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Occurement assessment of helminth parasites in *Euthynnus affinis* from Banten, Indonesia

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Abstract. *Indaryanto FR, Kamal MK, Butet NA, Affandi R, Tiuria R. 2024. Occurement assessment of helminth parasites in* Euthynnus affinis *from Banten, Indonesia. Biodiversitas 25: 4978-4985.* As an economically valuable fish, *Euthynnus affinis* requires regular surveillance and assessment of the prevalence of helminth parasitic infestation in Banten waters, Indonesia. In the districts of Cituis-Tangerang (North Banten), Labuan-Pandeglang (West Banten), and Binuangeun-Lebak (South Banten) in the waters of Banten, *E. affinis* were collected in November 2023 to January 2024. Seven species of helminth parasitic were identified to infect *E. affinis* in Banten: *Anisakis typica* (intensity 1.17; prevalence 14.65%), *Tentacularia* sp. (intensity 1; prevalence 0.64%), *Dinurus* sp. (intensity 17.75; prevalence 7.64%), *Didymozoid* sp. (intensity 2.25; Prevalence 7.64%), *Rhadinorhynchus* sp. (intensity 24.86; prevalence 87.90%), and *Acanthocephalus* sp. (intensity 24.86; prevalence 87.90%) are the seven species of helminth parasitic that infect *E. affinis* in Banten. The overall prevalence of helminth parasitic infection was categorized as moderately prevalence (89.17%) with a moderate intensity (27.32). Despite severe infestations of distinct helminth parasitic species, the mean condition factor (K) values for parasitized and non-parasitized fish did not differ appreciably. Positive allometric growth was observed in both parasitized and non-parasitic fish. Helminth parasitic infection exceeding 80 individuals/fish significantly affects the Gonado Somatic Index (GSI). Fish measuring 25-30 cm in total length were found to be susceptible to helminth parasitic infection; however, there was no correlation between fish length and parasite abundance (r^2 = 0.0223). Males had a higher infection rate compared to female fish. There was no statistically significant difference in the abundance of parasites across the three locations. The host's diet was found to affect the parasitic infection. The greatest diversity of parasite species was discovered in Labuan, West Banten.

Keywords: Acanthocephala, allometric growth, anisakis, potential risk, tentacularia

INTRODUCTION

Banten is a very strategic region in Indonesia. Eighty-six fish landing stations are dispersed across five districts or cities, providing support for the 8,651.20 km^2 province bounded by the Java Sea to the north, the Sunda Strait to the west, and the Indian Ocean to the south. Traditional fishing activities are typically conducted around the coast at a distance of two to six nautical miles, with full-day operations conducted in each location with distinct sea characteristics (Yonvitner et al. 2019). The production of the five main capture fisheries commodities in Banten Province included tuna/little tuna and anchovy. As a consequence, this province naturally contains a large diversity of fish and non-fish resources in addition to parasitic species. Parasitic organisms can cause biological, ecological, economic, and human health losses (Gómez and Nichols 2013).

Helminth parasites are one of the most common parasitic organisms found in fish. It can interfere with fish growth, cause stress, reduce body resistance, reduce fecundity, and even cause death. Condition factors (K) and length-weight relationships of fish can be applied to parasitological research to characterize the impact of parasitic infections on host health (Vuić et al. 2022). The presence of helminth parasites in food products can cause a decrease in quality, which will be economically detrimental (Bao et al. 2018). In addition, some helminth parasitic are also zoonotic or animal diseases that can infect humans and cause human illness, namely acute abdominal pain, diarrhea, and/or severe allergies if consuming raw or undercooked food (Amir et al. 2016; Mladineo et al. 2016; Guardone et al. 2018).

Euthynnus affinis (Cantor, 1849) belongs to the Scombridae family of little tuna, which is an economically important fish in Indonesia as a source of public nutrition and export commodities. In Indonesia, milkfish, mackerel, little tuna, and tuna are staples. Highly preferred by Indonesians due to its high protein content, accessibility at any time, and reasonable cost. This species is extremely migratory, with regular migration patterns linked to food resources and seasonal variations, and is found in vast areas of open tropical and subtropical waters (oceanic) or near coastlines (neritic) (Indaryanto et al. 2018).

According to Indaryanto et al. (2024), *Decapterus* sp., *Thyrsitoides marleyi* (Fowler, 1929), *E. affinis*, *Auxis rochei* (Risso, 1810), *Gempylus serpens* (Cuvier, 1829), *Katsuwonus pelamis* (Linnaeus, 1758), and *Trichiurus lepturus* (Linnaeus, 1758) have a high prevalence (prevalence >90%) in Indonesia, indicating that they are often infected with Anisakis. The helminth parasite community in *E. affinis* has been studied by several authors, including Rifani et al. (2022) identified four species of helminth parasites from Pangkal Pinang. Pambudi et al. (2021) identified seven species of helminth parasites from Banten, Pardede et al. (2020) identified three species of helminths parasites from East Java, Arizona et al. (2020) identified four species of helminths parasites from Bangka, Hidayati et al. (2016) identified two species of helminths parasites from Aceh, and Madhavi and Ram (2000) identified 23 species of helminth parasites from Bay of Bengal, India.

After the first human infection was reported in 1960 in the Netherlands, many cases of anisakid infections in humans have been reported worldwide because they cause anisakiasis. Most cases (more than 90%) have been reported in Japan and some from the Netherlands, France, and Spain (Santos et al. 2022). According to Indaryanto et al. (2024), Anisakis investigations from 2001 to 2023 have been carried out on about seventy marine fish species in Indonesian, i.e. *Anisakis* sp., *Anisakis simplex* ((Rudolphi, 1809) Dujardin, 1845), *Anisakis physeteris* (Baylis, 1923), *Anisakis pegreffii* (Campana-Rouget & Biocca, 1955), *Anisakis berlandi* (Mattiucci, Cipriani, Webb, Paoletti, Marcer, Bellisario, Gibson & Nascetti, 2014), *Anisakis typica* ((Diesing, 1860) Baylis, 1920) (*A. typica (s.s)*, *A. typica* var. *Indonesiansis*), and *Anisakis* sp. HC-2005.

There have been no clinical reports of anisakiasis in Indonesia, because most people consume cooked fish. However, with the increasing popularity of consuming raw fish due to globalization, it is essential study the potential risks associated with this practice. Consequently, it is necessary to continuously monitor and evaluate the prevalence of helminth parasitic infection in *E. affinis* from Banten waters. The waters of northern Banten are the waters of the Java Sea, the southern part is the waters of the Indian Ocean, and the two are connected by the waters of the Sunda Strait or the waters of western Banten, therefore the presence of parasitic helminths in Banten waters is exciting to observe. According to Fuentes et al. (2022), accurately identifying and studying the impact of intrinsic and extrinsic factors can determine the potential risk of anisakiasis to human health. Intrinsic variables, such as fish body size, age, gonad maturity, diet, and other parameters exclusive to the microhabitat or habitat inside the fish, play a significant role in this. Extrinsic factors include elements like the geographic location of waterways, climate, temperature, current patterns, which are connected to the macrohabitat or aquatic habitat/environment where fish reside. The purpose of this study is to monitor the parasite species that infect *E. affinis* in Banten waters and assess the potential risk to both the fish and human health based on various factors.

MATERIALS AND METHODS

Study area

Between November 2023 and January 2024, a total of 157 *E. affinis* samples were collected from the waters surrounding Banten, Indonesia. The samples were taken fron three locations: (1) Cituis-Tangerang District (North Banten) with 60 samples, (2) Labuan-Pandeglang District (West Banten) with 51 samples, and (3) Binuangeun-Lebak District (South Banten) with 46 samples (Figure 1). The fish samples, which represent the daily catch of fishermen, were purchased from fish traders at each region's fish auction. Sampling was conducted on Friday between 05:00-07:00 am. The fish were transported in styrofoam with ice to the aquaculture laboratory at the Universitas Sultan Ageng Tirtayasa, Banten, Indonesia. For a later inspection on Saturday morning (beginning at 7:00 am), the fish were kept in a freezer set at -20°C. Since the location was nearby, sampling for the Cituis area was done on Saturday morning and evaluated right away. Sampling was conducted weekly in the order Labuan-Binuangeun-Cituis, repeated 3 times.

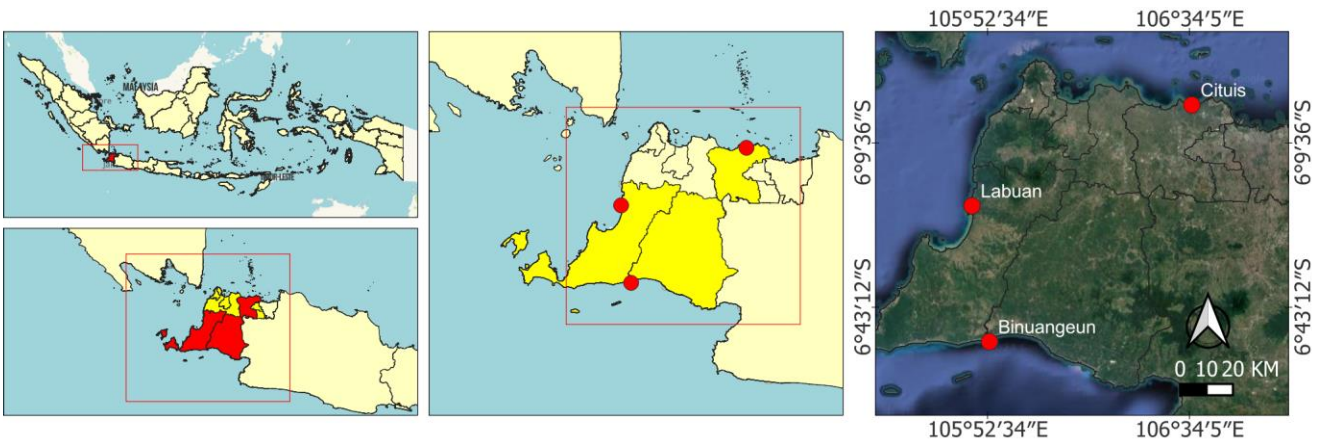

Figure 1. Location of the sampling sites: 1. Cituis, Tangerang District (North Banten); 2. Labuan, Pandeglang District (West Banten); and 3. Binuangeun, Lebak District (South Banten) in Banten Province, Indonesia

Procedures

The body cavities, digestive system, internal organs (such as the liver and gonads), and muscles were dissected and examined to collect helminth parasites. The parasites were observed, photographed, and measured using a compound LAECA microscope with a the LAECA Application Suit (LAS EZ) and the ImageJ application. An ichthyometer with 0.5 cm precision and electronic balance with 0.1 mg accuracy were used to measure the total length (Lt) and weight (Wt) of each fish. Additionally, an electronic balance with 0.01 mg accuracy were used to measure gonad weight (Wg). The parasites were identified using the following sources: Acanthoceplaha (Arai 1989), Trematoda (Gibson 1996), Zhang et al. (2013), Anisakidae (Arai and Smith 2016), Mattiucci et al. (2018), and Indaryanto et al. (2024).

Data analysis

The measurement of parasitism was calculated, such as abundance, main Intensity (mI), and prevalence (P(%)) according to Bush et al. (1997). The condition factor (K) is calculated based on the value of b (a constant from the regression results of the fish length-weight relationship). If the value of b = 3 or the fish growth pattern is isometric, the condition factor is formulated with Effendie (2002): $K=10^5Bt/L^3$; meanwhile, if the value of $b \neq 3$ or the fish growth pattern is allometric, the condition factor is formulated: $K=W/aL^b$ with K = condition factor; W = fish body weight (g); L = fish body length (cm); a and b = constants from the regression results of the fish length-weight relationship. The Gonado Somatic Index (GSI) was calculated using the formula according to Effendie (2002): GSI = Wg/Wt x 100% with Wg = weight (g). Density of infection were number of parasite per 100g of fish (Llarena-Reino et al. 2013).

The t-test is used to determine whether there is a statistically significant difference between the means of K values of parasitized and non-parasitized fish, between the means of K values of unparasitized and several abundance values of parasitized fish (20, 40 and >80 individuals), GSI values of parasitized and non-parasitized fish, GSI values of unparasitized and several abundance values of parasitized fish (20, 40 and >80 individuals), parasites of male and female fish.

To determine whether there is a statistically significant difference between three or more variables, a completely randomized Anova design is used, such as differences in location, abundance, and parasite species. The linear regression analyses were used to determine the correlation between fish length and parasite abundance and also the correlation between GSI and parasites abundance, analyzes were performed using Microsoft excel.

RESULTS AND DISCUSSION

Helminth parasites

Seven species of helminth parasitic infecting *E. affinis* in Banten were identified (Table 1), namely: *Didymozoid* sp. (Digenea), *Dinurus* sp. (Digenea), *Lecithochirium* sp. (Digenea), *Anisakis* sp. (Nematoda), *Tentacularia* sp. (Cestoda), *Rhadinorhynchus* sp. (Acanthocephala), and *Acanthocephalus* sp. (Acanthocephala). The *E. affinis* parasite from Banten was found to have a high density (5.10-9.67 parasite/100g fish weight) and a moderate intensity (19.89-42.64 individuals/infected fish), with an abundance of 1020-1749 parasite. The prevalence was found to be 86.27-91.30%.

Didymozoid sp. is a helminth parasite that lives on gill filaments (Figure 2.A). It is specific to the Scombridae family, which also includes tuna, little tuna, and mackerel (Lestari et al. 2016). It is yellow and has an elongated shape with spherical cysts on the sides. The cyst was not solved in this study, so it was not further identified. Gill infections can lead to respiratory distress, an increase in the opercular rate, and cases of severe infestations and host death (Dezfuli et al. 2021). Previous studies that also detected this parasite include Arizona et al. (2020), Rifani et al. (2022), even Madhavi and Ram (2000) identified this parasites, but was not found in the research of Pambudi et al. (2021).

Dinurus sp., *Lecithochirium* sp., *Anisakis* sp. *Tentacularia* sp., *Rhadinorhynchus* sp. and *Acanthocephalus* sp. dominated specific areas (Figure 3). *Dinurus* sp. and *Lecithochirium* sp. (Figures 2.B and 2.C) are helminth parasitic of the digenea group that infect mostly the stomach and slightly the intestine of *E. affinis*. Digenea has two suckers, the oral sucker in the front and the ventral sucker in the center. The ventral sucker in *Lecithochirium* sp. is larger than the oral sucker (3:2 ratio). However, both suckers in *Dinurus* sp. are almost the same size, at ± 100μm.

The ecsoma is the primary morphological distinction between them; otherwise they are nearly identical. While the ecsoma of *Lecithochirium* sp. is tiny and occasionally absent, it is highly developed and typically lengthy in *Dinurus* sp. (Gibson 1996). Ecsoma of *Dinurus* sp. can be elongated and shortened; when shortened, the shape will be wrinkled. *Dinurus scombri* (Yamaguti, 1934), *Dinurus tornatus* ((Rudolphi, 1819) Looss, 1907) (Arizona et al. 2020), and *Lecithocladium* sp. (Pambudi et al. 2021) were found in *E. affinis* from Indonesia. Considering digeneans cannot reconstruct organic matter that has not been simplified, the digestive tract serves as a microhabitat for them and a supply of organic matter that is also food that is easily absorbed by the parasitic body. Because digeneans are typically small (1-2 mm in length), mobile (causing no permanent feeding scars), and do not feed deeply attached to host tissues (e.g., few ingest blood), they may cause little to no apparent abnormalities in the gastrointestinal tract of fish (Indaryanto et al. 2015). *Dinurus* sp. was found in all three locations, while *Lecithochirium* sp. was only found in Labuan.

Table 1. Helminth parasitic in *Euthynnus affinis* from Banten, Indonesia

	Cituis, Tangerang			Labuan, Pandeglang			Binuangeun, Lebak		
	Abundance	**mI (range)**	**P(%)**	**Abundance**	**mI (range)**	**P(%)**	**Abundance**	**mI (range)**	**P(%)**
Trematoda									
Didymozoid sp.	8	2.67(1-5)	5.00	17	4.67(1-4)	7.84	2	2.00(2)	2.1
Dinurus sp.	82	27.33(1-80)	5.00	83	20.75(1-46)	7.84	48	12.00 (1-32)	8.70
Lecithochirium sp.	---	---	---	17	17.00(17)	1.96	---	---	---
Nematoda									
Anisakis sp.	11	1.10(1-2)	16.67	7	1.17(1-2)	11.76	9	1.29 (1-2)	15.22
Cestoda									
Tentacularia sp.	---	---	---	1	1.00(1)	1.96	---	---	---
Acanthocephala									
Rhadinorhynchus sp.	871	17.42(2-87)	83.33	895	20.81(1-100)	84.31	1666	39.67 (1-205)	91.30
Acanthocephalus sp.	102	7.28(1-43)	23.33	---	---	---	24	12.00 (2-22)	4.35
Total	1074	19.89(1-90)	90.00	1020	23.18(1-128)	86.27	1749	42.64(1-206)	91.30

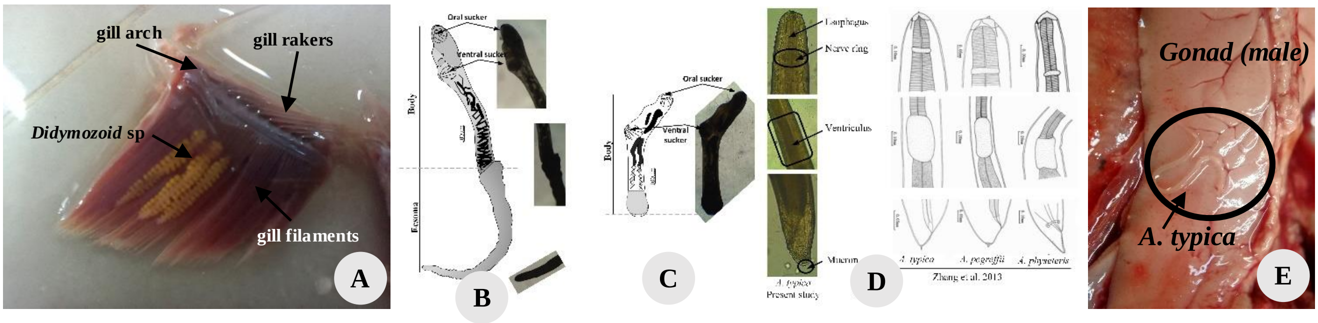

Figure 2. Helminth parasites in *Euthynnus affinis* from Banten, Indonesia. A. *Didymozoid* sp. in gill filaments; B. *Dinurus* sp.; C. *Lecithochirium* sp.; D. *Anisakis* sp.*a*; E. *Anisakis* sp.in *E. affinis* gonad

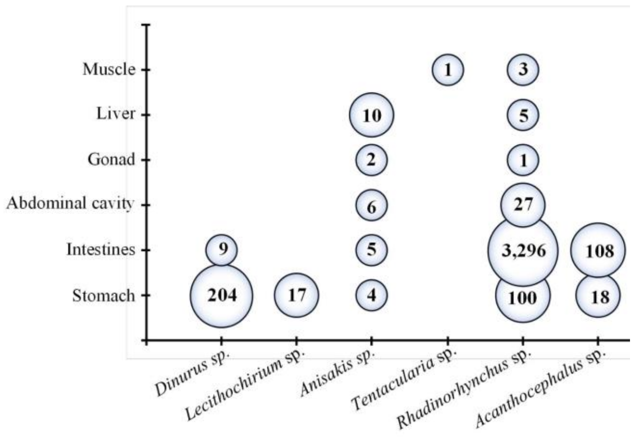

Figure 3. Helminth parasites predilection in *Euthynnus affinis*

All *Anisakis* sp. found were alive (Figures 2.D and 2.E), while other species were dead. The presence of a mucron on the posterior end of the detected anisakis indicates that it is Anisakis type I. The anisakis obtained had a long and rounded ventriculus. Based on Zhang et al. (2013) and Mattiucci et al. (2018), its characteristics are similar to *A. typica* but genetic identification is needed to confirm this. The density of this parasite was 6.72 fish/100g fish weight, and the size of *Anisakis* sp. was 16.73±10.02 mm. Frozen fish products should be considered spoiled if two or more parasites with a capsular diameter of more than 3 mm or non-capsular parasites with a body length of more than 10 mm are found in a 1 kg sample of fishery products, and no live helminth parasites (either nematodes, cestodes, or trematodes) are found in the fish (Alimentarius 2017).

Based on the degree of risk (low to high), parasite densities were divided into three groups: 1) densities < 2 parasites/kg; 2) 2-5 parasites/kg; and 3) > 5 parasites/kg (Llarena-Reino et al. 2013). While this grouping is appropriate for large fish, it should be applied per 100g of fish body weight for small fish like *E. affinis*. In this investigation, *Anisakis* sp. was detected in nearly every organ in the fish body, excluding the muscles, and it was significantly more prevalent in the liver. This result is comparable to *A. typica* infection in *E. affinis* from Makassar (Anshary et al. 2014), but it differs from *Anisakis* sp. infection in fish of the same kind from Pekalongan, East Java (Linayati and Madusari 2019) and Pangkalpinang, Bangka Belitung (Indaryanto et al. 2024), where *Anisakis* larvae were found to be dominant in the stomach and intestines in both instances. Nematodes typically occupy all fish organs, including the liver, which has a significant concentration of *Anisakis*. However, parasite excretion/secretion products have the effect of suppressing and reducing host immune responses and increasing parasite survival (Dezfuli et al. 2021). *Anisakis simplex, A. pegreffii*, and *Pseudoteranova* sp. are most commonly associated with human health problems so if these species are detected they have a high risk (D'amico et al. 2014), *A. physeteris* and *Contracaecum* sp. are rarely reported to infect humans or are of medium risk (Shamsi 2019; Shamsi and Barton 2023); while the remaining species including *A. typica* have no reported human infections.

Tentacularia sp. (Figure 4.A) are segmented worms (tapeworms) in Phylum Platyhelminthes, Class Cestoda. The parasite has four tentacles and resembles a caterpillar. *Tentacularia coryphaenae* (Bosc, 1802) has been recorded from the musculature, belly flaps and body cavity of the fish *G. serpens*, *T. marley*, *Trichiururs lepturus* (Linnaeus, 1758), *Brama dussumieri* (Cuvier, 1831), and *Alepisaurus ferox* (Lowe, 1833) from Pelabuhan Ratu, southern coast of West Java, Indonesia (Jakob and Palm 2006). This species is found in elasmobranchs (*Prionace glauca* (Linnaeus, 1758), *Carcharhinus longimanus* (Poey, 1861), and *Carcharhinus obscurus* (Lesueur, 1818), teleost fish (*Coryphaena equisilis* (Linnaeus, 1758), *K. pelamis*, and *Coryphaena hippurus* (Linnaeus, 1758), and cephalopods from various places (Knoff et al. 2004). Cestodes seldom pierce deeper, reaching the muscle layer and harming the intestinal architecture. Most fish cestodes merely harm the outermost layer of the intestinal wall, not seriously harming the fish's digestive tract (Dezfuli et al. 2021).

The most common helminth parasitic identified is Acanthocephala, which includes *Rhadinorhynchus* sp. and *Acanthocephalus* sp.. They found in nearly every organ, including the muscles and the gut. Adult acanthocephala resides in the intestine and take in nourishment from the host's intestinal lumen. The degree of penetration into the host tissues and the helminth population density determine how harmful acanthocephalans are (Dezfuli et al. 2021). Inflammatory nodules can result from *Rhabdinorhynchus* sp. that deeply pierce the fish's intestine (El Madhi et al. 2015). Acanthocephalans can also cause increasing weight loss and a head that is not proportionate to the body size, albeit these conditions hardly ever result in death (Valladão et al. 2019).

At most, three different parasite species can infect a single fish; most infections include only one or two parasite species, and only the stomach and intestine may contain two or three parasite species. Every parasite species has its dominant organ. Parasites require several essential metabolic factors from the fish as their host but their availability is limited in a host organ. Healthy fish are a healthy environment for parasites. It is not beneficial for the parasite to kill or injure its host. Parasites adapt and move from one organ to another so their host remains healthy and the parasite is not expelled from the host's body (Noble and Noble 1989).

Intrinsic factors of helminth parasites infections

In fisheries research and management, some of the most commonly utilized criteria include condition factors (K) and length-weight relationships, which offer insights into the overall health, fatness, growth rate, and age distribution of fish populations. These criteria can be applied to parasitological research to characterize the impact of parasitic infections on host health (Vuić et al. 2022). In this study, the fish that were not parasitized had a mean condition factor of 1.012, whereas the fish that were parasitized had a mean of 1.004. Despite being highly infested with several species of helminth parasitic, there was no statistically significant difference between the two groups (P>0.05). Positive allometric growth (b>3) was seen in the length-weight relationships of both parasitized and non-parasitized fish, suggesting that the host can retain its typical overall form. When a parasite feeds on the host's nutrients and causes sickness, the host becomes ill, and the immune system fights to protect the host from the parasite's infection. This study bears similarities to those conducted by Hadjou et al. (2017) and Pambudi et al. (2021). In an attempt to counteract the depletion of nutrients or energy, the host tries to devise plans by consuming more food. The value of the parasitized fish's condition factor is very low and displays a length-weight relationship with negative allometric growth (b < 3), as in the study by Vuić et al. (2022), indicating that the host's efforts are ineffective. The number of *Didymozoid* sp., *Anisakis* sp., and *Rhadinorhynchus* sp. showed no correlation with the host's body length by parasite type, whereas *D. euthynni* and *Acanthocephalus* sp. showed negative and positive correlations, respectively, and *Rhadinorhynchus* sp. tended to be parabolic or low in small and large fish.

Fish with a length of 25-35 cm were susceptible to helminth parasitic infection. Generally, there was no correlation between fish length and parasite abundance (r^2 = 0.0223) (Figure 5). Crustacea are the main part of the diet of *E. affinis,* also some molluscs and teleosts. Large *E. affinis* (above 52 cm) mainly feed on teleosts (Vigneshwaran et al. 2018). Large fish (>39 cm) have *Didymozoid* sp. in the gills and *Rhadinorhynchus* sp. in the stomach, muscle, and gut were discovered in Binuangeun and Labuan. *Tentacularia* sp. was discovered in the 33 cm muscle of a fish labuan.

In this investigation, the sex of the host had an impact on helminth parasitic infection; male fish (abundance average 25.78) had a higher infection rate (P < 0.05) than female fish (abundance average 10.00). The number of male fish samples obtained was greater than that of female fish. The male-female composition of the fish caught was related to the pattern of fish migration.

The mean GSI of unparasitized and parasitized fish was not significantly different (P > 0.05). Significantly different between unparasitized and parasitized fish with an abundance of > 80 individuals, but the K value was still not significantly different. This suggests that the ability of fish to reproduce is inhibited by infection with large numbers of parasites (more than 80 individuals). Although there was no statistically significant difference in K values, the K values of parasitized fish were relatively lower. This suggests that the infection of a large number of helminth parasites (more than 80 individuals) impedes the fish's capacity to reproduce and may also impede growth in a situation of a shortage of food. According to Figure 6, Helminth parasitic infection prevents gonadal development in fish with values less than one. It also demonstrates that parasitic infection reduces with increasing GSI values.

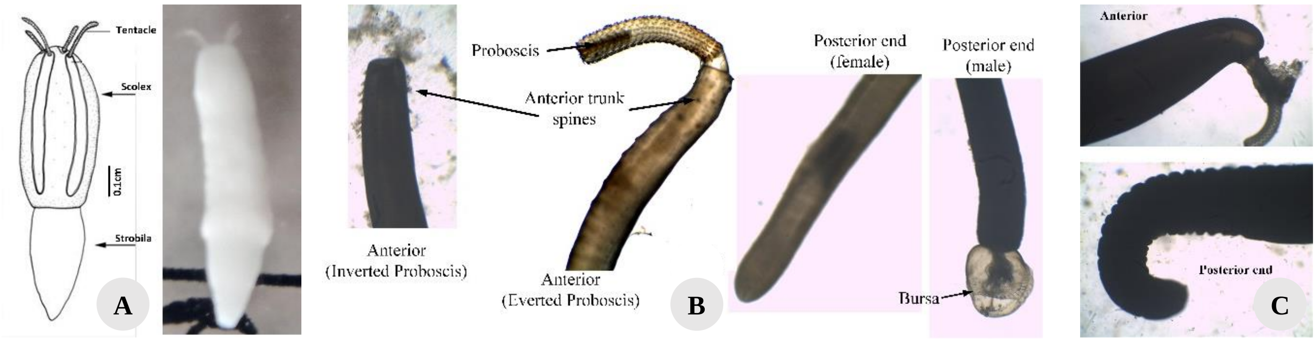

Figure 4. Helminth parasites in *Euthynnus affinis* from Banten, Indonesia. A. *Tentacularia* sp.; B. *Rhadinorhynchus* sp.; C. *Acanthocephalus* sp.

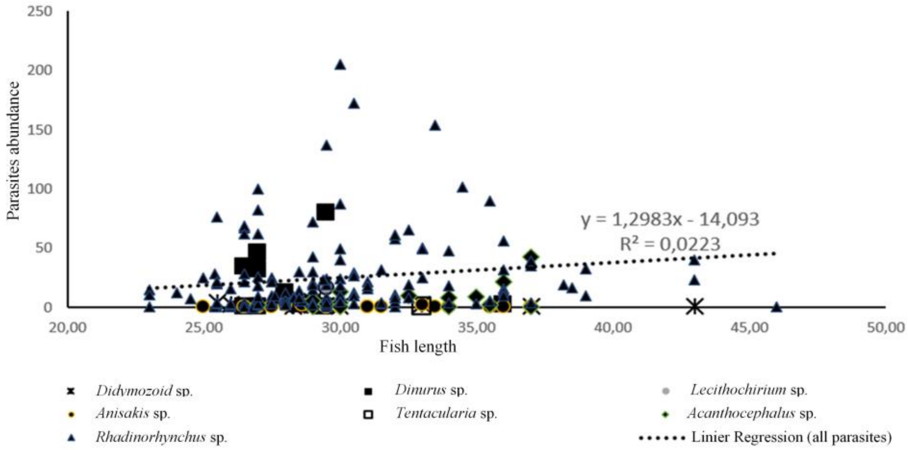

Figure 5. Correlation between fish length and parasites abundance

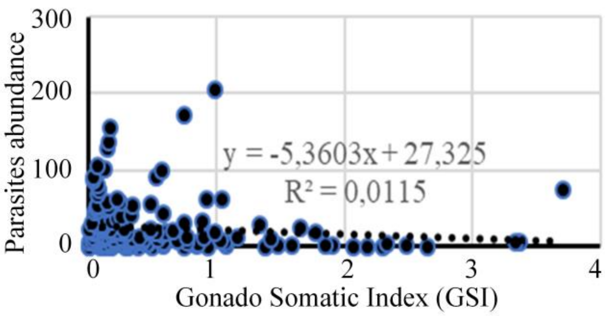

Figure 6. Correlation between gonado somatic index and parasites abundance

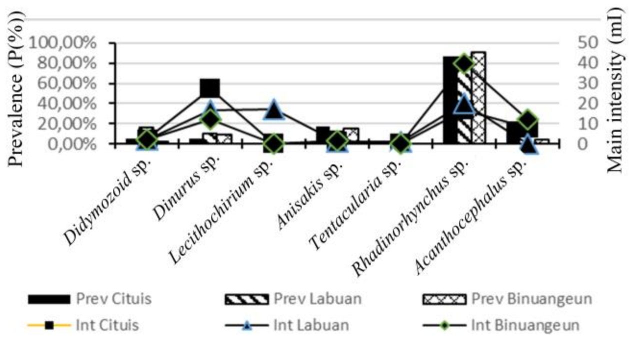

Figure 7. Intensity and prevalence of helminth parasites in *Euthynnus affinis* from three locations in Banten, Indonesia

Extrinsic factors of helminth parasites infections

The study found no significant differences (P>0.05) in parasite abundance levels infecting *E. affinis* among the three locations. Although Labuan contains the highest number of parasite species, its disease prevalence is lower than that of the other two regions. Because the water in all three locations differs, helminth parasitic diseases are extremely complicated in each location. Figure 7 illustrates the dominance of different parasites species in various locations: *Rhadinorhynchus* sp. predominates in Binuangeun, *Acanthocephalus* sp. is more common in Cituis, and *Didymozoid* sp. is primarily found in Labuan. Additionally, *D. euthynni* is present in both Labuan and Binuangeun, while *L. kawakawa* and *Tentacularia* sp. are exclusive to Labuan. The presence of *Tentacularia* sp. and *Anisakis* sp.can be attributed to the fact that fish consume squid. The prevalence of *Rhadinorhynchus* sp. can be caused by the fish diet's predominance of crustaceans.

Labuan is a transitional water body in the Sunda Strait region influenced by the Indian Ocean and Natuna Sea, along with various environmental factors such as water quality and other risks present in the water body. Therefore, this region has a greater diversity of fish and other organisms compared to the in other locations (Yonvitner et al. 2019).

Zoonotic species (*Anisakis* sp.) are among the parasitic species that infect fish, which may be harmful to human health. Although the intensity of *Anisakis* sp. is relatively low, it is important to be cautious due to their high prevalence rate and the fact that they can be found alive in consumed fish. This makes them potentially dangerous to human health if consumed raw or undercooked.

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REFERENCES

Alimentarius CO. 2017. Standard for quick frozen blocks of fish fillet, minced fish flesh and mixtures of fillets and minced fish flesh. CODEX STAN 165-1989.

Amir A, Ngui R, Ismail WH, Wong KT, Ong JS, Lim YA, Lau YL, Mahmud R. 2016. Case report: Anisakiasis causing acute dysentery in Malaysia. Am J Trop Med Hyg 95 (2): 410-412. DOI: 10.4269/ajtmh.16-0007.

Anshary H, Sriwulan, Freeman MA, Ogawa K. 2014. Occurrence and molecular identification of *Anisakis* Dujardin, 1845 from marine fish in Southern Makassar Strait, Indonesia. Korean J Parasitol 52 (1): 9-19. DOI: 10.3347/kjp.2014. 52.1.9.

Arai HP, Smith JW. 2016. Guide to the parasites of fishes of Canada Part V: Nematoda. Zootaxa 4185 (1). DOI: 10.11646/zootaxa.4185.1.1.

Arai HP. 1989. Acanthocephala. In Margolis L, Kabata Z (eds.). Guide to the Parasites of Fishes of Canada Part III: 1-41. Canadian Special Publication of Fisheries and Aquatic Sciences 107, Ottawa. 103 P.

Arizona MO, Adibrata S, Gustomi A. 2020. The prevalence of parasitic worms in little tuna (*Euthynnus affinis*) landed at Nusantara Fishery Harbor Sungailiat Bangka Regency. Aquat Sci 2 (2): 26-35. [Indonesian]

Bao M, Pierce GJ, Strachan NJC, Martinez C, Fernandez R, Theodossioi I. 2018. Consumers' attitudes and willingness to pay for Anisakis-free fish in Spain. Fish Res 202: 149-160. DOI: 10.1016/j.fishres.2017.06.018.

Bush AO, Lafferty KD, Lotz JM, Shostak AW. 1997. Parasitology meets ecology on its own terms: Margolis et al. revisited. J Parasitol 83 (4): 575-583. DOI: 10.2307/3284227.

D'amico P, Malandra R, Costanzo F, Castigliego L, Guidi A, Gianfaldoni D, Armani A. 2014. Evolution of the Anisakis risk management in the European and Italian context. Food Res Intl 64: 348-362. DOI: 10.1016/j.foodres.2014. 06.038.

Dezfuli BS, Giari L, Bosi G. 2021. Survival of metazoan parasites in fish: Putting into context the protective immune responses of teleost fish. Adv Parasitol 112: 77-132. DOI: 10.1016/bs.apar.2021.03.001.

Effendie MI. 2002. Biologi Perikanan. Yayasan Pustaka Nusatama, Yogyakarta. [Indonesian]

El Madhi Y, Hassouni T, Lamri D, Chiahoo B, El Halouani H, El Guamri Y, El Kharrim K, Darif H, Lamrioui D, Barkia H, Belghyti D. 2015. Helminths parasites of pompano, *Trachinotus ovatus* (L, 1758) from the Harbour Cap Water or Ras El Ma (Mediterranean Coast of Morocco). Intl J Innov Sci Res 16 (1): 128-131.

Fuentes MV, Madrid E, Cuesta C, Gimeno C, Baquedano-Rodríguez M, Soriano-Sánchez I, Bolívar AM, Sáez-Durán S, Trelis M, Debenedetti ÁL. 2022. Anisakid nematodes and potential risk of human Anisakiasis through the consumption of Hake, *Merluccius* spp., sold fresh in Spanish supermarkets. Pathogens 11 (6): 622. DOI: 10.3390/pathogens11060622.

Gibson DI. 1996. Trematoa. In: Margolis L, Kabata Z (eds.). Guide to the Parasites of Fishes of Canada part IV: Trematoda. NRC Research Press, Ottawa. 382 P.

Gómez A, Nichols E. 2013. Neglected wild life: Parasitic biodiversity as a conservation target. Intl J Parasitol: Parasites Wildl 2: 222-227. DOI: 10.1016/j.ijppaw.2013.07.002

Guardone L, Armani A, Nucera D, Costanzo F, Mattiucci S, Bruschi F. 2018. Human anisakiasis in Italy: A retrospective epidemiological study over two decades. Parasite 25: 41. DOI: 10.1051/parasite/2018034.

Hadjou Z, Ramdane Z, Tazi NAB, Bellal A, Charane M. 2017. Effect of parasitism on the length/weight relationship and the condition index in two groups of *Pagellus acarne* (Risso, 1826) (Perciformes Sparidae), parasitized and unparasitized specimens, from the Eastern Coast of Algeria. Biodiversitas 8 (4): 889-894.

Hidayati N, Bakri M, Rusli, Fahrimal Y, Hambal M, Daud R. 2016. Identification of parasites in mackerel (*Euthynnus affinis*) at fish auction in Lhoknga Aceh Besar. Jurnal Medika Veterinaria 10 (1): 5-8. DOI: 10.21157/j.med.vet..v10i1.4027. [Indonesian]

Indaryanto FR, Abdullah MF, Wardiatno Y, Tiuria R, Imai H. 2015. A description of *Lecithocladium angustiovum* (Digenea: Hemiuridae) in short mackerel, *Rastrelliger brachysoma* (Scombridae), of Indonesia. Trop Life Sci Res 26 (1): 31-40.

Indaryanto FR, Kamal MM, Butet N, Affandi R, Tiuria R. 2024. Article Review: Identifications and geographic distribution of six *Anisakis* species (Nematoda: Anisakidae) in Indonesia. Jurnal Veteriner 25 (1): 143-164. DOI: 10.19087/jveteriner.2024.25.1.143.

Indaryanto FR, Tiuria R, Wardiatno Y, Zairion. 2018. Long Jawed Mackerel (Scombridae: *Rastrelliger* sp.): Genetics, Biology, Reproduction, Habitat, Distribution, Growth, and Disease. IPB Press, Bogor. [Indonesian]

Jakob E, Palm HW. 2006. Parasites of commercially important fish species from the southern Java coast, Indonesia, including the distribution pattern of trypanorhynch cestodes. Verhandlungen der Gesellschaft fur Ichthyologie, Band 5: 165-191.

Knoff M, Clemente SCDS, Pinto RM, Lanfredi RM, Gomes DC. 2004. New records and expanded descriptions of *Tentacularia coryphaenae* and *Hepatoxylon trichiuri* homeacanth trypanorhynchs (Eucestoda) from Carcharhinid sharks from the state of Santa Catarina off-shore, Brazil. Rev Bras Parasitol Vet 13 (2): 73-80.

Lestari P, Lester RJG, Proctor C. 2016. Symbionts of bigeye and yellowfin tuna as potential stock markers for tuna in Indonesia archipelagic waters. In: Scientific Committee Twelfth Regular Session. Bali, Indonesia 3-11 August 2016.

Linayati L, Madusari BD. 2019. Prevalence and distribution of *Anisakis* sp. worms in internal organs of tuna (*Euthynnus affinis*) at fish auction in Pekalongan city. IOP Conf Ser: Earth Environ Sci 399: 012109. DOI: 10.1088/1755-1315/399/1/ 012109.

Llarena-Reino M, Abollo E, Pascual S. 2013. A scoring system approach for the parasite predictive assessment of fish lots: A proof of concept with Anisakids. Foodborne Pathog Dis 10 (12): 1067-1074. DOI: 10.1089/fpd.2013.1553.

Madhavi R, Ram BKS. 2000. Community structure of helminth parasites of the tuna, *Euthynnus affinis*, from the Visakhapatnam coast, Bay of Bengal. J Helminthol 74 (4): 337-342. DOI: 10.1017/S0022149X00000494.

Mattiucci S, Cipriani P, Levsen A, Paoletti M, Nascetti G. 2018. Molecular epidemiology of Anisakis and Anisakiasis: An ecological and evolutionary road map. Adv Parasitol 99: 93-263. DOI: 10.1016/bs.apar.2017.12.001.

Mladineo I, Popović M, Drmić-Hofman I, Poljak V. 2016. A case report of *Anisakis pegreffii* (Nematoda, Anisakidae) identified from archival paraffin sections of a Croatian patient. BMC Infect Dis 16: 42. DOI: 10.1186/s12879-016-1401-x.

Noble GA, Noble ER. 1982. Parasitology: The Biology of Animal Parasites, 5th Ed. Lea & Febiger, Philadelphia, USA.

Pambudi MR, Sulistiono S, Tiuria R, Kleinertz S. 2021. Infection patterns of helminth parasites in mackerel tuna (*Euthynnus affinis* Cantor, 1849) from Banten Waters, Indonesia. Ilmu Kelautan: Indones J Mar Sci 26 (2): 117-124. DOI: 10.14710/ik.ijms.26.2.117-124.

Pardede MA, Mahasri G, Ulkhaq MF. 2020. Intensity and prevalence of endoparasite helminths in little tuna (*Euthynnus affinis*) at Muncar and Panarukan Fish Auction Place, East Java, Indonesia. Iran J Aquat Anim Health 6 (2): 49-59. DOI: 10.52547/ijaah.6.2.49.

Rifani, Irwanto R, Kurniawan A. 2022. Identification and prevalence of endoparasite in mackarel tuna (*Euthynnus affinis*) at the auction place of fish Ketapang Pangkalpinang City. Jurnal Ilmu Kelautan Kepulauan 5 (1): 552-561. [Indonesian]

Santos MJ, Matos M, Guardone L, Golden O, Armani A, Caldeira AJR, Vieira-Pinto M. 2022. Preliminary data on the occurrence of *Anisakis* spp. in European Hake (*Merluccius merluccius*) caught off the Portuguese Coast and on reports of human anisakiosis in Portugal. Microorganisms 10 (2): 331. DOI: 10.3390/microorganisms 10020331.

Shamsi S, Barton DP. 2023. A critical review of anisakidosis cases occurring globally. Parasitol Res 122 (8): 1733-1745. DOI: 10.1007/s00436-023-07881-9.

Shamsi S. 2019. Parasite loss or parasite gain? Story of *Contracaecum* nematodes in antipodean waters. Parasite Epidemiol Control 4: e00087. DOI: 10.1016/j.parepi.2019.e00087.

Valladão GMR, Gallani SU, Jerônimo GT, de Seixas AT. 2019. Challenges in the control of acanthocephalosis in aquaculture: Special emphasis on *Neoechinorhynchus buttnerae*. Rev Aquacult 12 (3): 1360-1372. DOI: 10.1111/ raq.12386.

Vigneshwaran P, Ziyad AO, Ravichandran S, Veerappan N. 2018. Diet composition and feeding ecology of mackerel tuna *Euthynnus affinis* (Cantor, 1849) on the South-Eastern coast of India. Zool Ecol 28 (4): 286-291. DOI: 10.1080/21658005.2018.1515867.

Vuić N, Turković Čakalić I, Vlaičević B, Stojković Piperac M, Čerba D. 2022. The influence of *Contracaecum* larvae (Nematoda, Anisakidae) parasitism on the population of prussian carp (*Carassius gibelio*) in Lake Sakadaš, Croatia. Pathogens 11 (5): 600. DOI: 10.3390/pathogens11050600.

Yonvitner, Akmal SG, Boer M, Kurnia R, Yuliana E. 2019. Marine fish production and diversity record from Sunda Strait before tsunami disaster at 22 December 2018: Evidence from ports in Banten Province, Indonesia. J Nat Sci Res 9 (8): 16-22.

Zhang L, Du X, An R, Li L, Gasser RB. 2013. Identification and genetic characterization of *Anisakis* larvae from marine fishes in the South China Sea using an electrophoretic-guided approach. Electrophoresis 34 (6): 888-894. DOI: 10.1002/elps.201200493.