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# Infection status of *Anguillicoloides crassus* in wild European eels (Anguilla anguilla) from Four Rivers of the Northeast Mediterranean Region, Turkey

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**Abstract**: In this study the infection status of swimbladder nematode *Anguillicoloides crassus* in European eel (*Anguilla anguilla*) was evaluated for the northeast Mediterranean Region of Turkey. 170 fresh European eel samples were obtained from the four different river side fish markets (whilst processing stage) as follows 45 from Goksu River (G), 42 from Seyhan River (S), 42 from Ceyhan River (C), and 41 from Asi River (A) in two times during a period of 3 years. The number of infected eels (Ni), prevalence (P%), parasite abundance (A), and mean intensity (MI) values were calculated according to the sampled period/locations. The prevalence, parasite abundance, and mean intensity values of parasites were higher Asi River than others.

**Keywords:** Wild European eel, Fish market, *Anguillicoloides crassus*.

## Introduction

The European eel, *Anguilla anguilla* Linnaeus 1758, is a catadromous species found in all European waters and including in the southern part of the Mediterranean Sea (North Africa) (Rad et al., 2013; Jacoby and Gollock, 2014) also it is reported from Sea of Marmara, Aegean Sea, Black Sea and rivers of Turkey (Kara et al., 2010; Bilecenoğlu et al., 2014).

*Anguillicoloides crassus* (Kuwahara, Niimi & Itagaki, 1974) (Nematoda: Dracunculoidea) is an invasive nematode and a main swimbladder infection agent of European eel. The Japanese eel, *A. japonica* were known as a native host of this nematode (Koops and Hartmann, 1989; Molnár et al., 1991; Genc et al., 2005).

The impact (such as epithelial hyperplasia, petechial hyperaemia and lesions) and also seasonal prevalence of the swimbladder parasite on European eels (Kennedy and Fitch, 1990; Nagasawa et al., 1994; Barse et al., 2001) have been studied since 1985 (Neumann, 1985; Würtz et al., 1996; Würtz et al., 1998; Sures et al., 1999; Würtz and Taraschewski, 2000; Kirk, 2003; Weclawski et al., 2013; Barry et al., 2014; Schneebauer et al., 2016; Barry et al. 2017).

The aim of the present study was to monitor and evaluate the seasonal status of swimbladder parasite infections in European eels. Fish were obtained from fish markets during processing stage located near Göksu River, Seyhan River, Ceyhan River and Asi River in northeast Mediterranean region of Turkey. It is the first long term report on *A. crassus* of wild European eels in this region.

## Materials and Methods

The time between November and February is commonly considered to be the period of downstream migration for eels in northeast Mediterranean rivers (Turkey) based on observation of fishermen. According to the traditional fishermen practice, the study was planned and the data were collected and analysed regarding the infection levels/parameters of the eel swimbladder parasite *A. crassus*, which is an Asian originated parasitic swim-bladder nematode in European eel, *A. anguilla*, in the northeast Mediterranean rivers (Fig. 1).

A total of 170 fresh European eel samples were taken from the four different fish markets whilst fish processing stage for commercial purposes. Samples were obtained from fish markets located near Göksu River (Mersin), Seyhan River (Adana), Ceyhan River (Adana), and Asi

River (Hatay) in two times during the period of November 2015-February 2017 (Time I): November 2015-February 2016, Time II: November 2016-February 2017). The range of mean total length and weight of the 170 processed eels were TL: 57.28-70.04 cm and W: 499.31-741.09 g. Endo-parasitological examinations and evaluation were conducted utilizing standard techniques (Pilcher and Moore, 1993; Bush et al., 1997; Evans et al., 1999). The presence and the number of *A. crassus* were recorded. The parasites were collected from the swimbladder lumen of the eels by forceps. In accordance with the results of Blanc et al. (1992), all larvae with a body length of >1.5 mm were considered stage L4 larvae. The prevalence, mean intensity, and abundance values were calculated as described by Bush et al. (1997). For the purpose of identification, nematodes were cleaned carefully with distilled water and then fixed and stored in 70% alcohol in Fish Diseases Laboratory, Faculty of Fisheries, Mersin University.

## Results and Discussion

In Time I (Nov. 2015-Feb. 2016); 6 of 23 eel samples in Goksu River, 5 of 20 in Seyhan River, 6 of 21 in Ceyhan River and 10 of 20 eel samples in Asi River were found to be infected. In the Time II (Nov. 2016-Feb. 2017); 7 of 22 eel samples in Goksu River, 3 of 22 in Seyhan River, 2 of 21 in Ceyhan River and 8 of 21 in Asi River were found to be infected.

In Time I (Nov. 2015-Feb. 2016); prevalence (*P%*) ranges were calculated as 26.09%, for Goksu River; as 25.00%, for Seyhan River; as 28.57%, for Ceyhan River; as 50.00% and for Asi River. In Time II (Nov. 2016-Feb. 2017); prevalence (*P%*) ranges were calculated as 31.82%, for Goksu River; as 13.64%, for Seyhan River; as 9.52%, for Ceyhan River; as 38.10% and for Asi River.

The parasite abundance (*A*) and mean intensity (*MI*) values calculated according to the sampled period and locations were in Time I: 4 and 1.04 for Göksu River; 7.60 and 1.90 for Seyhan River; 2.33 and 0.67 for Ceyhan River; 3.60 and 1.80 for Asi River. In Time II: 5.29 and 1.68 for Göksu River, 6.00 and 0.82 for Seyan River, 5.50 and 0.52 for Ceyhan River, 3.25 and 1.24 for Asi River. In summary, results showed that the range of number of overall infected eels Ni: were detected as 2-10 according to four rivers. The range of overall prevalence as *P%*: 9.52-50 according to four rivers (infected eel rankings from high to low) are follows Asi > Göksu > Ceyhan > Seyhan; and the range of overall abundance as A: 2.33-7.60 (Seyhan > Göksu > Ceyhan > Asi); and the overall mean intensity were calculated as MI: 0.52-1.90 (Asi > Seyhan = Göksu > Ceyhan). The status of *A. crassus* infection in eels is shown in Table 1.


**Figure 1.** Map of study area

*Anguillicoloides crassus* is currently the most dangerous European eel nematode parasite, and has turned out to be more of a threat to the European eel than to its Japanese relative as an original host (Würtz and Taraschewski, 2000; Cakić et al., 2002; Rolbiecki, 2002; Genc et al., 2005; Genc et al., 2008; Rolbiecki and Rokicki, 2005; Rolbiecki, 2008; Jakob et al., 2009; Weclawski et al., 2013; Barry et al., 2014; Jakob et al., 2016; Schneebauer et al., 2016; Barry et al., 2017). A previous study on this parasite in same region in Turkey; Genc et al. (2005) reported prevalence and mean intensity of *A. crassus* as 82.86%; 3.31±1.32 for July and 56; 72.41% and 3.20±1.30 for November in Ceyhan River (Adana, Turkey). Genc et al. (2008) also recorded prevalence (%), and mean intensity values of samples were 61.11%, and 4.55±5.06 in Asi River (Hatay, Turkey).

Apparently, outside of Turkey in other European countries, infection rates of eels are high. Namely, more than half of the eel population are infected. Previous studies have well documented the level of eel infections. Möller et al. (1991) reported that the prevalence of *A. crassus* in the Elbe River (Germany) was 60.6%. Thomas and Ollevier (1992) have reported that prevalence of *A. crassus* in Kolenhaven, Albercanal (Belgium) was 90.2% in 17 specimens. Molnár et al. (1991) stated that

**Table 1.** Status of *Anguillicoloides crassus* infection in wild European eels (sampled from markets near the rivers from north-eastern Mediterranean region of Turkey).

| *Fish markets | Göksu | | Seyhan | | Ceyhan | | Asi | |
|---|---|---|---|---|---|---|---|---|
| *Time* | I | II | I | II | I | II | I | II |
| N | 23 | 22 | 20 | 22 | 21 | 21 | 20 | 21 |
| TL | 70.04±9.63 | 65.91±10.19 | 58.88±15.63 | 61.12±5.63 | 66.73±3.64 | 60.00±6.58 | 57.28±7.51 | 61.52±9.12 |
| W | 741.09±232.49 | 659.09±184.47 | 706.02±251.90 | 499.31±87.02 | 709.05±59.20 | 585.91±98.77 | 654.95±110.76 | 676.43±94.24 |
| TLi | 70.83±5.85 | 64.29±9.76 | 70.40±6.35 | 63.83±8.52 | 63.25±2.09 | 67.50±3.54 | 56.20±6.36 | 54.75±4.39 |
| Wi | 745.00±95.87 | 644.29±96.93 | 711.00±179.67 | 493.33±94.12 | 650.00±27.02 | 692.50±53.03 | 638.00±91.02 | 612.50±59.70 |
| Ni | 6 | 7 | 5 | 3 | 6 | 2 | 10 | 8 |
| TLu-i | 69.77±10.80 | 66.67±10.64 | 71.33±5.12 | 60.62±5.37 | 68.57±3.29 | 59.21±6.36 | 58.35±8.73 | 66.46±7.87 |
| Wu-i | 739.71±267.28 | 666±216.46 | 731.33±172.89 | 500.32±91.38 | 732.67±51.51 | 574.68±96.38 | 671.90±130.30 | 715.77±91.22 |
| Nu-i | 17 | 15 | 15 | 19 | 15 | 19 | 10 | 13 |
| Np | 24 (4.00±2.68) | 37 (5.28±1.60) | 38 (7.6±1.14) | 18 (6.00±3.00) | 14 (2.33±0.52) | 11 (3.6±1.27) | 36 (5.50±0.71) | 26 (3.5±2.33) |
| *P* (%) | 26.09 | 31.82 | 25.00 | 13.64 | 28.57 | 9.52 | 50.00 | 38.10 |
| *A* | 4 | 5.29 | 7.60 | 6.00 | 2.33 | 5.50 | 3.60 | 3.25 |
| *MI* | 1.04 | 1.68 | 1.90 | 0.82 | 0.67 | 0.52 | 1.80 | 1.24 |

*****Eels obtained from near Goksu, Seyhan, Ceyhan, and Asi River fish markets. I: Nov. 2015-Feb. 2016, II: Nov. 2016-Feb. 2017, N: Number of samples, TL cm: total length of sampled eels, W g: weight of sampled eels, TLi cm: total length of infected eels, Wi g: weight of infected eels, Ni: number of infected eels, Nu-i: number of un-infected eels, TLu-i cm: total length of un-infected eels, Wu-i g: weight of un-infected eels, Np: total number of parasites, *P*: prevalence (%) [=(Ni/Nf) x100)], *A*: parasite abundance (=Np/Ni), *MI*: mean intensity (=Np/Nf)

for the prevalence of nematodes in the swimbladder was 8% to 95% and documented the intensity of infection of individuals during mass mortality of eels in the Balaton Lake (Hungary). Norton et al. (2005) have reported that prevalence of *A. crassus* for Thames River (England) was 48%-52%. Finally, according to Aguilar et al. (2005), the prevalence of *A. crassus* on the Tea River (Spain) was 55.52%.

In our study, *A. crassus* prevalence values for the Time I were calculated as 25-50% and for Time II were found as 9.52-38.10%. Weclawski (2012) claimed that there were no significant similarities between the prevalence and the seasonal changes and also no correlations between the number of parasites per samples and the length of eels. Findings of the current study mimics the results of the study conducted by Weclawski (2012).

There is no long term report on *A. crassus* infection of eels in this region. In overall assessment, it is concluded that the highest prevalence, abundance, and mean intensity levels were found in Asi River samples compared to the other sampling sites. Thus, this is the first documented report on the occurrence of *A. crassus* in processing stage of European eels from the northeast Mediterranean region. This long term status of prevalence values will serve as a meaningful data for host-parasite relationship assessments and also for the future efforts on strategy development of fisheries management.

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