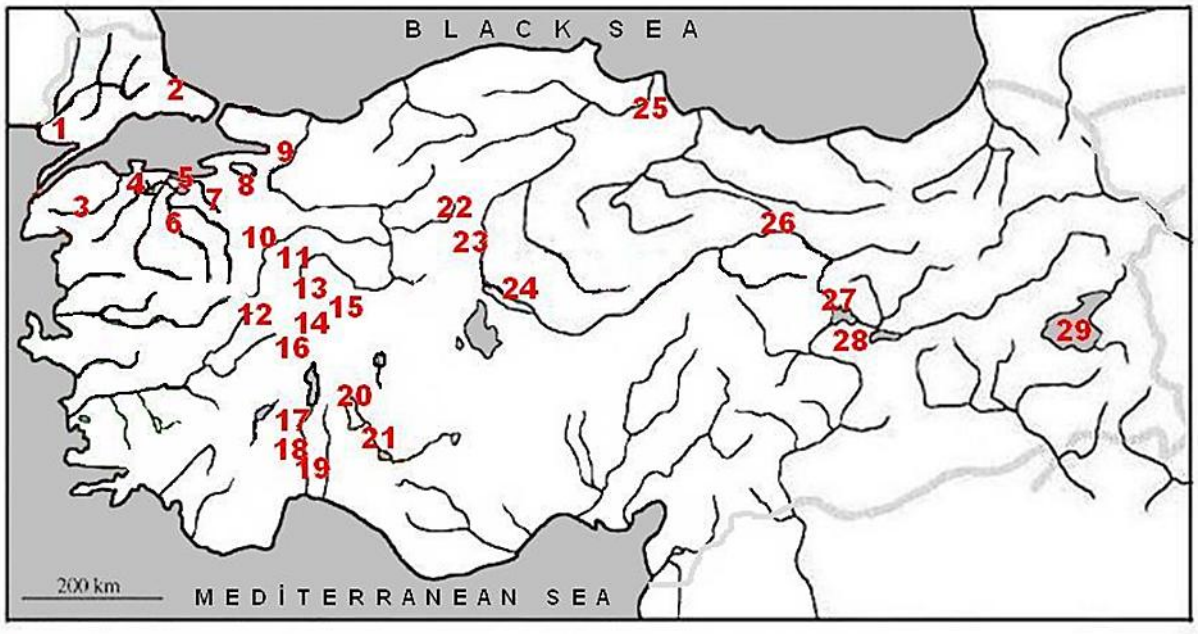

Figure 1. The distribution of *Schyzocotyle acheilognathi* in the inland waters of Turkey. (1. Sığırcı Lake, 2. Terkos Lake, 3. Kocadere Creek, 4. Manyas Lake, 5. Uluabat Lake, 6. Mustafa Kemal Paşa Creek, 7. Doğancı Dam Lake, 8. İznik Lake, 9. Sapanca Lake, 10. Enne Dam Lake, 11. Kunduzlar Dam Lake, 12. Serban Dam Lake, 13. Örenler Dam Lake, 14. Selevir Dam Lake, 15. Eber Lake, 16. Karamık Lake, 17. Kovada Lake, 18. Karacaören Dam Lake I, 19. Karacaören Dam Lake II, 20. Beyşehir Lake, 21. İncesu Creek-Konya, 22. Kirmir Creek, 23. Mogan Lake, 24. Hirfanlı Dam Lake, 25. Bafra Balık Lake, 26. Tödürge Lake, 27. Keban Dam Lake, 28. Hazar Lake, 29. Van Lake region).

Table 1. Records related to *Schyzocotyle acheilognathi* in the inland waters of Turkey.

Number	*Reported host fish species*	*Valid name of host fish species*	Host locality	Author/s
1	*Alburnus alburnus*	*Alburnus alburnus*	Mustafa Kemal Paşa Creek	Aydoğdu and Selver (2006)
2	*Alburnus alburnus*	*Alburnus alburnus*	Enne Dam Lake	Koyun (2001)
3	*Alburnus chalcoides*	*Alburnus chalcoides*	Tödürge Lake	Yıldırım (2006)
4	*Alburnus escherichii*	*Alburnus escherichii*	Kunduzlar Dam Lake	Öztürk (2011)
5	*Aphanius danfordii*	*Aphanius marassantensis*	Bafra fish lakes	Öztürk and Özer (2014)
6	*Atherina boyeri*	*Atherina boyeri*	Iznik Lake	Çolak (2013)
7	*Atherina boyeri*	*Atherina boyeri*	Bafra fish lakes	Öztürk and Özer (2014)
8	*Barbus plebejus escherichii*	*Barbus niluferensis*	Doğancı Dam Lake	Aydoğdu (2001)
9	*Blicca bjoerkna*	*Blicca bjoerkna*	Sapanca Lake	Soylu (2006)
10	*Capoeta capoeta umbla*	*Capoeta umbla*	Hazar Lake	Aksoy and Sarıeyyüpoğlu (2000)
11	*Capoeta capoeta umbla*	*Capoeta umbla*	Keban Dam Lake	Dörücü and İspir (2005)
12	*Capoeta trutta*	*Capoeta trutta*	Keban Dam Lake	Dörücü and İspir (2005)
13	*Carassius gibelio*	*Carassius gibelio*	Bafra fish lakes	Öztürk and Özer (2014)
14	*Chondrostoma regium*	*Chondrostoma regium*	Keban Dam Lake	Dörücü and İspir (2005)
15	*Ctenopharyngodon idella*	*Ctenopharyngodon idella*	Aquaculture condition	Uzbilek and Yıldız (2002)
16	*Cyprinus carpio*	*Cyprinus carpio*	Doğancı Dam Lake	Aydoğdu (2001)
17	*Cyprinus carpio*	*Cyprinus carpio*	Sığırcı Lake	Çolak (2012)
18	*Cyprinus carpio*	*Cyprinus carpio*	Keban Dam Lake	Dörücü and İspir (2005)
19	*Cyprinus carpio*	*Cyprinus carpio*	Hirfanlı Dam Lake	Erkul (1997)

Table 1. to be continued.

Number	*Reported host fish species*	*Valid name of host fish species*	Host locality	Author/s
20	*Cyprinus carpio*	*Cyprinus carpio*	Kirmir Creek	Erkul (1997)
21	*Cyprinus carpio*	*Cyprinus carpio*	Mogan Lake	Erkul (1997)
22	*Cyprinus carpio*	*Cyprinus carpio*	Kovada Lake	Kır and Tekin Özan (2007)
23	*Cyprinus carpio*	*Cyprinus carpio*	Karacaören I Dam Lake	Kır et al. (2004)
24	*Cyprinus carpio*	*Cyprinus carpio*	Karamık Lake	Kutlu and Öztürk 2006
25	*Cyprinus carpio*	*Cyprinus carpio*	Manyas Lake	Özturk (2000)
26	*Cyprinus carpio*	*Cyprinus carpio*	Selevir Dam Lake	Öztürk and Bulut (2006)
27	*Cyprinus carpio*	*Cyprinus carpio*	Eber Lake	Öztürk (2005)
28	*Cyprinus carpio*	*Cyprinus carpio*	Kunduzlar Dam Lake	Öztürk (2011)
29	*Cyprinus carpio*	*Cyprinus carpio*	Bafra fish lakes	Öztürk and Özer (2014)
30	*Cyprinus carpio*	*Cyprinus carpio*	Karacaören II Dam Lake	Samancı (2011)
31	*Cyprinus carpio*	*Cyprinus carpio*	Beyşehir Lake	Tekin Özan et al. (2008)
32	*Cyprinus carpio*	*Cyprinus carpio*	Van Lake Region	Topcu (1993)
33	*Cyprinus carpio*	*Cyprinus carpio*	İznik Lake	Türkmen (1990)
34	*Cyprinus carpio*	*Cyprinus carpio*	Sapanca Lake	Uzunay and Soylu (2006)
35	*Gambusia affinis*	*Gambusia holbrooki*	Bafra fish lakes	Öztürk and Özer (2014)
36	*Gobius fluviatilis*	*Neogobius fluviatilis*	Uluabat Lake	Oztürk et al. (2002)
37	*Leuciscus cephalus*	*Squalius cii*	Doğancı Dam Lake	Aydoğdu et al. (2001)
38	*Leuciscus cephalus*	*Squalius fellowesii*	Örenler Dam Lake	Kurupınar and Öztürk (2009)
39	*Leuciscus cephalus*	*Squalius pursakensis*	Kunduzlar Dam Lake	Öztürk (2011)
40	*Neogobius fluviatilis*	*Neogobius fluviatilis*	Bafra fish lakes	Öztürk and Özer (2014)
41	*Proterorhinus marmoratus*	*Proterorhinus marmoratus*	Bafra fish lakes	Öztürk and Özer (2014)
42	*Pseudophoxinus crassus*	*Pseudophoxinus crassus*	Incesu Creek	Aydoğdu et al. (2014)
43	*Rutilus frisii*	*Rutilus frisii*	Iznik Lake	Türkmen (1990)
44	*Rutilus rutilus*	*Rutilus rutilus*	Kocadere Creek	Selver et al. (2007)
45	*Sander lucioperca*	*Sander lucioperca*	Bafra fish lakes	Öztürk and Özer (2014)
46	*Silurus glanis*	*Silurus glanis*	Hirfanlı Dam Lake	Aydın (2003)
47	*Squalius cephalus*	*Squalius pursakensis*	Serban Dam Lake	Açıkel and Öztürk (2011)
48	*Tinca tinca*	*Tinca tinca*	Sapanca Lake	Akbeniz and Soylu (2009)
49	*Tinca tinca*	*Tinca tinca*	Terkos Lake	Demirtaş (2011)
50	*Tinca tinca*	*Tinca tinca*	Kovada Lake	Kır and Tekin Özan (2005)
51	*Tinca tinca*	*Tinca tinca*	Beyşehir Lake	Tekin Özan et al. (2006)
52	*Vimba vimba*	*Vimba vimba*	Bafra fish lakes	Öztürk and Özer (2014)

native fish species. *Schyzocotyle acheilognathi* has been reported from 26 fish species from seven families. It was identified in genus level by some researchers at different hosts and localities. *Schyzocotyle* sp. (Bothriocephalus sp.) was reported from *Cyprinus carpio*, *Esox lucius*, *Alburnus escherichii* in Mogan Lake (Sönmez, 1996), *C. carpio* in Uluabat Lake (Oğuz et al., 1996), and *C. carpio* in Iznik Lake (Aydoğdu and Altunel, 2002).

The host list is dominated by species of cyprinids. 19 of 26 host fish species belongs to Cyprinidae, and it was mostly observed in *C. carpio* (19) and *Tinca tinca* (4). Infections have also been reported in species of the following families: Atherinidae, Cyprinodontidae, Gobiidae, Percidae, Poeciliidae and Siluridae.

Schyzocotyle acheilognathi was recovered from the alien fishes, *Ctenopharyngodon idella*, *Carassius gibelio* and *Gambusia holbrooki*. Six of infected species have turned out to be endemic (*Alburnus escherichii*, *Squalius pursakensis*, *Barbus niluferensis*, *Pseudophoxinus crassus*, *Squalius fellowesii* and *Aphanius*

Table 2. Host record numbers of *Schyzocotyle acheilognathi* in Turkey.

Family	Host fish species	Distribution	Record
Atherinidae	*Atherina boyeri*	Throughout the Mediterranean and Black Sea	2
Cyprinidae	*Alburnus alburnus*	Europe and Asia	2
Cyprinidae	*Alburnus chalcoides*	Europe and Asia	1
Cyprinidae	*Alburnus escherichii*	Turkey	1
Cyprinidae	*Barbus niluferensis*	Turkey	1
Cyprinidae	*Blicca bjoerkna*	Europe and Asia	1
Cyprinidae	*Capoeta trutta*	Tigris-Euphrates basin	1
Cyprinidae	*Capoeta umbla*	Tigris and Euphrates	2
Cyprinidae	*Carassius gibelio*	Europe and Asia	1
Cyprinidae	*Chondrostoma regium*	Asia	1
Cyprinidae	*Ctenopharyngodon idella*	Asia	1
Cyprinidae	*Cyprinus carpio*	Europe to Asia	19
Cyprinidae	*Pseudophoxinus crassus*	Turkey	1
Cyprinidae	*Rutilus frisii*	Eurasia	1
Cyprinidae	*Rutilus rutilus*	Europe	1
Cyprinidae	*Squalius cii*	Europe and Asia	1
Cyprinidae	*Squalius fellowesii*	Turkey	1
Cyprinidae	*Squalius pursakensis*	Turkey	2
Cyprinidae	*Tinca tinca*	Eurasia	4
Cyprinidae	*Vimba vimba*	Eurasia	1
Cyprinodontidae	*Aphanius marassantensis*	Turkey	1
Gobiidae	*Neogobius fluviatilis*	Eurasia	2
Gobiidae	*Proterorhinus marmoratus*	Eurasia	1
Percidae	*Sander lucioperca*	Europe and Asia	1
Poeciliidae	*Gambusia holbrooki*	North America	1
Siluridae	*Silurus glanis*	Europe and Asia	1

marassantensis) to Turkey.

Discussion

One of the most persistent risks inherent with movements of living organisms around the world is that pathogens and parasites associated with the organisms spread to new hosts in the receiving area. This is particularly important where the organisms are cultured and thus concentrated in such a way as to increase their susceptibility to disease (Welcomme, 1988).

A variety of exotic and translocated fish species have been introduced into inland waters of Turkey in the past (Innal and Erk'akan, 2006). Introduction of fish species in Turkey, like elsewhere in the world, has had both positive and negative implications. But the impact of most introductions of fishes is still unknown (Çetinkaya, 2006). One of the major negative effects of fish introductions in Turkey is the wide spread distribution of *S. acheilognathi*. This study reports here on the current status of the Asian fish tapeworm, *S. acheilognathi* in the freshwater of Turkey. It was recorded to date in 26 fish species from 7 families. The pathway for introduction of this cestod appears to be translocation of infected fish species. Extensive introductions of common carp and grass carp may have contributed to make it one of Turkey's most widely distributed freshwater fish parasites.

Cyprinus carpio is one of the first transplanted species of Turkey. It was introduced to many water bodies for different reasons. Transplantation started in the 1960s by the Ministry of Agriculture and Rural Affairs and Ministry of Environment and Forestry and DSI (Genereal Directorate of State Hydraulics Works). Successful populations derived from escapes and releases remain in many inland waters resulting in a highly productive

fishery in Turkey (Innal and Erk'akan, 2006). The grass carp was introduced to Turkey in 1970s by DSI for the use of biological control (Ögretmen, 2006).

The impact of *S. acheilognathi* on freshwater biodiversity of Turkey is still largely unknown; however it is thought to be potentially effective on the populations of six endemic fish species of Turkey. Fish transfer studies should include the programme of identification and control of parasite species in aquatic habitats and fish hatchery stations.

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