

In the Shadow of an Invasive and Harmful Fish Parasite, *Schyzocotyle (Bothriocephalus) acheilognathi*: An Updated Invasion Revision with First Record and an Assessment of its Possible Threats to Host Fishes and Public Health

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ABSTRACT

Schyzocotyle acheilognathi (formerly *Bothriocephalus acheilognathi*), the Asian fish tapeworm of Asian origin, infects a wide range of freshwater fishes, particularly Cyprinidae, and poses a potential threat to native and endemic species in Türkiye. This study documents the first global record of *S. acheilognathi* in the endemic freshwater fish *Squalius pursakensis* (Hankó, 1925), while also providing an updated overview of its invasion and potential risks to host fishes and public health. A total of 98 specimens of *S. pursakensis* were collected seasonally from Sarısu Stream (Eskişehir, Türkiye) between February and November 2023. Of these, six were infected, yielding 25 parasites. The overall prevalence and mean intensity were 6.12 % and 4.87, respectively. Infection parameters were further analyzed according to season, host size, and sex. Literature review indicated that *S. acheilognathi* currently parasitizes 28 freshwater fish species in Türkiye, though only 106 of 427 fish species have been studied ichthyo-helminthologically. This highlights significant gaps in knowledge and the limited scope of current surveys. Histopathological effects, ecological consequences, and potential public health risks of the parasite warrant attention, given its capacity to spread rapidly across freshwater ecosystems. By reporting a new host and locality record for *S. acheilognathi*, this study expands the known geographical and host distribution of the parasite. Furthermore, the findings emphasize the need for continuous monitoring, comprehensive parasitological surveys, and risk assessments to safeguard aquatic biodiversity and reduce possible threats to fish populations and human health.

Key words: Endemic fish, invasive tapeworm, spread revision, public health, zoonoses

İstilacı ve Zararlı Bir Balık Paraziti Olan *Schyzocotyle (Bothriocephalus) acheilognathi*'nin Gölgesinde: İlk Kayıtlarla Güncellenmiş Bir İstila Revizyonu ve Konak Balıklar ve Halk Sağlığı için Olası Tehditlerinin Değerlendirilmesi

Öz

Asya kökenli Asya balık tenyası olan *Schyzocotyle acheilognathi* (eski adıyla *Bothriocephalus acheilognathi*), özellikle Cyprinidae olmak üzere çok çeşitli tatlı su balıklarını enfekte eder ve Türkiye'deki yerli ve endemik türler için potansiyel bir tehdit oluşturur. Bu çalışma, endemik tatlı su balığı *Squalius pursakensis*'te (Hankó, 1925) *S. acheilognathi*'nin ilk küresel kaydını belgelemekle birlikte, istilası ve konukçu balıklar ile halk sağlığı için potansiyel riskleri hakkında güncel bir genel bakış sunmaktadır. Şubat ve Kasım 2023 arasında Sarısu Deresi'nden (Eskişehir, Türkiye) mevsimsel olarak toplam 98 *S. pursakensis* örneği toplandı. Bunlardan altısı enfekte olmuş ve 25 parazit tespit edilmiştir. Genel yaygınlık ve ortalama yoğunluk sırasıyla 6.12 % ve 4,87 olarak bulunmuştur. Enfeksiyon parametreleri ayrıca mevsime, konukçu büyüklüğüne ve cinsiyete göre analiz edilmiştir. Literatür taraması, *S. acheilognathi*'nin Türkiye'de şu anda 28 tatlı su balığı türünde parazitlik yaptığını, ancak 427 balık türünden yalnızca 106'sının ichthyo-helmintholojik olarak incelendiğini göstermiştir. Bu

durum, bilgi eksikliğini ve mevcut araştırmaların kapsamının sınırlı olduğunu ortaya koymaktadır. Tatlı su ekosistemlerinde hızla yayılma kapasitesi göz önüne alındığında, parazitin histopatolojik etkileri, ekolojik sonuçları ve potansiyel halk sağlığı riskleri dikkat gerektirmektedir. *S. acheilognathi* için yeni bir konak ve yerellik kaydının raporlanmasıyla, bu çalışma parazitin bilinen coğrafi ve konak dağılımını genişletmektedir. Ayrıca, bulgular sucul biyolojik çeşitliliği korumak ve balık popülasyonları ile insan sağlığına yönelik olası tehditleri azaltmak için sürekli izleme, kapsamlı parazitolojik araştırmalar ve risk değerlendirmelerine olan ihtiyacı vurgulamaktadır.

Anahtar kelimeler: Endemik balık, istilacı tenya, yayılma revizyon, halk sağlığı, zoonozlar

INTRODUCTION

Schyzocotyle acheilognathi, known as the Asian fish tapeworm, was originally described as *Bothriocephalus acheilognathi* from the cyprinid fish *Acheilognathus rhombeus* in Japan (Yamaguti, 1934). Subsequent molecular studies reassigned the species to the genus *Schyzocotyle*, and its currently accepted name became *Schyzocotyle acheilognathi* (Brabec et al., 2015).

Originally considered endemic to East Asia (Bauer and Hoffman, 1976a), the parasite was introduced into Europe through the translocation of infected cyprinid fishes, particularly *Ctenopharyngodon idella* and *Cyprinus carpio*, for aquaculture purposes during the mid-20th century. Following its introduction, *S. acheilognathi* rapidly established and spread in both cultured and wild freshwater fish populations across several European countries.

Due to its low host specificity, increasing global fish trade, and improved transportation networks, the parasite has expanded far beyond its native range. It is now reported from numerous freshwater fish species worldwide and is present on every continent except Antarctica.

The remarkable invasion success of *S. acheilognathi* is attributed to its broad definitive and intermediate host range, high transmission potential, and ability to adapt to diverse freshwater environments (Figure 1).

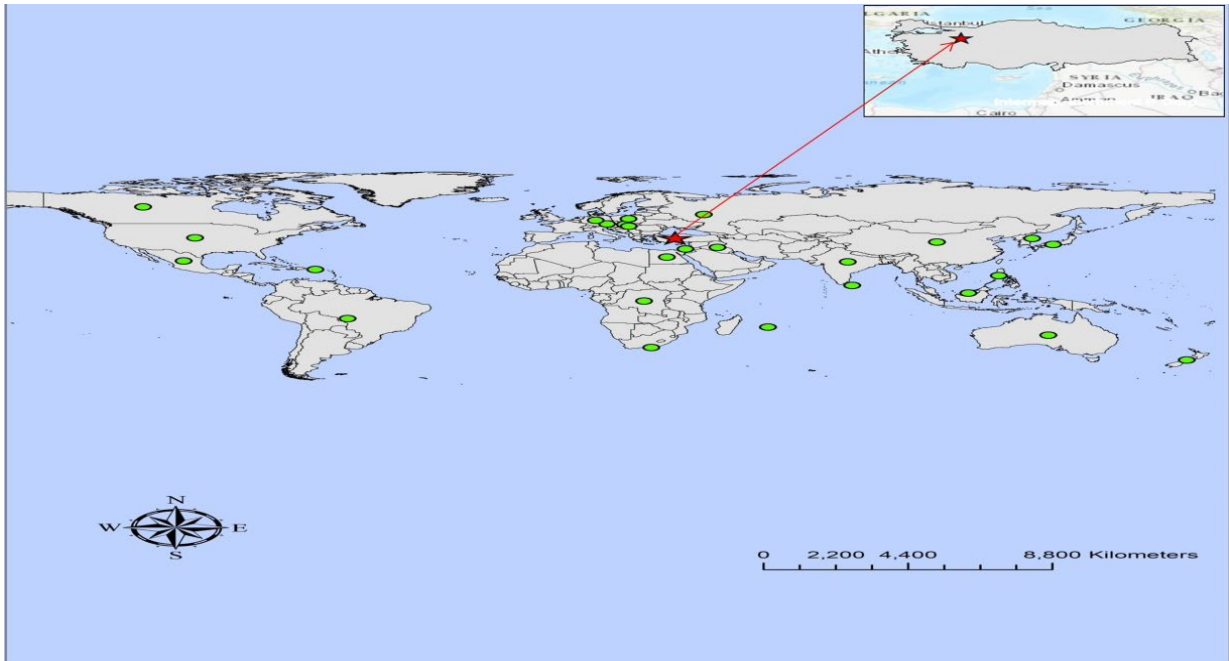


Figure 1. Global distribution of *Schyzocotyle acheilognathi*.

Extensive host records further demonstrate the remarkable ecological plasticity of *S. acheilognathi*. Comprehensive reviews have documented the parasite in hundreds of freshwater fish species across multiple families and orders, with cyprinids representing the most frequently infected group (Dove and Fletcher, 2000; Scholz et al., 2012; Kuchta et al., 2018). These findings clearly indicate its low host specificity and strong capacity to exploit diverse taxonomic groups.

Türkiye is one of the global centers of freshwater biodiversity, hosting 427 inland fish species, 215 of which are endemic (Çiçek et al., 2023). However, only a limited proportion of these species has been investigated for helminth infections. To date, *S. acheilognathi* has been recorded in 28 freshwater fish species in Türkiye, including three endemic species (Özer, 2021). Prior to the present study, no record existed for *S. acheilognathi* infecting *Squalius pursakensis*. Thus, this study provides the first report of this parasite in this endemic host species and increases the number of known host species in Türkiye to 29.

S. acheilognathi is widely recognized as a pathogenic cestode, particularly affecting juvenile and small-sized fish. Heavy infections may cause intestinal obstruction, mucosal damage, enteritis, impaired nutrient absorption, growth retardation, and increased mortality (Salgado-Maldonado et al., 1986; Scholz et al., 2012; Kuchta et al., 2018). Such pathological effects can compromise fish health and negatively impact both wild populations and aquaculture productivity.

Endemic fish species represent one of the most vulnerable components of freshwater ecosystems. Given the invasive nature, broad host range, and documented pathogenicity of *S. acheilognathi*, its presence may pose a significant threat to native and endangered endemic fish populations. Accordingly, several authors have emphasized the necessity of evaluating its ecological impact on endemic species (Choudhury and Cole, 2012; İnnal et al., 2016). The parasite has even been recognized as a Pathogen of Regional Significance (PRI) in certain regions due to its potential impact on native fish fauna (USFWS, 2015).

Regarding zoonotic potential, human infections are considered extremely rare, with only a single molecularly confirmed case reported to date (Yera et al., 2013).

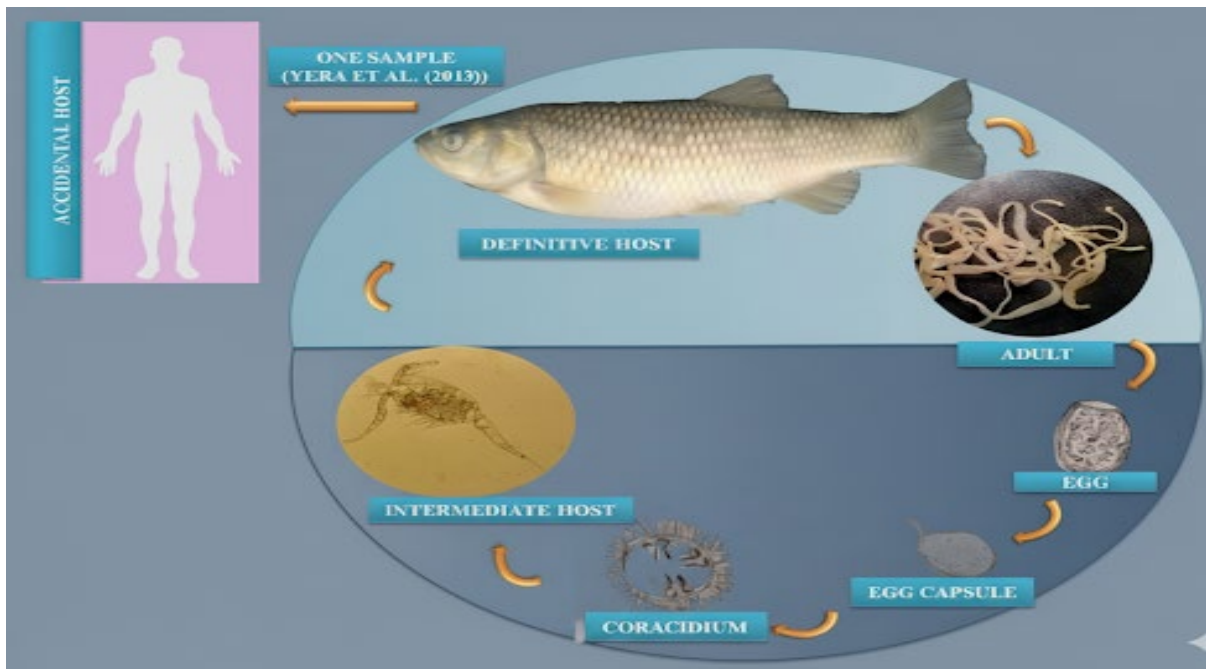


Figure 2. General schematic of the life cycle of *Schyzocotyle acheilognathi*, created by the author.

Although zoonotic infections caused by *S. acheilognathi* are considered extremely rare, concerns have been raised regarding its potential for transmission to humans, particularly in regions where the consumption of raw or undercooked freshwater fish is common. A single human case, in which parasite eggs were detected in a patient presenting with abdominal pain, was molecularly confirmed by Yera et al. (2013). To date, this remains the only documented and verified case of human infection reported in the literature.

In Türkiye, *S. acheilognathi* has been recorded in 28 freshwater fish species distributed across different regions of the country, many of which possess economic importance and are included in local dietary practices. However, traditional fish consumption habits in Türkiye generally do not involve the intake of raw or undercooked freshwater fish, which likely reduces the current risk of zoonotic transmission.

Nevertheless, changing dietary trends, increasing globalization, and the growing popularity of raw fish consumption worldwide may alter exposure patterns in the future. Therefore, although the zoonotic potential of *S. acheilognathi* appears to be limited at present, continuous surveillance and awareness remain important from a public health perspective.

MATERIALS AND METHODS

Squalius pursakensis were collected from the Sarısu Stream (Eskişehir, Türkiye)(39°49'38"N 30°15'25"E). The fish were captured alive using an electrofisher (Samus 1000) between February and November of 2023 (Fig. 3).

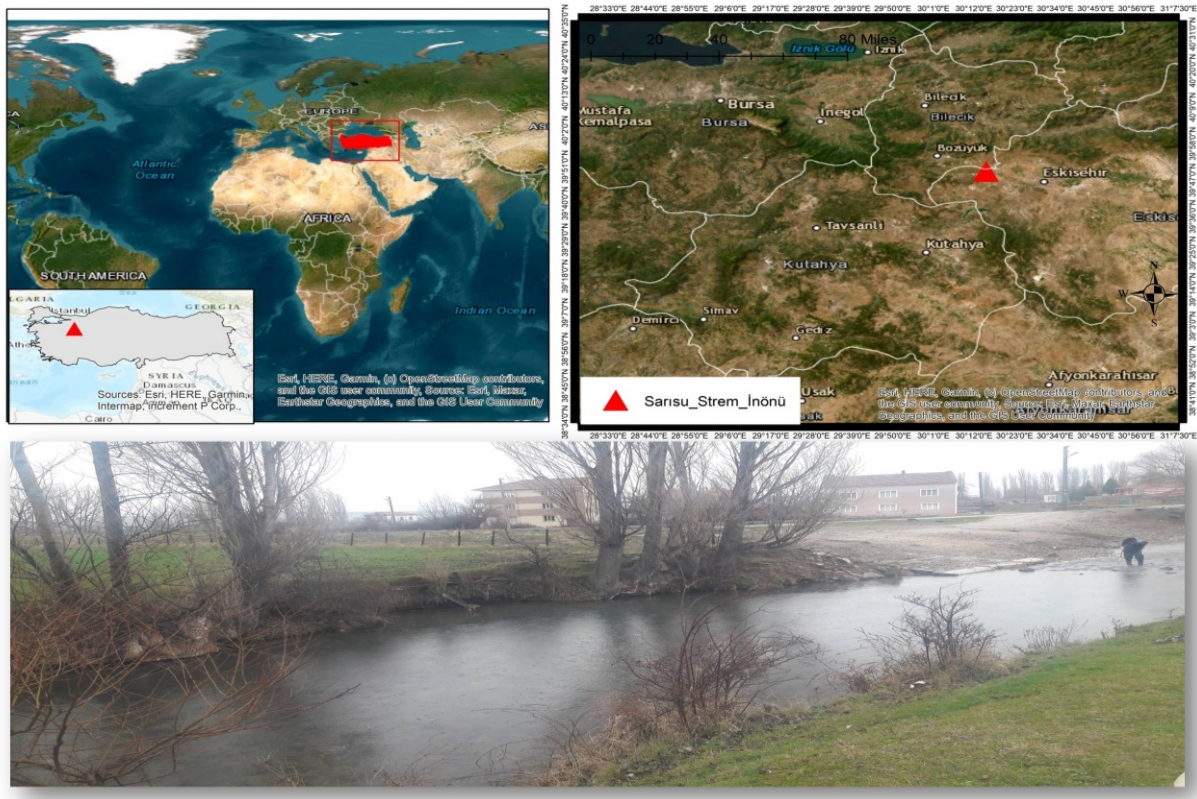


Figure 3. Sampling locality (indicated in red) of *S. pursakensis* collected from the Sarısu Stream in Eskişehir, Türkiye, created by the author.

Samples consisting of 16–36 individuals of *S. pursakensis* were collected from the Sarısu Stream between winter (February) and autumn (September) 2023, with sampling conducted once every three months (one sample per season). A total of 98 individuals of *S. pursakensis* were caught. To minimize stress and preserve the vitality of these ecologically valuable endemic fish, specimens were immediately transferred to oxygenated plastic tanks containing one or two drops of clove oil and then immediately transported to the research laboratory for parasitological examinations. Prior to parasite examination, the total length of each fish was measured using an ichthyometer (expressed in cm). The fish samples were examined predominantly after their capture for the cestode parasite species using standard techniques. When cestodes were found, they were gently removed using fine dissecting needles under stereomicroscopic observation (Nikon SMZ 745 and Olympus SZ61). The parasites collected were washed in 0.9% saline solution to remove intestinal debris. Cestodes were fixed following the protocol of Cribb and Bray (2010). Subsequently, to confirm taxonomic identification, some cestode parasite were stained and then mounted as permanent preparations following the methods of Georgiev et al. (1986). Parasitological data on the cestode parasite specimens on the host fish were categorized according to the host sex, and sampling season. The photomicrographs of all cestode parasite specimens were taken using a photographic camera mounted Leica DMR microscope with phase contrast and an Olympus BX-50 research microscope. Cestodes were identified according to identification keys of Markevic (1951), Bychowkaya–Pavlovskaya et al. (1962), Gussev et al. (1987), Khalil et al. (1994), Hoffman (1999)(Fig. 4).



Figure 4. Photomicrographs of *Schyzocotyle acheilognathi* collected in the present study, created by the author (scale bar = 1 mm).

Prevalence, mean intensity, and mean abundance were used as defined by Bush et al. (1997). Standard descriptive statistics, such as standard deviation, were computed using Microsoft Excel (Office 2000). To assess whether there were significant differences in the mean intensity of *S. acheilognathi* infection in *S. pursakensis* across different seasons, the Kruskal-Wallis test was employed for comparisons involving more than two groups. The relationship between infection levels and host sex was evaluated using the Mann-Whitney U test for two-group comparisons. A significance threshold of $\alpha \leq 0.05$ was adopted for all statistical tests. All analyses were conducted using SPSS version 28.

Data Collection

This article covers the distribution of *Schyzocotyle acheilognathi* from 2021 to the present. A total of 3 reference articles were accessed to gather information on the distribution of this parasite seen in native and endemic fish species in Türkiye. To this end, nine databases were searched to collect data regarding the distribution of freshwater fish parasites in Türkiye over the last four years: Science Direct, Pub Med, Springer, Scopus and Google Scholar, Web of Science, Zoological Record, Biological Abstracts and Fisheries Abstracts, using the following keywords: “*S. acheilognathi*”, “natural fish”, “endemic fish”, “invasion” and “Türkiye”. The keywords were used individually or in different combinations to collect all publications indicating parasitism of freshwater fish in Türkiye between 2021 and 2025, all duplicate records were omitted, the titles and abstracts of the remaining research studies were reviewed. Articles were selected for inclusion on the basis of the following eligibility criteria: the host fish are only freshwater fish (native and endemic), the sampling was done in Türkiye, and the content was available as a full-text journal article, research project report, thesis, proceedings of congress, or symposium proceedings, in Turkish, English, or French, etc. A set of 3 references were retained (Table 1), data regarding: the host fish species, authors, city and date were extracted from each article.

Table 1. Invasion of *S. acheilognathi* in different host fish in Türkiye after 2021

Host	Authors	City	Date
<i>Acanthobrama marmid</i>	Ural et al.	Elazığ (Türkiye)	2024
<i>Barbus oligolepis</i>	Aydoğdu	Balıkesir (Türkiye)	2023
<i>Cyprinus carpio</i>	Memiş and Pekmezci	Samsun (Türkiye)	2024

RESULTS AND DISCUSSION

Among the 98 examined *Squalius pursakensis*, 6 host samples were infected with cestode parasites located in intestine of the studied host specimens. The cestode was identified as *Schyzocotyle acheilognathi* based on the following combination of characteristics; Scolex heart-shaped, with two shallow bothria, not armed with hooks (Fig. 4); neck absent, with the first proglottid immediately posterior to the scolex (Fig. 4) ...etc. A total of 25, *S. acheilognathi* individuals were found, with a low prevalence (6.12%) and a low mean infection intensity (4.16 worms/fish). Its mean abundance of infection was found to be 0.25. The minimum and maximum parasites counted per infected host were 1 and 12, respectively. Seasonal prevalence of infection was highest in summer 14.28%, followed by autumn 5.55%, and then this species was not detected in the winter and spring samples. The mean intensity ranged from 2 to 8, with the highest levels recorded in autumn; the lowest mean intensity level was detected in summer at 2 parasites/ fish (range – 1-4) (Fig. 5).

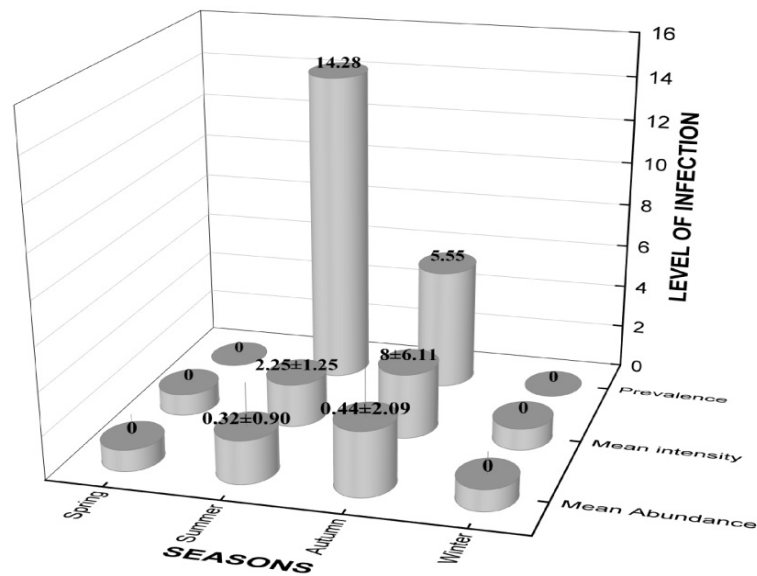


Figure 5. Seasonal distribution of *S. acheilognathi* infection parameters in *S. pursakensis* from Sarisu River, Eskişehir Province

However, seasonal differences in infection parameters were assessed using the Kruskal-Wallis H test, which did not reveal statistically significant differences ($p = 0.095$). The infection levels of *S. acheilognathi* according to sex of the host fish were evaluated. Of the 98 specimens examined, 42 were female and 56 were male. Prevalence level of *S. acheilognathi* was higher in males (7.14%; $n = 4$) than females (4.76%; $n = 2$).

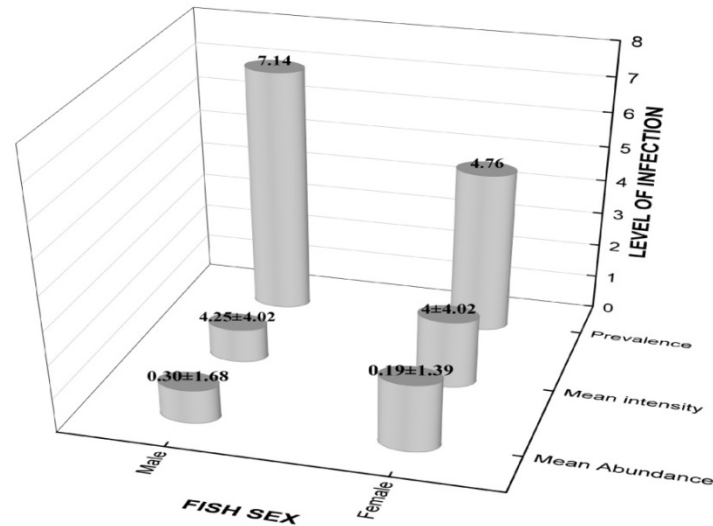


Figure 6. Sex-based distribution of *S. acheilognathi* infection parameters in *S. pursakensis* from the Sarısu River (Eskişehir Province)

Similarly, the mean intensity reached its maximum level (4.25 ± 4.02) in males, whereas the abundance was higher in females (0.19) compared to males (0.30). Furthermore, this parasite species was found numerically more in male host fish individuals (17 individuals). Despite these, there was not statistically significant sex – related difference in the number of this species based on the Mann – Whitney U test ($P = 0.340$).

Based on a review of the latest data, table 1 describes the distribution *S.acheilognathi* infreshwater fish in different governorates of Türkiye during the last 4 years. The data show that these parasites have been reported in 3 fish species and continue to spread among natural and endemic fish species of Türkiye. *S. acheilognathi*, which was found to parasitize 200 different freshwater fish species belonging to ten orders by Scholz et al. (2012), owes its infection success to its wide host range and very low host specificity. This parasite species has proven its ability by parasitizing 28 different freshwater fish species (native and endemic) distributed in different geographical regions of Türkiye until 2021 (Özer, 2021).

In studies conducted to date on the identification of *S. acheilognathi*, it has been observed that the infection levels of this species vary in each host species living in different habitats. As stated by the researchers who conducted these studies, the differences in infection rates of this species are due to the differences in physical and biological factors such as habitat size, water chemistry, host age, nutrition and migration in each habitat (Kennedy 1990).

In addition to the above views, some authors have suggested that the infection levels of parasite species in any host fish population are determined by the physiological and biological characteristics of the host fish species and environmental conditions (Khanum et al. 2008 and Santoro et al., 2020). When our best literature information on infection of *S. acheilognathi* in host fish species was compared with the infection findings in the present study, moderate infection values were recorded in the host fish species in the present study, *S. pursakensis*.

Within the scope of this study, databases were also searched to identify studies conducted after 2021 in order to update the information on the Asian fish tapeworm *S. acheilognathi* infestation in native and endemic freshwater fish species in Türkiye. Table (1) shows the distribution of this species in freshwater fishes in different habitats of Türkiye over the last 4 years. It is hoped that this review will draw attention to the distribution of *S. acheilognathi* and highlight the need for more such parasitological studies in the future.

When the above findings are evaluated in terms of Invasion Risk Hotspot based on host and locality; The prevalence and intensity of infection in *S. acheilognathi* host fish species are closely linked to host-ecology interactions. In this context, infection levels in *S. pursakensis* are probably determined by the density of suitable intermediate hosts and the conditions of transmission in the aquatic habitat (Hanzelová and Žitnan, 1986; Marcogliese and Esch, 1989b). The infection prevalence of 6.12% and the intensity rate of 4.16 recorded in this study indicate that this species has a moderate level of transmission ability in *S. pursakensis*, which is distributed in the locality where the study was conducted. And it suggests that *S. acheilognathi* intermediate

hosts are widespread in the locality where the research was conducted, and this is of critical importance in terms of possible epidemic risk for other fish species (natural and endemic) in the environment.

S. acheilognathi was transported to Türkiye through aquaculture (Innal et al., 2016), but there are no studies to date on the widespread distribution of *S. acheilognathi* in other fish species in the habitats where *S. pursakensis* is distributed. Local water temperature, host fish feeding behaviors, and geographic isolation are among the factors that may influence infection rates of this parasite species. Additionally, epidemiological variables such as seasonality and fish age distribution also play important roles in shaping infection parameters.

Although the infection prevalence rate was low in this study, the relatively high infection intensity of this parasite species observed in infected host fish individuals suggested that there may be important implications for the health of the *S. pursakensis* population. For example, severe infections of this parasite species in host fish species can negatively affect the nutritional status and growth performance of the parasitized fish species by disrupting their nutrient absorption (Bauer et al., 1969). In this context, it was concluded that the infection prevalence of 6.12% and the intensity level of 4.16 in this study would not pose a health threat to the host fish population. However, considering that *S. pursakensis* is a vulnerable endemic species, increased infection prevalence and density pressure in host fish individuals of this parasite species may negatively affect the population dynamics of this fish species in the locality.

In conclusion, the findings of this study indicate a moderate level of transmission ability of *S. acheilognathi* in the *S. pursakensis* population distributed in Sarısu Stream (Eskişehir, Türkiye), emphasizing the need for continuous monitoring of possible health effects.

As for the evaluation of Türkiye Case Studies of this parasite species in fish species in Türkiye and its discussion in terms of threatened Endemic Species; Worldwide, endemic freshwater fish species are highly susceptible to threats such as habitat loss, pollution, and invasive pathogens due to their often restricted and isolated habitats (Miller, 1986; Salgado-Maldonado and Pineda-López, 2003). In addition, despite their critical role in biodiversity, these species are also vulnerable to infection by invasive parasites. In this context, *S. acheilognathi* poses significant threats to endemic fish populations in different geographical regions due to its wide host range and adaptability (Bauer and Hoffman, 1976b; Dove and Fletcher, 2000; Choudhury and Cole, 2012).

The above information has been documented in studies conducted in America, Asia and Europe, where this parasite causes increased mortality, reproductive failure and population declines in locally endemic species (Hanzelová and Žitnan, 1986; Marcogliese and Esch, 1989b). Its designation as a Pathogen of Regional Significance (PRI) by the U.S. Fish and Wildlife Service demonstrates that its prevalence and impact are recognized globally (U.S. Fish and Wildlife Service, 2015).

Similarly, in Mexico, the negative effects of this parasite species on endemic fish have been investigated, highlighting the threat the parasite poses to ecosystem health (Salgado-Maldonado and Pineda-López, 2003). In addition, it was emphasized in the relevant study that the distribution of the parasite in the Chiapas region could serve as an example of the risk it poses to biodiversity on a regional and potentially continental scale.

Similarly, Türkiye has an important position on the global biodiversity map thanks to its rich and unique freshwater fauna. But this wealth is increasingly threatened by the spread of invasive parasites. Global effects of invasive parasites on endemic fish have been observed, and their effects on host fish include increased stress, increased susceptibility to diseases, impaired growth and reproductive success, and increased risk of local extinction (Miller, 1986; Salgado-Maldonado and Pineda-López, 2003).

In this context, the potential damage and spread risk of *S. acheilognathi* to endemic species in Türkiye increases the need for protection measures and monitoring programs. In fact, records of *S. acheilognathi* infection in Türkiye are increasing day by day and the number of freshwater fish species infected with this parasite species is changing every day. With this study, the number of host fish species infected with this species increases from 28 to 29, and 4 of the 29 species constitute endemic species. One of these species was reported to the literature with this study. Endemic species such as *S. pursakensis*, which are distributed in Türkiye, are particularly susceptible to pathogenic pressures such as *S. acheilognathi* infection due to their restricted habitat and limited genetic diversity (Geldiay and Balık, 2007). This study, which was the first to detect this parasite species in *S. pursakensis* in Türkiye, is a new and critical warning for the possible negative effects it may have on endemic fish and for their protection. This cestode species, which has the ability to spread rapidly and successfully, has a wide range of hosts and intermediate hosts, and has biological flexibility such as easily adapting to various freshwater environments, is thought to complicate control efforts in natural aquatic systems in Türkiye, and the detection of the parasite in local habitats such as the Sarısu River may pose a hidden threat to other endemic species.

Regarding the evaluation of the Zoonotic Potential of this species based on this study and the Turkish Case Studies; Although *S. acheilognathi* is known as a parasitic agent that infects many different species of freshwater fish on every continent except Antarctica, cases of infection in humans are extremely rare. The single documented human case reported by Yera et al. (2013) indicates that the zoonotic potential of this parasite should not be completely ignored. This finding suggests that *S. acheilognathi* may, although rarely, cause infections in humans and may pose a potential public health risk if fish from natural aquatic environments are consumed without adequate monitoring.

To date, *S. acheilognathi* has been reported to be present in 28 different freshwater fish species (29 in this study), many of which are of economic value and distributed in different regions of Türkiye. However, as far as we know, no human cases of this parasite have been reported in Türkiye. However, especially if fish are not adequately cooked, infectious larvae or other developmental stages of the parasite can be transmitted to humans, potentially leading to gastrointestinal symptoms. The fish species in which this parasite species was recorded in Türkiye are used in traditional local cuisine. However, since the local population that consumes this type of fish as food does not have a tradition of eating raw fish, we do not currently consider the fish species in which this parasite was recorded to pose a possible zoonotic risk to humans. However, we think that the zoonotic potential of this parasite species may emerge if people who consume these fish species start the tradition of eating raw fish. In this context, the report prepared by Yera et al. (2013) is a critical warning that although *S. acheilognathi* is rare, it carries the potential for human infection assuming that this parasite has the capacity to reproduce appropriately within the human host. In this context, increasing attention is being drawn to the indirect effects of invasive aquatic parasites on public health worldwide (Salgado-Maldonado and Pineda-López, 2003; Miller, 1986). In addition, the uncontrolled spread of species such as *S. acheilognathi* in natural freshwater ecosystems poses an important problem in terms of aquaculture safety and biosecurity. Infections with this parasite species can compromise ecosystem health and increase the risk of emergence and spread of other pathogens, including zoonotic agents.

CONCLUSION

Continuous monitoring of *Schyzocotyle acheilognathi* infections in 427 fish species (native and endemic) distributed in the inland waters of Türkiye is mandatory and of great importance for the evaluation of the potential zoonotic effects of the parasite and for public health awareness. Although this parasitic infection, which is frequently seen in some fish species, is rare in some species, its potential for human infection should not be overlooked. Furthermore, even though there is only one documented human case of *S. acheilognathi* to date, rare human infections should be included in risk assessments to inform effective management and mitigation strategies for species with zoonotic potential.

Declaration of interests

The author declared that there is no conflict of interest.

Author Contributions

Nurten AYDOĞDU: Investigation, Conceptualization, Data curation, Funding acquisition, Formal analysis, Writingreview & editing.

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REFERENCES

- Andrews, C., Chubb, J.C., Coles, T., Dearsley, A. (1981). The occurrence of *Bothriocephalus acheilognathi* Yamaguti, 1934 (B. gowkongensis) (Cestoda: Pseudophyllidea) in the British Isles. *Journal of Fish Diseases*, 4(1), 89-93. <https://doi.org/10.1111/j.1365-2761.1981.tb01113.x>
- Aydoğdu, N. (2023). Susurluk Havzası'nda yaşayan bazı balık türlerinde tespit edilen helmintik parazitler üzerine bir araştırma (Doctoral dissertation, Balıkesir University (Turkey)). (Order No. 31285741). Available from ProQuest Dissertations & Theses Global. (3110350139). Retrieved from <https://www.proquest.com/dissertations-theses/susurluk-havzasi-nda-yasayan-bazi-balik/docview/3110350139/se-2>
- Bauer, O.N., & Hoffman, G.L., (1976). Helminth range extension by translocation of fish. Wildlife diseases (Proc. 3rd Internat. Wildlife Dis. Conf., Munich, 1975.) [ed. by Page, L.A.]. New York, USA: Plenum Press, 163-172.
- Bauer, O.N., Musselius, V.A., Strelkov, Yu.A. (1969). Diseases of Pond Fishes. Moscow, USSR: "Kolos". [English version published in 1973 by Israel Program for Scientific Translations, Jerusalem, Israel; 220 pp.]
- Boonthai, T., Herbst, S. J., Whelan, G. E., Van Deuren, M. G., Loch, T. P., & Faisal, M. (2017). The Asian fish tapeworm *Schyzocotyle acheilognathi* is widespread in baitfish retail stores in Michigan, USA. *Parasites & vectors*, 10(1), 618. <https://doi.org/10.1186/s13071-017-2541-6>
- Britton, J .R., Gozlan, R.E., & Copp, G.H.(2011). Managing non-native fish in the environment. *Fish and fisheries* 12, 256-274. <https://doi.org/10.1111/j.1467-2979.2010.00390>
- Bunkley-Williams, L., & Williams, E. H. (1994). Parasites of Puerto Rican freshwater sport fishes. San Juan & Mayagüez, PR: Puerto Rico Department of Natural and Environmental Resources and Department of Marine Sciences, University of Puerto Rico.
- Bush, A.O., Lafferty, K.D., Lotz, J.M., & Shostak, A.W. (1997). Parasitology meets ecology on its own terms: Margolis et al. Revisited. *The Journal of Parasitology* 83, 575–583. <https://doi.org/10.2307/3284227>
- Buza, L., Molnár, K., Szakolczai, J. (1970). [English title not available]. (*Bothriocephalus acheilognathi* elofor dulasa magyarorszagon.) *Holaszat*, 16:42-43.
- Bychovskaya-Pavlovskaya I E, Gussev AV, Dubinina MN, et al.(1962) *Key to parasites of freshwater fishes of the USSR*. Jerusalem: Moskova–Leningrad: Izdatel'stvo Akademi Nauk SSR.
- Choudhury, A. & Cole, R.A .(2012). *Bothriocephalus acheilognathi* Yamaguti (Asian tapeworm).In Francis R A (eds), *In: A handbook of global freshwater invasive species*. Oxford UK: Earthscan, pp. 385-400.
- Cribb, T. H., & Bray, R.A. (2010). Gut wash, body soak, blender and heat-fixation: approaches to the effective collection, fixation and preservation of trematodes of fishes. *Systematic Parasitology*, 76, 1-7. <https://doi.org/10.1007/s11230-010-9229-z>
- Çiçek, E., Sungu, r S., Fricke, R. & Seçer, B. (2023). Freshwater lampreys and fishes of Türkiye; an annotated checklist, 2023. *Turkish Journal of Zoology*, 47, 324-468. <https://doi.org/10.55730/1300-0179.3147>
- De León, G. P. P., Lagunas-Calvo, O., García-Prieto, L., Briosio-Aguilar, R., & Aguilar-Aguilar, R. (2018). Update on the distribution of the co-invasive *Schyzocotyle acheilognathi* (= *Bothriocephalus acheilognathi*), the Asian fish tapeworm, in freshwater fishes of Mexico. *Journal of Helminthology*, 92(3), 279-290. <https://doi.org/10.1017/S0022149X17000438>
- Denis, A., Gabron, C., & Lambert, A. (1983). Presence in France of two parasites of east Asian origin: *Diplozoon nipponicum* Goto 1891 and *Bothriocephalus acheilognathi* Yamaguti, 1934 (Cestoda) in *Cyprinus carpio* (Teleostei, Cyprinidae). (Presence en France de deux parasites d'origine Est-asiatique: *Diplozoon nipponicum* Goto 1891 et *Bothriocephalus acheilognathi* Yamaguti, 1934 (Cestoda) chez *Cyprinus carpio* (Teleostei, Cyprinidae).) *Bulletin Français de la Pêche et de la Pisciculture*, 289:128-134. <http://dx.doi.org/10.1051/kmae:1983012>
- Dove, A.D.M., & Fletcher, A.S. (2000). The distribution of the introduced tapeworm *Bothriocephalus acheilognathi* in Australian freshwater fishes. *Journal of Helminthology*, 74, 121-127. <https://doi.org/10.1017/S0022149X00700782>
- Geldiay, R., & Balık, S. (2007). *Freshwater Fishes of Turkey*. V. Edition. Bornova Izmir: Ege University Press.
- Georgiev, B., Biserkov, V. & Genov, T. (1986.) In toto staining method for cestodes with iron acetocarmine. *Helminthologia*, 23, 279-281.
- Gussev, A. V., Poddubnaya, A.V. & Abdeeva, V.V. (1987). Key to parasites of the freshwater fishes of the USSR. In ON Bauer . (eds), *Fauna*. Nauka Russia: pp. 583.
- Han, J. E., Shin, S.P., Kim, J.H., Choresca, Jr C.H., Jun, J.W., Gomez, D.K. & Park, S.C. (2010). Mortality of cultured koi *Cyprinus carpio* in Korea caused by *Bothriocephalus acheilognathi*. *Afr. J. Microbiol. Res*, 4, 543-546.

- Hansen, S.P., Choudhury, A. & Cole, R.A. (2007). Evidence of experimental postcyclic transmission of *Bothriocephalus acheilognathi* in bonytail chub (*Gila elegans*). *Journal of Parasitology*, 93, 202-204. <https://doi.org/10.1645/GE-686R.1>
- Hanzelová, V. & Žitňan, R. (1986). Embryogenesis and development of *Bothriocephalus acheilognathi* Yamaguti, 1934 (Cestoda) in the intermediate host under experimental conditions. *Helminthologia*, 23, 145–155.
- Heckmann, R.A., Greger, P.D., & Deacon, J.E. (1987). New host records for the Asian fish tapeworm, *Bothriocephalus acheilognathi*, in endangered fish species from the Virgin River, Utah, Nevada, and Arizona. *Journal of Parasitology*, 73(1), 226-227.
- Hoffman, G.L. (1999). *Parasites of North American Freshwater fishes*. England: Comstock Publishing Associates division of Cornell University Press.
- Innal D, Aydoğdu, A. & Güçlü, S.S. (2016). Invasion of *Bothriocephalus acheilognathi* (Cestoda: Pseudophyllidea) in Turkey. *Acta Biologica Turcica*, 29, 20-25. <https://izlik.org/JA57YJ47HH>
- Kennedy, C.R. (1990). Helminth communities in freshwater fish: structured communities or stochastic assemblages?. In: Esch, G.W., Bush, A.O., Aho, J.M. (eds) *Parasite Communities: Patterns and Processes*. Springer, Dordrecht. https://doi.org/10.1007/978-94-009-0837-6_6
- Khalil, L. F., Jones, A., & Bray, R. A. (Eds.). (1994). *Keys to the cestode parasites of vertebrates* (pp. xiii+-751).
- Khanum, H., Ferdows, J., & Farhana, R. (2008). Community of helminth parasites in *Rita rita* (Hamilton Buchanan). *Journal of Biological Science*, 16, 133-135.
- Kuchta, R., Choudhury, A., & Scholz, T. (2018). Asian fish tapeworm: the most successful invasive parasite in freshwaters. *Trends in Parasitology*, 34, 511-523.
- Malevitskaya, M.A. (1958). The introduction of a parasite with a complex life cycle, *Bothriocephalus gowkongensis* Yeh, 1955, during acclimatization of fish from the Amur River. *Doklady Akademii Nauk SSSR*, 123(3), 961-964.
- Marcogliese, D.J., & Esch, G.W. (1989a). Alterations in seasonal dynamics of *Bothriocephalus acheilognathi* in a North Carolina cooling reservoir over a seven-year period. *Journal of Parasitology*, 75(3), 378-382.
- Marcogliese, D.J. (2008). First report of the Asian fish tapeworm in the Great Lakes. *Journal of Great Lakes Research*, 34(3):566-569. http://www.iaglr.org/jglr/db/view_contents.php?pub_id=2661&mode=view&table=yes&topic_id=&mode=toc&volume=34&issue=3
- Marcogliese, D.J., & Esch, G.W. (1989b). Alterations in seasonal dynamics of *Bothriocephalus acheilognathi* in a North Carolina cooling reservoir over a seven-year period. *The Journal of Parasitology*, 75, 378-382.
- Markevich, A. P. (1951). Parasitic fauna of freshwater of the fish of the Ukrainian SSR", trans by Rofael, N. N. *Kudus*, 157, 213-224.
- Memiş, E. & Pekmezci, G.Z. (2024). Türkiye’de Sazan Balıklarının (*Cyprinus carpio*) Enfekte Eden Asya Balık Sestodu *Schyzocotyle acheilognathi* (Cestoda: Bothriocephalidae) Türünün Moleküler Karakterizasyonu. *Journal of Anatolian Environmental and Animal Sciences*, 9, 397-402. <https://doi.org/10.35229/jaes.1495499>
- Miller, R. R. (1986). Composition and derivation of the freshwater fish fauna of Mexico. In *Anales de la Escuela Nacional de Ciencias Biológicas*, 30, 121-153.
- Minervini, R., Lombardi, F., Cave, D di. (1985). [English title not available]. (L'introduzione di *Bothriocephalus acheilognathi* Yamaguti 1934, in Italia: osservazioni su popolazioni naturali e di allevamento di carpa (*Cyprinus carpio*).) *Rivista Italiana di piscicoltura e ittiopatologia*, 20, 27-32.
- Özer, A. (2021). Checklist of Marine, Freshwater, and Aquarium Fish Parasites in Turkey. *Turkish Marine Research Foundation (TUDAV) Publication No: 62, Istanbul, Turkey*. 311 p.
- Paperna, I. (1996). Parasites, infections and diseases of fishes in Africa: an update. CIFA Technical Paper, No. 31:230 pp. <http://www.fao.org/docrep/008/v9551e/v9551e00.htm>
- Paperna, I. (1991). Disease caused by parasites in the aquaculture of warm water fish. *Annual Review of Fish Diseases*, 1991, 155-194.
- Petkov, P. (1972). Occurrence of *Bothriocephalus gowkongensis* in carp bred in artificial water-reservoirs in the Pleven district. *Veterinarnomeditsinski Nauki*, 9(9), 75-78.
- Radulescu, I., & Georgescu, R. (1962). Contributions to the knowledge of the parasitofauna of the species *Ctenopharyngodon idella* in the first year of acclimatization in the Popular Republic of Romania. (Contributii la cunoasterea parasitofaunei speciei *Ctenopharyngodon idella* in primul an de aclimatizare in P.R. România.) *Buletinul Institutului de Cercetari si Proiectari Piscicole*, 21, 85-91.

- Salgado-Maldonado, G., & Pineda-Lopez, R.F. (2003). The Asian fish tapeworm *Bothriocephalus acheilognathi*: a potential threat to native freshwater fish species in Mexico. *Biological Invasions*, 5, 261-268. <https://doi.org/10.1023/A:1026189331093>
- Salgado-Maldonado, G., Aguilar-Aguilar, R., & Reyes-Bustos, C. (1986). Pathogenicity of *Bothriocephalus acheilognathi* Yamaguti, 1934 (Cestoda: Pseudophyllidea) in *Oreochromis aureus* (Pisces: Cichlidae). *Anales del Instituto de Biología, Universidad Nacional Autónoma de México, Serie Zoología*, 57, 107–117.
- Salgado-Maldonado, G., Matamoros, W. A., Kreiser, B. R., Caspeta-Mandujano, J. M., & Mendoza-Franco, E. F. (2015). First record of the invasive Asian fish tapeworm *Bothriocephalus acheilognathi* in Honduras, Central America. *Parasite*, 22, 5. <https://doi.org/10.1051/parasite/2015007>
- Santoro, M., Iaccarino, D., & Bellisario, B. (2020). Host biological factor and geographic locality influence predictors of parasite communities in sympatric sparid fishes off the Southern Italian coast. *Scientific Reports*, 10, 13283. <https://doi.org/10.1038/s41598-020-69628-1>
- Scholz, T., Kuchta, R., & Williams, C. (2012). *Bothriocephalus acheilognathi*. In: Fish parasites: pathobiology and protection [ed. by Woo, P. T. K., Buchmann, K.]. Wallingford, UK: CABI, 282-297. <http://www.cabi.org/cabebooks/ebook/20113395272>
- Ural, M.Ş., Sağlam, N., Kaya, H., & Orsay, H. (2024). Investigation of endohelminths observed in fish that can be caught in the Fırat River (Keban). *Ecological Life Sciences*, 19, 105-114. <https://www.doi.org/10.12739/NWSA.2024.19.3.5A0215>
- U.S. Fish and Wildlife Service (2015). *National Wild Fish Health Survey*. Washington DC USA: US Fish and Wildlife Service. <http://www.fws.gov/wildfishsurvey/> (accessed July 1, 2025).
- Yamaguti, S. (1934). Studies on the helminth fauna of Japan. Part 4. Cestodes of fishes. *Japanese Journal of Zoology*, 6, 1–112.
- Yera, H., Kuchta, R., Brabec, J., Peyron, F., & Dupoy-Camet, J. (2013). First identification of eggs of the Asian fish tapeworm *Bothriocephalus acheilognathi* (Cestoda: Bothriocephalidea) in human stool. *Parasitology International*, 62, 268-271. <http://www.sciencedirect.com/science/journal/13835769>