

ORIGINAL RESEARCH

Parasite Assemblage, Prevalence and Zoonotic Potential in the Spotfin Bigeye *Priacanthus tayenus* from the South China Sea, East-Coast Peninsular Malaysia

Suhairi Mazelan¹, Faizah Shaharom², Wahidah Wahab¹, Muhammad Hafiz Borkhanuddin^{2,3}, Nor Asma Husna Mohammed Yusoff^{1,4}, Sharifah Raina Manaf⁵, Norazizah Kemat⁶, Nora Faten Afifah Mohamad⁷, Ruhil Hayati Hamdan⁸, Melissa B. Martin^{2,3}, Mazlan Abd Ghaffar^{1,2,4,9}, Ahmad Shuhaimi Draman¹, Khor Waiho^{1,4,9}, Shengkang Li^{9,10}, Yenni Putri Sari¹¹, Mohd Ihwan Zakariah^{1,4*}

¹Higher Institution Centre of Excellence, Institute of Tropical Aquaculture and Fisheries (HICoE-AKUATROP), Universiti Malaysia Terengganu (UMT), Terengganu, Malaysia

²Faculty of Marine Science and Environment, Universiti Malaysia Terengganu (UMT), Terengganu, Malaysia

³Institute of Oceanography and Environment (INOS), Universiti Malaysia Terengganu (UMT), Terengganu, Malaysia

⁴Food Security Research Cluster, Universiti Malaysia Terengganu, Terengganu, Malaysia

⁵Universiti Teknologi MARA (UiTM) Sarawak Branch, Mukah Campus, Sarawak, Malaysia

⁶Department of Fisheries, Kuantan Biosecurity Centre, Pahang, Malaysia

⁷Universiti Putra Malaysia Bintulu Sarawak Campus, Sarawak, Malaysia

⁸Department of Paraclinical Studies, Faculty of Veterinary Medicine, Universiti Malaysia Kelantan (UMK), Kelantan, Malaysia

⁹STU-UMT Joint Shellfish Research Laboratory, Shantou University, Guangdong, P.R. China

¹⁰Marine Biology Institute, Science Center, Shantou University, Guangdong P.R. China

¹¹Laboratory of Fisheries, Marine Science Study Program, Faculty of Agriculture, Universitas Bengkulu, Bengkulu, Indonesia

ARTICLE INFO

Article history:

Received: January 2, 2026

Accepted: March 15, 2026

Published: March 30, 2026

Keywords:

food security; fish parasites; *Priacanthus tayenus*; seafood safety; zoonotic helminths

*Corresponding author:

Mohd Ihwan Zakariah

E-mail address:

ihwanz@umt.edu.my

All authors have reviewed and approved the final version of the manuscript.

ORCID: <https://orcid.org/0000-0003-3061-0427>

ABSTRACT

Background: Marine capture fisheries are central to food security in Southeast Asia, yet commercially harvested fish can harbour parasites of ecological and public-health significance.

Objective: To characterise the parasite assemblage of the spotfin bigeye *Priacanthus tayenus* from the South China Sea off east-coast Peninsular Malaysia (Terengganu) and to benchmark the zoonotic and quality-relevant taxa against seafood-safety standards.

Methods: Fifty wild-caught fish (total length 13.3 ± 2.1 cm) were examined by standard parasitological post-mortem; parasites were slide-mounted and identified morphologically. Infection and diversity indices, a chi-square test, Spearman correlations, a Welch t-test and principal component analysis (PCA) were computed; $\alpha = 0.05$.

Results: A total of 365 specimens of ten taxa (six ectoparasite and four endoparasite groups) were recovered. The anisakid nematode *Hysterothylacium* sp. dominated (177 specimens; 48.5% relative dominance; 60% prevalence) and *Didymozoon* sp.1 was most prevalent (62%). Prevalence differed among taxa ($\chi^2 = 130.47$, $df = 9$, $p < 0.001$) and correlated strongly with abundance ($\rho = 0.939$, $p < 0.001$). Diversity was moderate (Shannon $H' = 1.327$; Berger-Parker $d = 0.485$) and PC1 explained 94.0% of the infection-parameter variance.

Conclusion: Visible zoonotic anisakid larvae and trypanorhynch cestodes conflict with the visible-parasite provisions of EU Regulation (EC) 853/2004, underscoring the need for candling, evisceration, freezing and routine surveillance to safeguard seafood safety and food security in this fishery.

Introduction

Marine capture fisheries are a pillar of food security, nutrition and coastal livelihoods across Southeast Asia, where pelagic and demersal fish supply affordable animal protein to large coastal populations.¹⁻² The same productivity that sustains these fisheries also sustains diverse parasite communities, because commercially

harvested fish frequently serve as intermediate or paratenic hosts for helminths and as substrates for crustacean ectoparasites.³⁻⁴ Parasites are therefore simultaneously a determinant of product quality, a hazard to consumers, and a sensitive indicator of the ecological condition of the waters in which the host lives.⁵⁻⁶

The public-health dimension of fish parasitism is substantial. A global review identified 762 anisakidosis cases across 34 countries and noted that high-consumption nations such as Indonesia and Vietnam are almost certainly under-reported,⁷ while fish-borne trematode infection remains common in endemic Southeast-Asian communities.² Anisakidosis arising from anisakid larvae in raw or undercooked marine fish has risen worldwide,^{7–8} and surveys of commercial fish repeatedly report high anisakid prevalence.^{9–10}

Priacanthus tayenus (Priacanthidae) is among the most commonly harvested commercial species in Southeast-Asian fisheries, processed into fillets, surimi and dried products. Its parasite-acquisition pathways are diverse: anisakid nematodes such as *Hysterothylacium* reach fish through crustacean and fish intermediate hosts;^{3,11} didymozoid and digenean trematodes depend on molluscan first intermediate hosts and complex multi-host cycles;^{12–13} and parasitic copepods attach directly to gills and body surfaces under strong hydrographic and seasonal control.^{4,14}

Parasitological monitoring rests on standardised methods. Classical morphological identification is increasingly combined with molecular confirmation and quantitative ecological metrics — prevalence, mean abundance, mean intensity and diversity indices — to make surveys comparable across studies,^{9–10} and multivariate ordination now complements taxonomy in describing infracommunity structure.¹⁵ On the regulatory side, seafood-safety frameworks set explicit expectations: EU Regulation (EC) No 853/2004 requires fishery products to be free of visible parasites at market, while the Indonesian SNI 2729 specifies fresh-fish quality; both motivate routine parasite inspection of landed catch.^{16–17}

Parasite assemblages also function as bioindicators. Because each parasite integrates the trophic, hydrographic and pollution history of its host, community-level metrics respond to environmental stress and habitat change,^{5,18} and parasite biodiversity has been shown to track water quality and host condition.^{6,15} Yet for the east coast of Peninsular Malaysia, which fronts the productive South China Sea, quantitative parasitological baselines for *P. tayenus* are scarce; although the monogenean fauna of this host has been examined elsewhere in its range,¹⁹ no study has coupled morphological identification with infection indices, diversity metrics and seafood-safety benchmarking for this coast.

This study therefore delivers the first integrated, quantitatively analysed assessment of the parasite assemblage of *P. tayenus* from the South China Sea off east-coast Peninsular Malaysia (Terengganu). Its specific aims were: (i) to identify and describe the ecto- and endoparasite taxa infecting the host; (ii) to quantify infection through prevalence, abundance, intensity, dominance and diversity indices, supported by inferential statistics, correlation and ordination; and (iii) to benchmark the zoonotic and quality-relevant taxa

against national and international seafood-safety standards, thereby linking aquatic biodiversity, food security and consumer protection.

Materials and Methods

Study Design and Setting

A cross-sectional parasitological survey was conducted on the spotfin bigeye *Priacanthus tayenus* harvested from the east coast of Peninsular Malaysia, fronting the South China Sea. The host fish were obtained from the commercial marine capture fishery serving the Terengganu coast (Kuala Nerus/Kuala Terengganu region; approximate landing-ground coordinates 5.2–5.4° N, 103.0–103.2° E), a tropical demersal–pelagic shelf habitat adjacent to a fisheries-dependent shoreline. The actual location and institutional affiliations are retained without anonymisation. The full sampling-site and host characteristics are summarised in Table 1.

Materials, Samples, and Data Sources

A total of fifty freshly landed *P. tayenus* were purchased from the commercial catch and transported to the laboratory on flaked ice to preserve parasite integrity. For each fish, total length (TL, cm) and body weight (BW, g) were recorded before examination. Specimens were not the product of experimental procedures on live animals and no human subjects were involved; accordingly, no human-research ethics approval was required for this environmental field survey. Each fish was examined externally and internally for ectoparasites (skin, fins, nostrils, operculum, gill arches, buccal cavity) and endoparasites (gut, intestine, body cavity, viscera). Examinations were cross-checked against reference keys, motile ectoparasites were enumerated once per host to avoid double-counting, and voucher slides were retained at HICoE-AKUATROP; recovered prevalences are therefore minimum estimates.

Experimental Variables and Analytical Procedures

Recovered parasites were relaxed, fixed, stained and slide-mounted for light-microscope examination and camera-lucida drawing. Parasites were identified to the lowest reliable taxonomic rank using current keys and species descriptions for parasitic copepods, monogeneans, anisakid nematodes, didymozoid and digenean trematodes and microsporidians.^{4,12,19–22} Body dimensions (total length, fore-body and hind-body length and width, sucker diameter, scolex and proboscis features) were measured in millimetres or micrometres and are reported as mean ± standard deviation with range and sample size. Taxa for which diagnostic structures were missing or damaged were identified to genus, family, order or class.

Ecological infection parameters were computed for every taxon, with the host fish as the sampling unit: prevalence (percentage of hosts infected), mean abundance (parasites of a taxon divided by all hosts examined), mean intensity (parasites divided by infected hosts) and relative dominance (a taxon's specimens as a percentage of all specimens).^{4,15} Wilson score 95%

confidence intervals were computed for every prevalence. Community structure was characterised at the component-community level by species richness (S), the Shannon–Wiener index ($H' = -\sum p_i \ln p_i$), Pielou's evenness ($J' = H'/\ln S$), the Gini–Simpson index ($1 - D = 1 - \sum p_i^2$), the Berger–Parker dominance index ($d = N_{\max}/N$) and Margalef's richness index ($dMg = (S - 1)/\ln N$), where p_i is the proportional abundance of taxon i and N the total number of specimens.⁵

Data Analysis

Analyses were performed in Python 3 (NumPy 1.26). A chi-square goodness-of-fit test evaluated the homogeneity of prevalence across the ten taxa, with Cohen's w as the effect size. Spearman rank-correlation coefficients (treated as exploratory) quantified associations among prevalence, abundance, intensity and dominance. A Welch (unequal-variance) t-test compared the total body length of *Didymozoon* sp.1 and *Didymozoon* sp.2, with Cohen's d and the small-sample-corrected Hedges' g as effect sizes. Principal component analysis (PCA) on the standardised infection-parameter matrix summarised the epidemiological structure; components were retained by the Kaiser (eigenvalue > 1)

criterion and the ordination is treated as descriptive given the ten-taxon configuration. Significance was set at $\alpha = 0.05$ and exact p-values are reported to three decimal places. Zoonotic and quality-relevant taxa were benchmarked against EU Regulation (EC) No 853/2004 and the Indonesian SNI 2729.^{16–17} The host-by-taxon count matrix and analysis code are available from the corresponding author.

Results

Host Characteristics and Sampling Overview

The fifty examined *P. tayenus* had a mean total length of 13.3 ± 2.1 cm and a mean body weight of 58.6 ± 27.6 g, as detailed in Table 1, consistent with the size of commercially landed individuals. A total of 365 parasite specimens belonging to ten taxa were recovered, comprising six ectoparasite groups (*Didymozoon* sp.1, *Didymozoon* sp.2, *Pseudolernanthropus epinepheli*, *Lernanthropus priacanthi*, *Caligus* sp. and *Monogenea*) and four endoparasite groups (*Hysterothylacium* sp., *Microsporidia*, *Digenea* and *Trypanorhyncha*). Ectoparasites accounted for 165 specimens (45.2%) and endoparasites for 200 specimens (54.8%).

Table 1. Sampling-site and host characteristics of *Priacanthus tayenus* from the South China Sea, east-coast Peninsular Malaysia (n = 50).

Characteristic	Value / Description
Study area	East coast of Peninsular Malaysia (Terengganu)
Water body	South China Sea (tropical coastal shelf)
Approx. landing-ground coordinates	5.2–5.4° N, 103.0–103.2° E
Habitat / adjacent land use	Coastal demersal–pelagic fishing grounds; fisheries-dependent shoreline
Sampling period	Single survey campaign (wet/inter-monsoon season)
Specimen source	Commercial marine capture fishery (freshly landed catch)
Host species	<i>Priacanthus tayenus</i> (Spotfin bigeye; Priacanthidae)
Sample size (n)	50 fish
Mean total length	13.3 ± 2.1 cm (mean $\pm$ SD)
Mean body weight	58.6 ± 27.6 g (mean $\pm$ SD)
Examination	Whole-body ecto- and endoparasitological post-mortem; permanent slides

Parasite Infection Parameters and Quality Status

The infection parameters for all ten taxa are presented in Table 2 and illustrated in Figure 1. The anisakid nematode *Hysterothylacium* sp. dominated the assemblage numerically, with 177 specimens recovered from 30 fish (prevalence 60.0%, mean abundance 3.54 parasites fish⁻¹, mean intensity 5.90, relative dominance 48.5%). The didymozoid trematode *Didymozoon* sp.1 was the most prevalent taxon, infecting 31 of 50 fish (prevalence 62.0%) with 120 specimens (mean

abundance 2.40; mean intensity 3.87; dominance 32.9%) on the gills, nostrils, operculum and fins. As shown in Table 2, *Pseudolernanthropus epinepheli* (prevalence 24.0%; 22 specimens on gill arches 1–2) and *Didymozoon* sp.2 (16.0%) were of intermediate frequency, whereas the microsporidian in sporophorous vesicles (10.0%), *Monogenea* (6.0%), *Digenea* (4.0%), *Lernanthropus priacanthi* (2.0%), *Caligus* sp. (2.0%) and *Trypanorhyncha* (2.0%) were uncommon, the last three each represented by only one or two specimens.

Table 2. Parasite taxa of *Priacanthus tayenus*: site of infection, infection parameters (prevalence with Wilson 95% CI; mean abundance in parasites fish⁻¹; mean intensity; relative dominance), zoonotic potential and quality/safety status relative to EU Regulation (EC) 853/2004. ✓ = within criterion; X = exceeds/visible parasite.

Parasite taxon	Group (eco-type)	Site of infection	n	Prev. % [95% CI]	Abu nd.	Inte ns.	Dom . (%)	Zoonotic	Quality / safety
<i>Hysterothylacium</i> sp.	Nematoda (endo)	Gut, intestine, body cavity	17	60.0 [46–72]	3.54	5.90	48.5	Yes (anisakiasis)	Exceeds (X)
<i>Didymozoon</i> sp.1	Trematoda, Didymozoidae (ecto)	Gills, nostril, operculum, fins	12	62.0 [48–74]	2.40	3.87	32.9	No	Visible cysts (X)
<i>Pseudolernanthropus epinepheli</i>	Copepoda (ecto)	Gill arches 1–2	22	24.0 [14–37]	0.44	1.83	6.0	No	Within (✓)
<i>Microsporidian in sporophorous vesicle</i>	Microsporidia (endo)	Body cavity	19	10.0 [4–21]	0.38	3.80	5.2	No	Within (✓)
<i>Didymozoon</i> sp.2	Trematoda, Didymozoidae (ecto)	Operculum joints	16	16.0 [8–29]	0.32	2.00	4.4	No	Visible cysts (X)
<i>Monogenea</i>	Monogenea (ecto)	Gills	4	6.0 [2–16]	0.08	1.33	1.1	No	Within (✓)
<i>Digenea</i>	Trematoda, Digenea (endo)	Intestine	3	4.0 [1–14]	0.06	1.50	0.8	Possible	Within (✓)
<i>Lernanthropus priacanthi</i>	Copepoda (ecto)	Gills	2	2.0 [0.4–11]	0.04	2.00	0.5	No	Within (✓)
<i>Caligus</i> sp.	Copepoda (ecto)	Maxilla membrane	1	2.0 [0.4–11]	0.02	1.00	0.3	No	Within (✓)
<i>Trypanorhyncha</i>	Cestoda (endo)	Body-cavity wall	1	2.0 [0.4–11]	0.02	1.00	0.3	Plerocercoid (rare)	Exceeds (X)

As Figure 1 shows, mean abundance closely tracked prevalence across the assemblage (Spearman $\rho = 0.939$), and the prevalence of the ten taxa was highly heterogeneous ($\chi^2 = 130.47$, $df = 9$, $p < 0.001$; Cohen's $w = 1.18$, a large effect), confirming that the taxa should be treated individually. The Wilson 95% confidence intervals in Table 2 were narrow for the common taxa (e.g., *Didymozoon* sp.1, 48–74%) but wide for the rare taxa (0.4–11% for the single-host taxa), so the latter prevalences are imprecise minima. Three distinct

considerations were separated when assigning the quality/safety status in Table 2: zoonotic hazard to the consumer, the legal visible-parasite criterion, and general product acceptability. The anisakid larvae and the trypanorhynch plerocercoid are the principal zoonotic and visible-parasite concerns; the conspicuous didymozoid cysts are an acceptability issue rather than a zoonotic one; and the gill-attached copepods, lying outside the edible fillet, are largely irrelevant to the marketed portion.

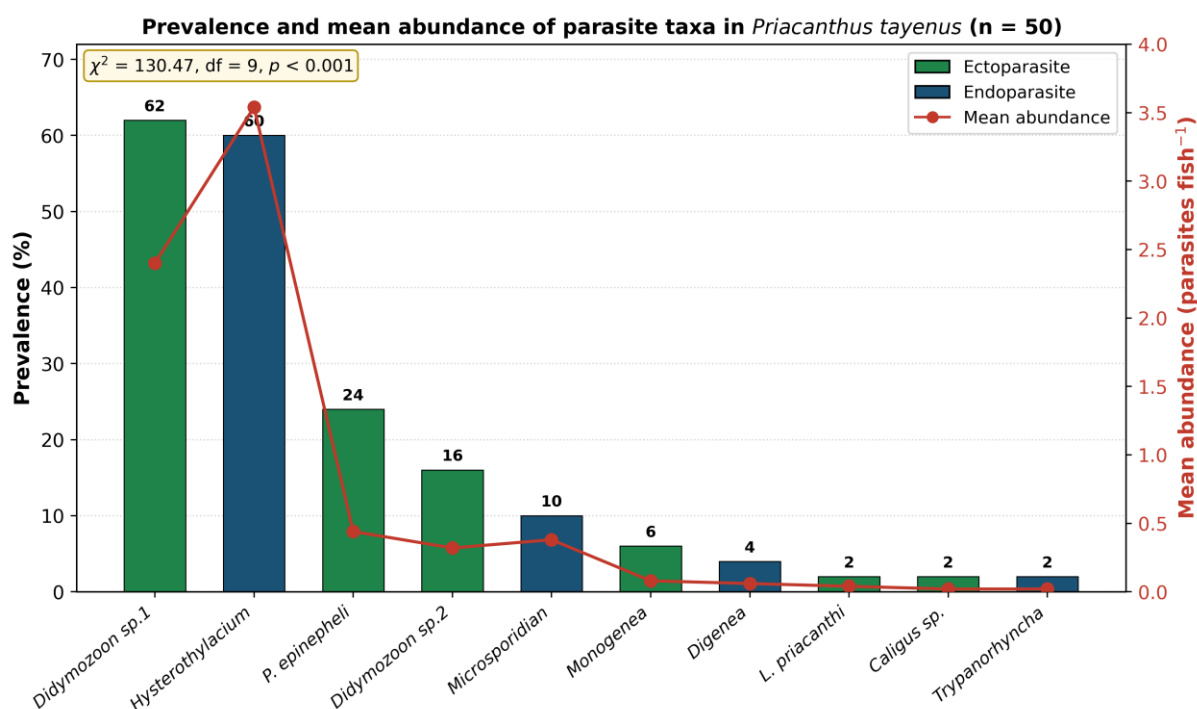


Figure 1. Prevalence (bars; ectoparasites green, endoparasites blue) and mean abundance (red line, right axis on a different scale) of the ten parasite taxa in *Priacanthus tayenus* (n = 50). Prevalence differed significantly among taxa ($\chi^2 = 130.47$, $df = 9$, $p < 0.001$).

Community Diversity and Statistical Structure

The community-level indices, inferential tests, correlations and ordination are compiled in Table 3. The assemblage showed moderate diversity (Shannon $H' = 1.327$; Pielou $J' = 0.576$; Gini-Simpson $1 - D = 0.648$; Margalef $dMg = 1.525$) but pronounced dominance, with a Berger-Parker index of 0.485 reflecting that

Hysterothylacium sp. alone constituted almost half of all specimens. As visualised in the correlation matrix of Figure 2, prevalence correlated very strongly with abundance ($\rho = 0.939$, $p < 0.001$) and with dominance ($\rho = 0.939$, $p < 0.001$), abundance correlated strongly with intensity ($\rho = 0.818$, $p = 0.004$), and prevalence correlated moderately with intensity ($\rho = 0.648$, $p = 0.043$).

Table 3. Diversity indices, inferential tests, correlations and ordination for the parasite assemblage of *Priacanthus tayenus*.

Metric / test	Result	Interpretation
Species richness (S)	10 taxa	—
Total parasite specimens	365	—
Shannon-Wiener diversity (H')	1.327	Moderate assemblage diversity
Pielou evenness (J')	0.576	Moderate evenness; uneven dominance
Simpson diversity ($1 - D$)	0.648	Moderate dominance concentration
Berger-Parker dominance (d)	0.485	<i>Hysterothylacium</i> sp. $\approx$ half of all specimens
Margalef richness (dMg)	1.525	Moderate species richness for $n = 50$
Ecto : endo individuals	165 : 200 (45.2% : 54.8%)	Endoparasites slightly more abundant
χ^2 prevalence homogeneity	$\chi^2 = 130.47$, $df = 9$, $p < 0.001$; Cohen $w = 1.18$	Highly heterogeneous; large effect
Spearman: prevalence–abundance	$\rho = 0.939$, $p < 0.001$	Very strong positive association
Spearman: abundance–intensity	$\rho = 0.818$, $p = 0.004$	Strong positive association
Spearman: prevalence–intensity	$\rho = 0.648$, $p = 0.043$	Moderate positive association
Welch t-test: <i>Didymozoon</i> sp.1 vs sp.2	$t = 2.61$, $df = 19.5$, $p = 0.017$; $d = 0.81$; $g = 0.79$	sp.1 longer; large effect
PCA eigenvalues (PC1; PC2)	$\lambda_1 = 3.76$ (94.0%); $\lambda_2 = 0.19$ (4.8%)	One dominant gradient; only PC1 retained

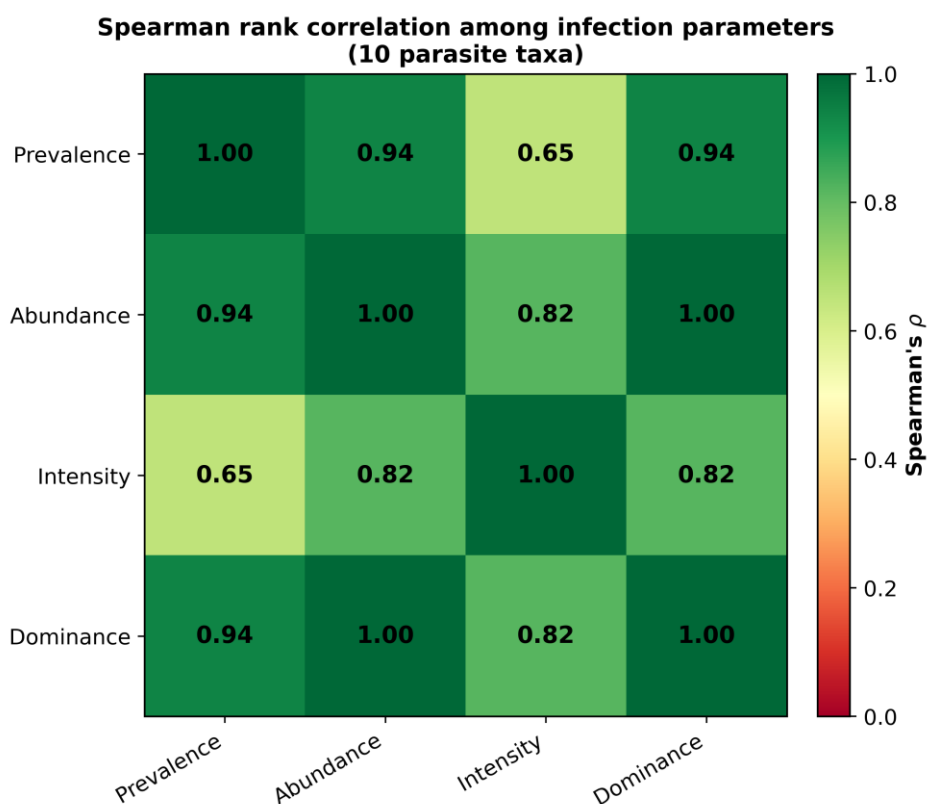


Figure 2. Spearman rank-correlation matrix among parasite infection parameters (prevalence, abundance, intensity, dominance) across the ten taxa ($n = 10$).

Principal component analysis of the standardised infection-parameter matrix reduced the four variables to a single dominant axis: PC1 explained 94.0% of the total variance ($\lambda_1 = 3.76$) and PC2 a further 4.8% ($\lambda_2 = 0.19$; cumulative 98.8%), so only PC1 was retained under the Kaiser criterion. Prevalence, abundance and dominance loaded almost equally on PC1, whereas mean intensity

loaded most heavily on PC2, indicating that intensity carries information partly independent of how widespread a taxon is. As the biplot in Figure 3 shows, *Hysterothylacium* sp. and *Didymozoon* sp.1 separate clearly from the remaining taxa along PC1 as the dominant, widespread members of the assemblage, while the rare taxa cluster near the origin.

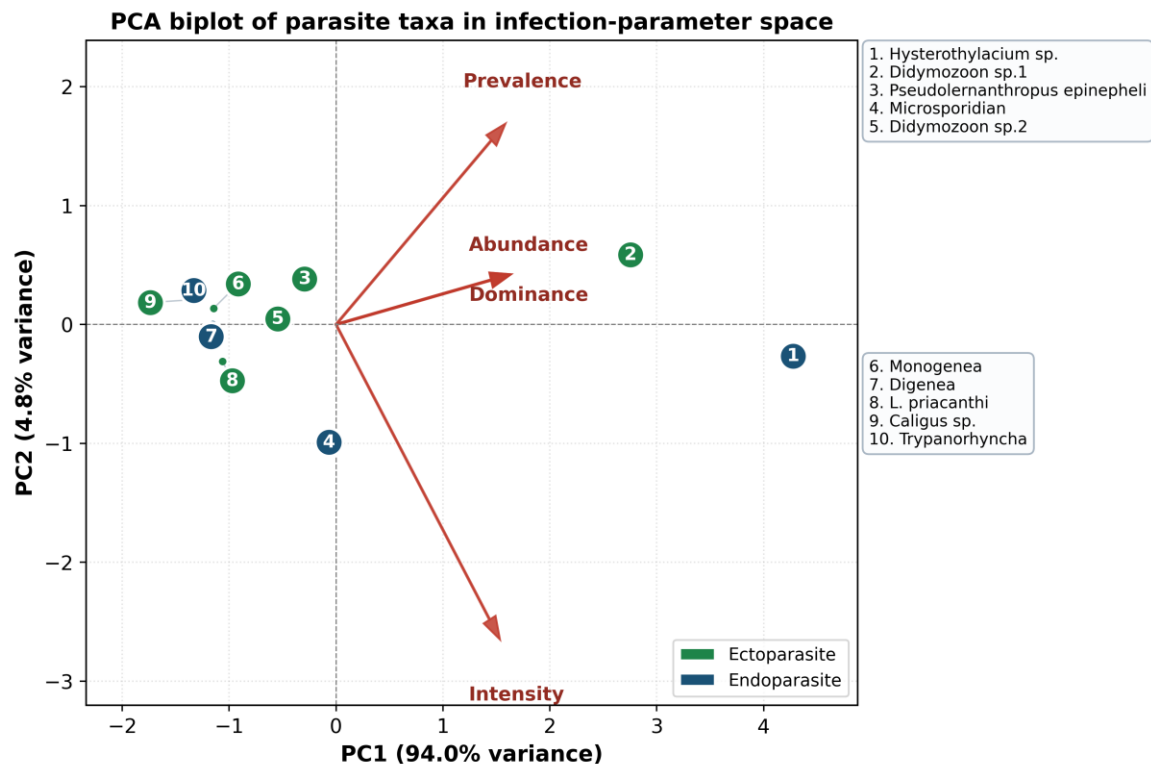


Figure 3. PCA biplot of the ten parasite taxa in infection-parameter space (PC1 = 94.0%, PC2 = 4.8% of variance). Arrows are variable loadings; symbols denote ectoparasites (green) and endoparasites (blue).

Morphological Identification of Principal Taxa

Among the ectoparasites, *Didymozoon* sp.1 occurred as paired worms in yellowish cysts (0.5–1.5 cm) with a slender anterior and broad posterior body; total length averaged 7.50 ± 3.02 mm (4.0–14.78 mm; $n = 30$) with a single terminal sucker (0.17 ± 0.03 mm). *Didymozoon* sp.2 was shorter and more thread-like posteriorly (5.21 ± 2.05 mm; 2.13–7.80 mm; $n = 9$). The two morphotypes differed significantly in body length (Welch $t = 2.61$, $df = 19.5$, $p = 0.017$; Table 3), with a large effect size (Cohen $d = 0.81$; Hedges $g = 0.79$). *Pseudolernanthropus epinepheli* females (115.9 ± 2.81 μ m total length; $n = 10$) bore two long, looped egg strings (182–210 eggs) and attached to

gill arches by the second antenna and first maxilliped; males were not recovered. *Lernanthropus priacanthi* (0.77–0.82 mm) and a single *Caligus* sp. (3.05 mm, with frontal lunules) completed the copepod fauna. Among endoparasites, *Hysterothylacium* sp. larvae (12.08 ± 2.53 mm; $n = 23$) showed three lips, a muscular oesophagus with ventricular appendix and an intestinal caecum; only first- and third-stage larvae were recovered, consistent with the fish acting as an intermediate/paratenic host.^{3,11} The trypanorhynch plerocercoid (9.15 mm) had two bothridia and four hook-bearing tentacles with four proboscis bulbs, and was assigned to Trypanorhynchidae.

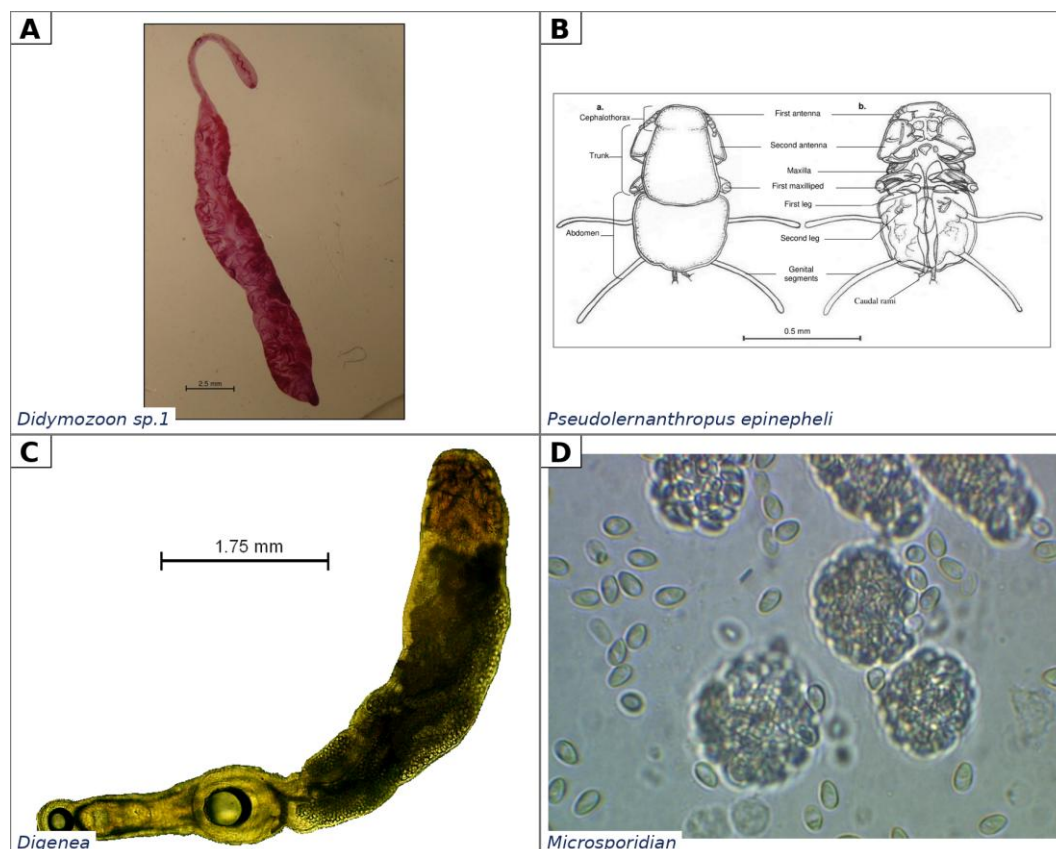


Figure 4. Representative morphology of the principal parasite taxa recovered from *Priacanthus tayenus*: (A) *Didymozoon* sp.1 stained whole-mount, the most prevalent ectoparasite; (B) *Pseudolernanthropus epinepheli* (schematic; dorsal and ventral views); (C) a digenean trematode (scale bar = 1.75 mm); (D) microsporidian spores within a sporophorous vesicle under light microscopy. Images are the authors' own specimens.

Discussion

This study provides the first quantitatively analysed parasite assessment of *Priacanthus tayenus* from the South China Sea off east-coast Peninsular Malaysia. Ten taxa were recovered from fifty hosts, with the anisakid nematode *Hysterothylacium* sp. dominating the assemblage (48.5% of specimens; 60% prevalence) and the didymozoid *Didymozoon* sp.1 the most prevalent taxon (62%). Moderate diversity ($H' = 1.327$) combined with high dominance (Berger–Parker $d = 0.485$) is typical of tropical marine infracommunities, in which one or two trophically transmitted helminths numerically overwhelm a long tail of rare taxa.^{4,15}

The numerical supremacy of *Hysterothylacium* is ecologically coherent. Anisakid larvae accumulate in the viscera and musculature of fish that occupy intermediate or paratenic positions in marine food webs, and their abundance reflects the density of infected crustacean and fish prey.^{3,11} The recovery of only first- and third-stage larvae confirms that *P. tayenus* functions as an intermediate/paratenic host rather than a definitive host.^{9–10} Comparable dominance of anisakid larvae, frequently at very high prevalence, has been reported in marketed marine fish elsewhere,^{9,16} reinforcing the view that this is a widespread feature of commercial demersal–pelagic species rather than a local anomaly.

The strong, almost linear coupling between prevalence and abundance ($\rho = 0.939$) and between abundance and intensity ($\rho = 0.818$), together with a PCA in which a single axis captured 94.0% of the variance, indicates that the epidemiology of this assemblage is governed primarily by one gradient of infection success: taxa that are common are also abundant and dominant. Mean intensity, which loaded on the second axis, adds a partly independent dimension, since a few uncommon taxa reach high intensities in the few hosts they infect. This structure mirrors quantitative analyses of other fish helminth and parasite communities.^{5,15}

The host's feeding ecology explains the composition of the assemblage. As a nocturnally active mesopredator that consumes small fish, crustaceans and cephalopods over soft-bottom and reef-associated grounds, *P. tayenus* accumulates the larval parasites of its prey, so the dominance of trophically transmitted helminths directly reflects local food-web structure and integrates the trophic and environmental history of the host.^{6,18} This mechanistic link is what justifies treating the assemblage as a bioindicator: a future shift in the prevalence or dominance of these helminths would signal a change in the food web and, indirectly, in the environmental conditions that shape it.^{5,15}

Among the ectoparasites, the dominance of didymozoid trematodes is notable. *Didymozoon* cysts are conspicuous, yellowish and visible without dissection, a

feature that supports their use as biological markers of host biology, and didymozoid infections of commercial fish are increasingly documented with integrative methods.¹² The significant length difference between the two morphotypes (Hedges $g = 0.79$) is consistent with their treatment as distinct species pending molecular confirmation.^{19,22} The parasitic copepods — *Pseudolernanthropus epinepheli*, *Lernanthropus priacanthi* and *Caligus* sp. — attach to the gills and maxillary membrane and are of particular concern for aquaculture, where caligid and related infections cause gill damage, osmoregulatory failure and secondary infection.^{4,14} That *Pseudolernanthropus* rather than *Caligus* dominated the copepod fauna likely reflects the rough, spined scales of *P. taylori*, which impede caligid attachment except on soft membranes.²⁰

The endoparasite fauna carries the clearest environmental and public-health signal. *Hysterothylacium* and related anisakids are the agents of human anisakiasis, which follows ingestion of viable larvae in raw or undercooked fish and manifests as abdominal pain, nausea and, rarely, intestinal obstruction or perforation, with allergic sensitisation to parasite antigens compounding the risk.^{7,9} Although *Hysterothylacium* is generally considered of lower zoonotic potency than *Anisakis* *sensu stricto*, its larvae are routinely treated as a seafood-safety hazard,^{10–11} and the trypanorhynch plerocercoid recovered here, while rarely infecting humans, further reduces product acceptability. Digenean trematodes complete the picture: several fish-borne digeneans mature in the human intestine after consumption of infected fish, a recognised regional concern in Southeast Asia.^{2,13}

These findings have direct regulatory implications. EU Regulation (EC) No 853/2004 requires fishery products to be free of visible parasites when placed on the market, and the Indonesian SNI 2729 sets quality expectations for fresh fish. The visible anisakid larvae, trypanorhynch cyst and conspicuous didymozoid cysts documented here would not meet the visible-parasite criterion, implying that a proportion of landed *P. taylori* could be downgraded or rejected under strict inspection.^{16–17} Translating this into action requires supply-chain measures: prompt evisceration at capture, candling of fillets at processing, and freezing at -20°C for at least 24 h (or -35°C for 15 h) to inactivate larvae before any raw or lightly cured consumption, enforced by the Department of Fisheries and food-safety authorities.^{8–9} Embedding these graduated controls would protect consumers, preserve market value and support the food-security role of the fishery.^{1–2}

Placing the present prevalences in a comparative frame underlines their significance. In blue whiting from Portuguese waters, every one of fifty examined fish carried anisakid larvae,⁹ and anisakid nematodes — including *Hysterothylacium* — are widely recorded in commercially important marine fish and squid from the Bay of Bengal, the nearest comparable tropical Asian setting.³ The 60% *Hysterothylacium* prevalence and 48.5% dominance recorded here for *P. taylori* therefore

sit within the range reported for heavily fished demersal–pelagic species, and the additional detection of anisakids in marketed and ready-to-eat products elsewhere^{16–17} shows that the hazard persists along the supply chain rather than being confined to the point of capture. Such cross-study comparison is only possible because standardised infection indices were computed, illustrating the value of the quantitative upgrade adopted in this work.¹⁰

The less abundant taxa, although individually rare, are epidemiologically and ecologically informative. The microsporidian in sporophorous vesicles recovered from the body cavity belongs to a group whose diversity in regional fishes is still being catalogued,²² and its presence, together with the gill-infecting monogeneans, signals the breadth of the infracommunity that a single host can support. Monogeneans are highly host- and site-specific and are sensitive indicators of gill condition,¹⁹ so even the four specimens recovered here are worth documenting as part of the baseline. The Microsporidia and monogeneans also illustrate the detection limits of a morphology-only survey, because their small, fragile bodies are readily lost during processing — a further argument for complementary molecular screening in future campaigns.²²

Because the South China Sea is a shared, transboundary resource, the seafood-safety and food-security implications of these findings extend beyond a single landing site. Capture fisheries remain central to protein and micronutrient supply across the region,¹ and fish-borne parasitic infections continue to impose a measurable burden on endemic communities,² a burden that global reviews suggest is substantially under-reported in high-consumption Southeast-Asian nations.⁷ Aligning local post-harvest practice with the visible-parasite expectations of EU Regulation (EC) 853/2004 and the Indonesian SNI 2729, and harmonising inspection across neighbouring fisheries, would therefore yield benefits for consumer protection, market access and regional food security simultaneously.¹⁶

The principal strengths of this study are its integration of morphological identification with a full quantitative layer (infection indices, diversity indices, inferential tests, correlation and ordination), its explicit regulatory benchmarking, and its provision of a previously missing baseline for an economically important food fish from this coast.^{5–6} Several limitations should temper interpretation. The survey represents a single location and effectively a single season, so spatial and temporal variability remain uncharacterised; the field impression that parasitic copepods were more numerous during the monsoon is a hypothesis for formal seasonal study, not a result.⁴ Identifications rest on morphology alone, and several taxa could be resolved only to genus, family or class because diagnostic specimens were lost, damaged or immature; molecular barcoding (COI/ITS) is needed for species-level confirmation and zoonotic-risk refinement.^{10,19,22} Finally, intermediate-host relationships and the viability of larvae to humans were not assessed and should be addressed in future work.

Finally, the wild-stock data reported here have practical relevance for the region's expanding marine aquaculture. Several of the taxa recovered from *P. tayenus* — notably the lernanthropid and caligid copepods and the gill monogeneans — are recognised problems in cage culture, where they can proliferate rapidly and cause mass mortality of young fish through gill damage, osmoregulatory failure and secondary infection.^{4,14} Documenting the natural reservoir of these parasites in a sympatric wild host therefore supports biosecurity planning for any culture of bigeye or co-located species, and reinforces the case for using parasite surveillance as a routine, low-cost component of both fisheries monitoring and aquaculture health management.^{15,19}

Conclusion

The spotfin bigeye *Priacanthus tayenus* from the South China Sea off east-coast Peninsular Malaysia harbours a moderately diverse but strongly dominated parasite assemblage of ten taxa, led numerically by the zoonotic anisakid *Hysterothylacium* sp. (48.5% dominance; 60% prevalence) and in prevalence by *Didymozoon* sp.1 (62%). Prevalence was highly heterogeneous among taxa ($\chi^2 = 130.47$, $p < 0.001$) and tightly coupled to abundance ($\rho = 0.939$), with a single PCA axis explaining 94.0% of the epidemiological structure. The presence of visible zoonotic and quality-relevant parasites is inconsistent with the visible-parasite provisions of EU Regulation (EC) 853/2004 and the intent of SNI 2729, indicating that landed bigeye should be subject to candling, prompt evisceration and freezing before raw consumption. We recommend seasonal, multi-site monitoring coupled with molecular identification to confirm species, refine zoonotic risk and use this parasite assemblage as an indicator of aquatic ecosystem health and seafood safety in the regional fishery.

Declarations

Ethical Approval. The specimens were obtained from the commercial marine capture fishery as already-landed catch; the study involved post-mortem parasitological examination only, with no experimental procedures on live animals and no human subjects. Formal ethics approval and consent were therefore not required.

Conflict of Interest. The authors declare that they have no competing interests.

Funding. This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors. Institutional support was provided by Universiti Malaysia Terengganu (UMT).

Author Contributions. Following the CRediT taxonomy: F. Shaharom and S. Li – conceptualisation and methodology; N. A. H. Mohammed Yusoff, S. R. Manaf, N. Kemat, N. F. A. Mohamad and R. H. Hamdan – investigation, formal analysis and writing of the protocol; M. I. Zakariah – writing of the original draft; S. Mazelan, M. H. Borkhanuddin and M. B. Martin – parasite identification and validation; M. Abd Ghaffar, A. S.

Draman and K. Waiho – resources and visualisation; W. Wahab – specimen preparation. All authors reviewed and approved the final manuscript.

Data Availability. The host-by-taxon infection-count matrix and the analysis code underlying the findings of this study are available from the corresponding author upon reasonable request.

Use of Artificial Intelligence. Generative AI and AI-assisted tools were not used during the preparation of this manuscript. The authors verified all scientific content, data, analyses and conclusions; no AI tool was used to generate, alter or fabricate data or results, and the authors take full responsibility for the integrity and accuracy of the work.

Acknowledgements. The authors thank the laboratory staff of HICoE-AKUATROP and the Faculty of Science and Marine Environment (FSSM), and the Department of Fisheries, Malaysia, for their support, and Universiti Malaysia Terengganu (UMT) for the research opportunity.

References

1. Kaminski AM, Little DC, Middleton L, et al. The role of aquaculture and capture fisheries in meeting food and nutrition security: testing a nutrition-sensitive pond polyculture intervention in rural Zambia. *Foods*. 2022; 11(9): 1334. doi: 10.3390/foods11091334.
2. Nguyen TTB, Dermauw V, Bui DT, et al. Incidence of fish-borne trematode infections and associated factors: results from a cohort study in highly endemic communities in northern Vietnam. *Parasitol Res*. 2023; 122(6): 1415–1425. doi: 10.1007/s00436-023-07846-y.
3. Bao M, Cipriani P, Giulietti L, et al. Ascaridoid nematodes infecting commercially important marine fish and squid species from Bangladesh waters in the Bay of Bengal. *Food Waterborne Parasitol*. 2022; 27: e00157. doi: 10.1016/j.fawpar.2022.e00157.
4. May-Tec AL, Banos-Ojeda C, Mendoza-Franco EF. Parasitic crustaceans (Branchiura and Copepoda) parasitizing the gills of puffer fish species (Tetraodontidae) from the coast of Campeche, Gulf of Mexico. *ZooKeys*. 2022; 1089: 73–92. doi: 10.3897/zookeys.1089.79999.
5. Biswas JK, Pramanik S, Kumar M. Fish parasites as proxy bioindicators of degraded water quality of River Saraswati, India. *Environ Monit Assess*. 2023; 195(7): 818. doi: 10.1007/s10661-023-11411-6.
6. Latief L, Gilbert BM, Avenant-Oldewage A. Effects of water quality on fish parasite biodiversity and physiological responses in the host fish *Clarias gariepinus* from a eutrophic lake subjected to acid mine drainage in South Africa. *Integr Environ Assess Manag*. 2024; 20(5): 1539–1553. doi: 10.1002/ieam.4885.
7. Shamsi S, Barton DP. A critical review of anisakidosis cases occurring globally. *Parasitol Res*. 2023; 122(8): 1733–1745. doi: 10.1007/s00436-023-07881-9.
8. Della-Morte D, Ambrosi C, Chiereghin F, et al. Methods for inactivation of seafood Anisakis larvae and prevention of human anisakiasis: a mini-review. *Eur Rev Med Pharmacol Sci*. 2023; 27(11): 5246–5256. doi: 10.26355/eurrev_202306_32643.
9. Rigkou A, Hemnani M, Martins AL, et al. Detection and characterization of visceral anisakid nematodes in blue whiting from Portuguese waters. *Foods*. 2024; 13(23): 3802. doi: 10.3390/foods13233802.
10. Martin-Carrillo N, Garcia-Livia K, Baz-Gonzalez E, et al. Morphological and molecular identification of Anisakis

- spp. (Nematoda: Anisakidae) in commercial fish from the Canary Islands coast (Spain): epidemiological data. *Animals*. 2022; 12(19): 2634. doi: 10.3390/ani12192634.
11. Bao M, Levsen A, Giulietti L, et al. Anisakis (sensu lato) and Hysterothylacium (Nematoda: Ascaridoidea) in adult Atlantic bluefin tuna caught in Norway. *Food Waterborne Parasitol*. 2025; 39: e00261. doi: 10.1016/j.fawpar.2025.e00261.
 12. Khormi MA, Abdelsalam M, Baghdadi HB, et al. Morphological, molecular, and pathological characterization of didymozoid trematode infection in the nasal cavity of orange-spotted grouper (*Epinephelus coioides*) from Arabian Gulf waters. *PLoS One*. 2026; 21(5): e0343608. doi: 10.1371/journal.pone.0343608.
 13. Khallaf M, El-Bahrawy A, Awad A, et al. Prevalence and molecular characterization of *Centrocestus formosanus* in wild tilapia from the western Nile Delta of Egypt. *Parasitol Int*. 2025; 108: 103068. doi: 10.1016/j.parint.2025.103068.
 14. Yanar A, Kamanli SA, Sonmez S, et al. *Caligus minimus* Otto, 1821 (Copepoda: Caligidae): a commercially important but poorly described parasite of cultured European sea bass, *Dicentrarchus labrax*. *Parasitol Int*. 2024; 104: 102964. doi: 10.1016/j.parint.2024.102964.
 15. Pravdova M, Kolarova J, Grabicova K, et al. Response of parasite community composition to aquatic pollution in common carp: a semi-experimental study. *Animals*. 2023; 13(9): 1464. doi: 10.3390/ani13091464.
 16. Papapostolou EN, Chaintoutis SC, Gousia P, et al. Food safety concerns: *Anisakis* spp. in ready-to-eat fish from the Greek market. *Pathogens*. 2025; 14(10): 981. doi: 10.3390/pathogens14100981.
 17. Rahman MMIA, Elbarbary NB, Darwish WS, et al. Occurrence of *Anisakis* spp. in fish and fish products in Egyptian markets. *Open Vet J*. 2025; 15(6): 2774–2781. doi: 10.5455/OVJ.2025.v15.i6.45.
 18. Muns-Pujadas L, Dallares S, Constenla M, et al. Revealing the capability of the European hake to cope with micro-litter environmental exposure and its inferred potential health impact in the NW Mediterranean Sea. *Mar Environ Res*. 2023; 186: 105921. doi: 10.1016/j.marenvres.2023.105921.
 19. Kritsky DC, Al-Darwesh AA, Ali AH. Taxonomic status of *Diplectanum robustitubum* (Monogenoidea: Diplectanidae) from the purple-spotted bigeye *Priacanthus tayenus* and the description of *Platycephalotrema parile* n. sp. in the Arabian Gulf. *Acta Parasitol*. 2024; 69(2): 1295–1303. doi: 10.1007/s11686-024-00849-4.
 20. Paschoal F, Couto JV, Pereira FB, et al. A new species of hatschekiid copepod (Crustacea: Hatschekiidae) parasitic on the porkfish *Anisotremus virginicus* (Haemulidae), with notes on previously known species of *Hatschekia* off Brazil. *Acta Parasitol*. 2022; 67(3): 1126–1135. doi: 10.1007/s11686-022-00551-3.
 21. Mic R, Rehulkova E, Seifertova M. Species of *Ergasilus* von Nordmann, 1832 (Copepoda: Ergasilidae) from cichlid fishes in Lake Tanganyika. *Parasitology*. 2023; 150(7): 579–598. doi: 10.1017/S0031182023000239.
 22. Weng M, Xie D, Zhang Q, et al. First report of *Ovipleistophora diplostomuri* and *O. ovariae* in China provides new insights into the intraspecific genetic variation and extends their distribution. *Parasitology*. 2021; 149(3): 314–324. doi: 10.1017/S0031182021001852.