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Parasitic Survey of Two Marine Fish Species, *Rastrelliger kanagurta* (Cuvier, 1816) and *Sardinella gibbosa* (Bleeker, 1849) from the Suez Gulf, Egypt

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ABSTRACT

This study was designed to investigate the parasites associated with *Rastrelliger kanagurta* and *Sardinella gibbosa*. A total of 220 fish samples from two marine species were randomly collected from fish markets in South Sinai Governorate, Egypt, during the spring season of 2023 by fishermen. Of these, 120 specimens were *Rastrelliger kanagurta* and 100 specimens were *Sardinella gibbosa*. Parasitological examinations revealed that *Rastrelliger kanagurta* had a total prevalence of 75% (84% in males and 66.6% in females), with two trematode species—*Prodistomum orientalis* and *Opechona bacillaris*—as well as the nematode parasite *Anisakis* sp. (larvae). For *Sardinella gibbosa*, the total prevalence was 65% (45% in males and 20% in females), with the presence of *Anisakis* sp. (adult and larval stages). To accurately identify the detected parasites, all species were photographed, morphological observations were recorded, and an electron microscopic examination was conducted on adult *Anisakis* sp. Based on the current findings, further studies are recommended to expand the parasitological database, including more observations on the parasitological effects on the host, human health, the surrounding ecosystem, and the host-parasite relationship in the Suez Gulf region, Egypt.

INTRODUCTION

Parasitic infections pose a significant challenge in the fisheries sector, particularly in marine fish and economically significant species, as they can compromise visual quality and palatability **(Sethi *et al.*, 2013)**. Marine fish serve as an excellent supply of protein, omega-3, fatty acids, minerals and vitamins. Several diseases, like parasitic infestations, as well as secondary fungal and bacterial infections, transfer a risk to most consumers **(Park *et al.*, 2009)**. Scientific studies have limited our understanding of the impact of parasites on fish, which can lead to chronic mortality. In extensive human activities, it increasingly becomes challenging to investigate the impact of parasites on marine fish species in the wild open sea. The Suez Gulf is located to the west of the Sinai Peninsula in the far northern region of the Red Sea; it is an extension of the western portion of the Red Sea. This sector of the Egyptian Red Sea fisheries, one of the most productive, yields more than 64% of the total fish production **(GAFRD, 2017)**.

Rastrelliger kanagurta (Cuvier, 1816), known as the Indian mackerel, is a pelagic species that typically inhabits the western portion of the Pacific and Indian oceans. It is highly valued as a significant source of affordable protein and is frequently used as bait **(Amin *et al.*, 2015)**. *R. kanagurta* constitutes a significant fishery throughout the Suez Gulf region with extensive data exists about dietary practices and consumption behaviors, but there was a limitation in parasitic distribution affecting this species. Various geographic regions have reported individual or uncommon parasite species, including monogeneans, crustaceans, and isopods **(Rameshkumar & Ravichandran, 2010)** metazoans **(Madhavi & Triveni, 2012)**, and trematodes **(Al-Zubaidy & Mhaisen, 2014)**. Parasitic infestations in wild fish necessitate urgent intervention, particularly in species that infect locally significant food fish, adversely impacting their visual quality, palatability, and market value.

Sardinella gibbosa, known as the sardine, is one of the most abundant coastal pelagic species globally in the family Clupeidae. It is indigenous to shallow tropical waters and is often associated with coral reefs **(El-Betar & Osman, 2021)**. A few reports on parasitic infestations in various *Sardinella* species (*S. fimbriata, S. gibbosa, S. aurita*, *S. albella*) are available **(Rijin *et al.*, 2020)**.

S. gibbosa distribution on the Mediterranean eastern coast was recorded because of its migrations from the Red Sea throughout the Suez Canal, which confirms the presence of its population in the Red Sea **(Stern & Goren, 2015)**.

Helminths are prevalent parasites in marine ecosystems, with trematodes being significant endoparasites of both vertebrates and invertebrates **(Diaz Briz *et al.*, 2012)**. Trematodes possess indirectly life cycles; they inhabit numerous vertebrates like snails and small fishes as intermediate hosts during their stages of development as a larva. The trematodes comprise 148 known families, about 2800 conventional genera, comprising nearly 18,000 fictional species **(Swiderski & Georgiev, 2009)**.

Marine fish are commonly home to *Anisakis* nematodes, which are members of the Anisakidae family and inhabit hosts at different levels of the food chain **(Lymbery & Cheah, 2007)**. Their life cycle includes primary and secondary intermediate hosts as small crustaceans and fishes or cephalopods, respectively, then marine mammals as definitive hosts. Humans inadvertently serve as hosts for *Anisakis* larvae typically by ingesting contaminated raw or inadequately cooked seafood **(Ivanović *et al.*, 2017)**.

Despite the lack of data on parasitic infestations in marine fish, it is crucial to investigate the parasites associated with *Rastrelliger kanagurta* and *Sardinella gibbosa*. This study aimed to fill this gap and will serve as a foundational database for future research in this area. The objective of the study was to detect, isolate, identify, and assess the severity of infestations caused by various parasites, as well as examining the morphological characteristics of the isolated parasites. The findings would provide valuable parasitological data for future investigations.

MATERIALS AND METHODS

1. Ethical statement approval

The later protocol including fish were confirmed according to the standards of instructions of EAURC (Ethical Animal Use in the Research Committee), Faculty of Science, Suez Canal University, Egypt (with approval number, REC 368/2024).

2. Fish samples collection and identification

A total of 220 fish specimens were randomly collected by fishermen during the spring season of 2023, consisting of 120 *Rastrelliger kanagurta* (Indian mackerel) and 100 *Sardinella gibbosa* (sardine) from fish markets in South Sinai Governorate, Egypt. The fish samples were transported in ice boxes to the Aquatic Pathology Laboratory at the National Institute of Oceanography and Fisheries (NIOF) in the Suez and El-Aqaba branches, Egypt, for identification and examination of clinical and postmortem signs, along with detailed parasitological inspection. The fish species were separated into male and female groups and identified according to FISHBASE, the largest international fish database in the world **(Farghal *et al.*, 2021)**.

3. Clinical and post-mortem evaluation

The fish samples were initially examined for clear clinical signs, followed by dissection for post-mortem evaluation to record abnormalities associated with parasitic infestations **(Noga, 2010)**.

4. Parasitological examinations and identifications

The collected fish samples were separated into males and females, then examined externally using dissecting stereomicroscope (OPTICA B-150, Italy), for the detection of any attached parasites. Post-mortem signs were observed after each sample was opened and signs were carefully examined considering each organ separately in a Petri dish using a saline solution and a light microscope (40X and 100X magnification), following the methods outlined by **Li *et al.* (2022)** and **Nashaat *et al.* (2023)**. Parasite identification was carried out using international keys detailed in the study of **Hoffman (2019)**.

Scanning electron microscope examinations

The isolated parasites were transferred to an electron microscopy unit in Assiut University (EMU), Egypt, to complete the scanning electron microscope (SEM) process. Samples were repeatedly rinsed in saline solution to get rid of any debris adheres. Parasites were processed in a phosphate buffer solution for washing, and then fixed in 3%

glutaraldehyde **(Colwell *et al.,* 2007)**. The samples were dehydrated using liquid CO2 and were adhered to metallic blocks with silver paint. A gold sputter coater was used to cover the samples with a thin layer of gold (15nm thickness). The samples were photographed using a scanning electron microscope (SEM, JEOL JSM 5400 LV, England) with a magnification range of 15–25 kV **(Bozzola, 1999)**.

RESULTS

1. Fish identification and parasitic prevalence

Fish samples identified as *Rastrelliger canagurta* (Indian mackerel) and *Sardinella gibbosa* (Sardine) were measured for weight, total length, and forked length.

For *Rastrelliger kanagurta*, the average weight of males was 28.5 ± 2 g, with total and forked lengths of 14.5 ± 1 and 13 ± 1cm, respectively. Females had an average weight of 37.3 ± 3g, with total and forked lengths of 15 ± 2 and 14.2 ± 2cm, respectively. The recorded infestations included digenean trematodes (adult worms) from two species in the family Lepocreadiidae: *Prodistomum orientalis* and *Opechona bacillaris*, as well as nematode larvae of *Anisakis* sp. isolated from the pyloric caeca. The total prevalence was 75% (84% in males and 66.6% in females).

For *Sardinella gibbosa*, males had an average weight of 14.5 ± 1 g, with total and forked lengths of 13.5 ± 1 and 12 ± 1cm, respectively. Females had an average weight of 18.2 ± 2g, with total and forked lengths of 14.5 ± 2 and 13.5 ± 2cm, respectively. The recorded infestations included nematodes of *Anisakis* sp. (larvae and adult forms), isolated from the pyloric caeca and intestine, with a total prevalence of 65% (45% in males and 20% in females). Males of both species exhibited higher levels of parasitic infestations compared to females, likely due to their continuous movement and varied feeding behavior, which increases the likelihood of parasitic invasions. In contrast, females, which are primarily responsible for offspring care, are less exposed to such risks.

Table 1. Fish species and parasitic prevalence

Species / Parameters	***Rastrelliger canagurta*** **(Cuvier, 1816)**		***Sardinella gibbosa*** **(Bleeker, 1849)**	
	M*	**F***	**M***	**F***
Wt (g)	28.5±2	37.3±3	14.5±1	18.2±2
TL (cm)	14.5±1	15±2	13.5±1	14.5±2
FL (cm)	13±1	14.2±2	12±1	13.5±2
Total examined	75	45	60	40
	120		100	
Infestation	63 (84%)	30 (66.6%)	45 (75%)	20 (50%)
Total infestation	93 (77.5%)		65 (65%)	
Parasites	*Prodistomum orientalis* (T*) *Opechona bacillaris* (T*) *Anisakis* sp. (larvae) (N*)		*Anisakis* sp. (N*) (adults and larvae)	

*Parasitic infestation means total fish infested ×100/ total examined. Wt: weight, TL: total length, FL: forked length, M: males, F: females, T: trematodes, N: nematodes.

2. Clinical and post-mortem signs observations

The observed clinical signs in both *R. kanagurta* and *S. gibbosa* fish species were light to moderate. These signs included the accumulation of excess mucus on the body in some samples (but not all), small abdominal lesions, inflammation patches, reddish eyes, and hemorrhaging in the gills (PLATE I a and PLATE II a). Post-mortem examination of each organ separately revealed no significant changes, except for slight enlargement of the liver and spleen, which could be a defense mechanism in response to the presence of internal parasites. The fish samples were stored on ice, so it was not possible to assess the histopathological effects of these internal parasites on the tissues of the internal organs.

3. Parasitic identification and morphological characters

Rastrelliger kanagurta (Indian mackerel) exhibited mixed metazoan parasitic infestations, including digenetic trematodes and nematode larvae. These parasites were found together in the same host, with a prevalence of two to five trematodes and three to ten nematodes.

Family: Lepocreadiidae (Trematodes) showed two species:

1. ***Prodistomum orientalis*** (Layman, 1930) (PLATE I b & c): Based on five specimens, this species is characterized by a less elongated body shape, with a cylindrical pharynx larger than the pre-pharynx, and a cup-shaped oral sucker. The anterior biforked intestine extends from the ventral sucker to the posterior part of the body. The posterior gonads are separated into testis and ovary, with a median seminal vesicle. A detailed description is provided by **Gibson *et al.* (2002)**.
2. ***Opechona bacillaris*** (Molin, 1859) (PLATE I d & e): Based on five specimens, this species has an outstretched body with a narrow anterior part and an oral sucker. It also has a pigmented eyespot, a small ventral sucker for attachment, a clear esophagus with a smaller pseudo-esophagus, and the gonads located posteriorly. A detailed description is provided by **Looss & Cuffey (1907)**.
3. ***Anisakis*** nematode larvae (Family: Anisakidae) (PLATE I f): Based on five specimens, these larvae have a smooth, elongated body with a cephalon, a median abdomen, and a pointed posterior end. They possess a primitive digestive tract, with the anus not visible in the photographed specimens. A detailed description is provided by **Setyobudi *et al.* (2019)**.

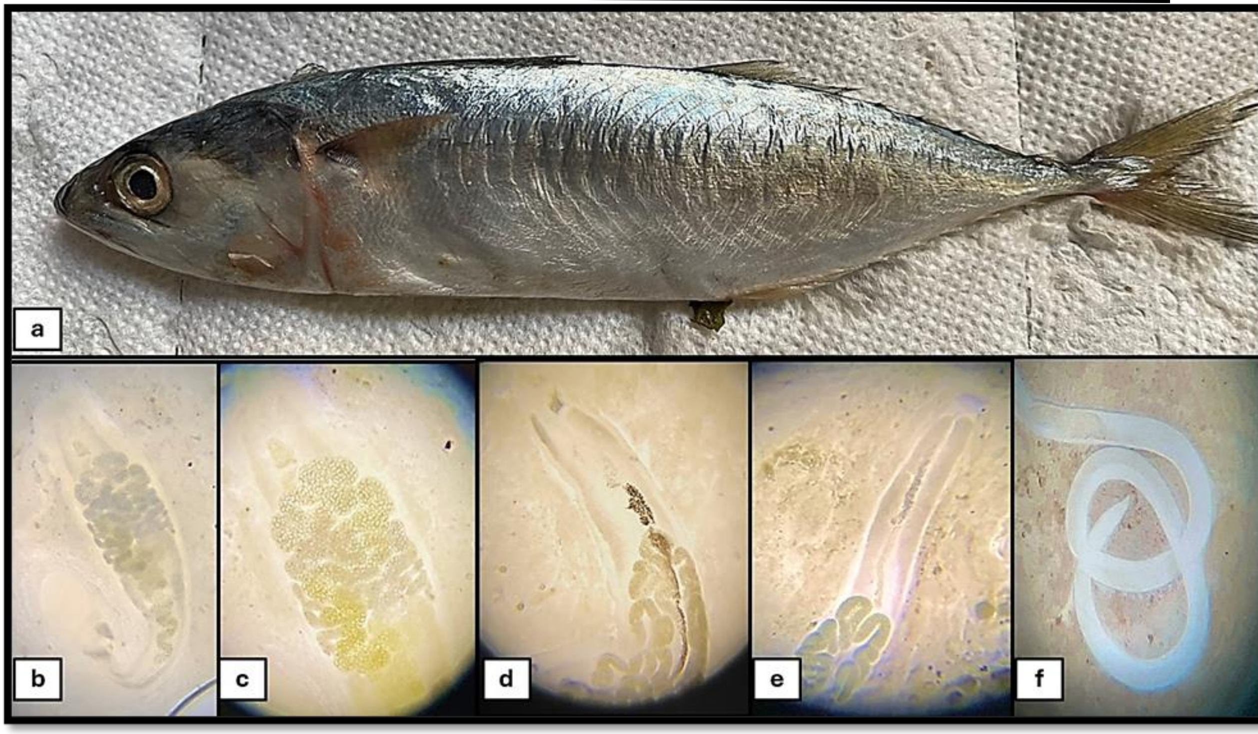

PLATE I. Parasitic identification in infested *Rastrelliger kanagurta*:
(a) *Rastrelliger kanagurta* fish showing inflammation patches in the gill arch region;
(b and c) *Prodistomum orientalis* trematode parasite with a cylindrical pharynx, clear digestive system, and branched intestine (40x magnification);
(d and e) *Opechona bacillaris* trematode parasite with an elongated body, narrowing anteriorly (40x magnification);
(f) *Anisakis* nematode larvae with a pointed posterior end and a primitive digestive system (40x magnification)

***Sardinella gibbosa* (Sardine)**

Heavy infestations of both adult and larval *Anisakis* nematodes were observed in the same host (PLATE II). Based on five specimens, the adult worms are characterized by a smooth, cylindrical body with the head located anteriorly and containing a boring tooth inside the mouthparts. Transverse annulations are visible across the median body part, and the posterior tail is pointed, featuring an anus and a cactus-shaped tail. The larval phase is smaller than the adults and has primitive body organelles.

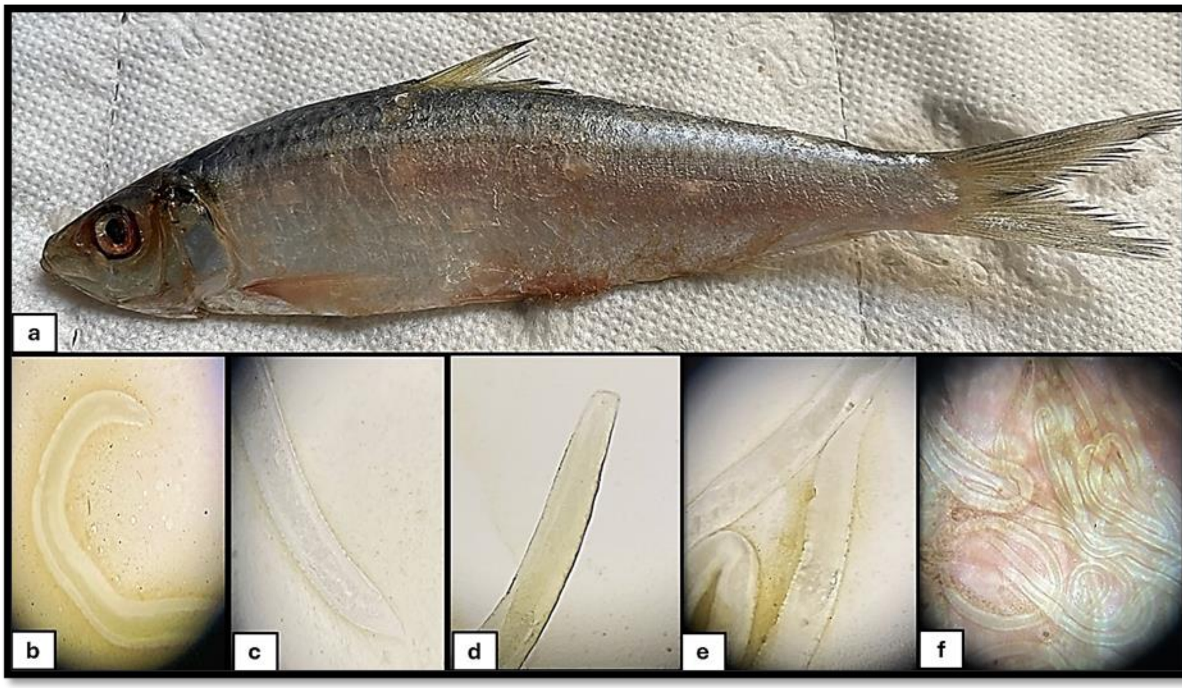

PLATE II. Parasitic identification in infested *Sardinella gibbosa*:
(a) *Sardinella gibbosa* fish showing hemorrhage on the abdominal side and in the eyes;
(b and c) *Anisakis* nematode adult worm with a posterior pointed tail and segmented transverse annulations (40x magnification);
(d) *Anisakis* nematode adult worm, anterior head region with visible digestive tract (40x magnification);
(e) *Anisakis* nematode adult worms showing distinct segmented transverse annulations (40x magnification);
(f) Heavy infestations of both *Anisakis* adult and larval stages inside the intestine of *S. gibbosa* (10x magnification)

4. Scanning electron microscope findings (SEM)

A scanning electron microscopy was used to confirm the morphological identification of *Anisakis* nematodes (PLATE III). Due to processing limitations, the trematodes could not be photographed. However, the *Anisakis* nematodes were successfully prepared and photographed, showing the following characteristics: the adult worms have a head located anteriorly with well-defined mouthparts. The body is cylindrical with transverse annulations, and the tail region features an anus and a cactus-shaped tail, a characteristic observed in adult males, but not in females.

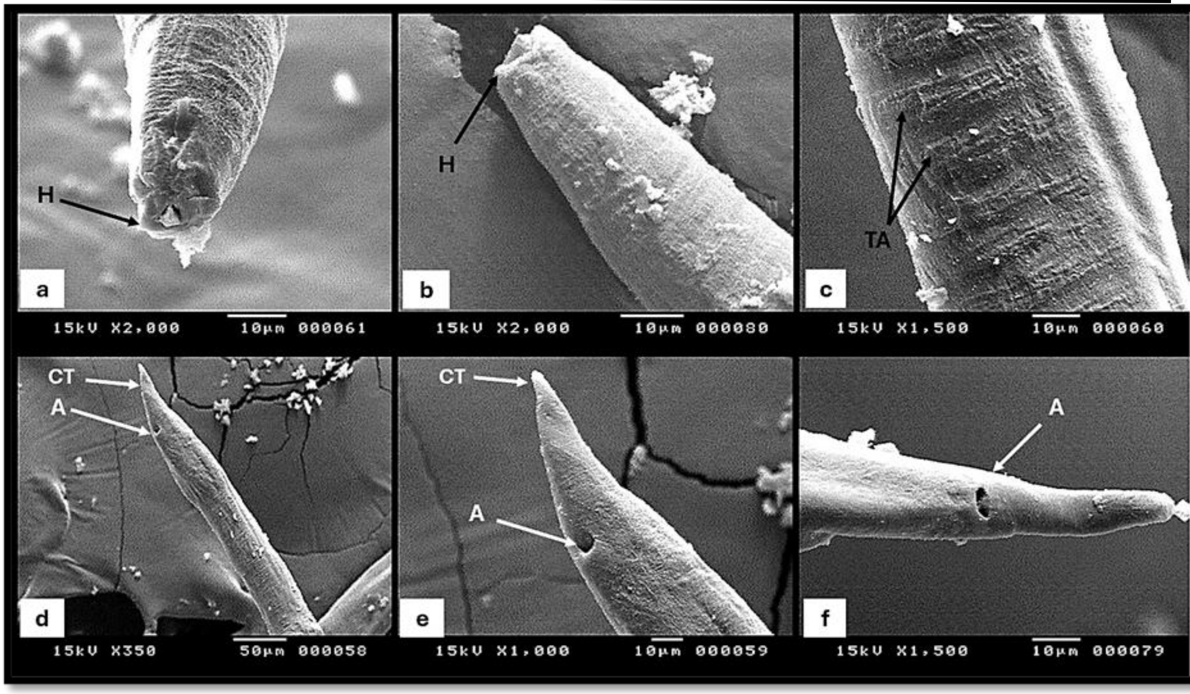

PLATE III. Scanning electron microscopy of adult *Anisakis* nematode:
(a and b) Adult *Anisakis* nematode isolated from *Sardinella gibbosa*, showing the head (H) with mouthparts (10µm);
(c) Middle region of the *Anisakis* nematode with visible transverse annulations (TA) (10µm);
(d, e, and f) Tail region with anus (A) and cactus-shaped tail (CA) (10 and 50µm)

DISCUSSION

The findings in this study highlight the presence of mixed metazoan parasitic infestations in two marine species, *Rastrelliger kanagurta* (Indian mackerel) and *Sardinella gibbosa* (sardine), which were found to harbor both trematodes and nematodes. Previous studies on these species have been limited, and a comparative analysis of the findings can provide valuable insights into parasitic infestations in these fish species.

R. kanagurta, a significant and affordable food source in Egypt, has been shown to suffer from various parasitic diseases, including bacterial and fungal infections, which pose health risks to consumers **(Mahdy *et al.*, 2022)**. The present study identified two species of digenetic trematodes (*Prodistomum orientalis* and *Opechona bacillaris*) along with *Anisakis* nematode larvae, which were found in the pyloric caeca of the host. These findings align with earlier studies, such as those by **Rokkam and Lakshmi (2011)**, who documented *Opechona bacillaris* and other parasitic species in *R. kanagurta*. Moreover, **Al-Zubaidy and Mhaisen (2014)** reported four trematode species infecting *R. kanagurta* from the Red Sea coastal waters of Yemen, including *Prodistomum orientalis*, *Opechona bacillaris*, and others.

R. kanagurta is a planktonivorous species during its juvenile stage, feeding mainly on zooplankton and phytoplankton. However, as the fish matures, it becomes a macroplanktonic feeder, consuming smaller fish and crustaceans **(Madhavi & Triveni, 2012)**. The presence of *Anisakis* larvae in the pyloric caeca further corroborates earlier findings of **Setyobudi *et al.* (2019)**, who reported a 47.2% prevalence of *Anisakis* larvae in *Rastrelliger* species from Indonesia, as well as the outcomes of **Chaiphongpachara *et al.* (2022)**, who identified *Anisakis* nematodes from *R. kanagurta* in the Gulf of Thailand.

The *Anisakis* genus, specifically *Anisakis* larvae, is notorious for causing anisakiasis in humans, a parasitic disease linked to the consumption of raw or undercooked fish **(Pravettoni *et al.*, 2012)**. Symptoms of anisakiasis include acute to chronic allergic responses such as diarrhea, nausea, vomiting, abdominal pain, and tissue destruction caused by the larvae's movement through the host's body **(Bouree *et al.*, 1995)**. The spread of *Anisakis* spp. is influenced by various environmental factors, including climate change, water circulation, salinity, and host migratory behavior, and they serve as important biological indicators in marine ecosystems **(Ángeles-Hernández *et al.*, 2020)**.

Parasitic infestations in the *Clupeidae* family, particularly in sardines, have also been reported in other studies. For instance, **Rijn *et al.* (2020)** identified *Clavellisa ilishae* copepods from *Sardinella longiceps* along the Cochin and Malabar coasts of India. Furthermore, **Rameshkumar and Ravichandran (2015)** reported the presence of external isopods, *Norileca triangulata*, attached to the gills of *Sardinella gibbosa* from the Parangipettai coast of India, with a prevalence of 7.5%.

In conclusion, this study provides valuable information on the parasitic infestations of *R. kanagurta* and *S. gibbosa*, highlighting the diversity of parasites affecting these species. The findings underscore the need for continued research on parasitic infections in marine species, particularly those consumed by humans, to better understand the potential health risks and ecological impacts associated with these parasites.

CONCLUSION

Marine fish species can be infested by single or multiple parasitic species. In this study, *Rastrelliger kanagurta* was found to be infested by two trematode species, *Prodistomum orientalis* and *Opechona bacillaris*, as well as the larval nematode *Anisakis sp.*, with a total prevalence of 77.5%. On the other hand, *Sardinella gibbosa* exhibited parasitic infestations limited to *Anisakis sp.* nematodes, both adult and larval stages, with a total prevalence of 65%. This study represents the first investigation of parasitic infestations in marine fish species from the Suez Gulf region of Egypt, providing essential baseline data. It will serve as a foundational reference for future studies focusing on the parasitological effects on host health, human health implications in Egypt, and the broader ecosystem of the region.

REFERENCES

Al-Zubaidy, A.B. and **Mhaisen, F.T. (2014).** Four new records of trematodes from the Indian mackerel *Rastrelliger kanagurta* (Cuvier, 1816) from the Yemeni coastal waters of the Red Sea. *Am. J. Life Sci.,* **2**: 141-145.

Amin, A.M.; Sabrah, M.M. and **El-Ganainy, A. A. (2015).** Population structure of indian mackerel, *Rastrelliger kanagurta* (Cuvier, 1816), from the Suez Bay, Gulf of Suez, Egypt. *Int. J. Fish. Aquat. studies,* **3**(1): 68-74.

Ángeles-Hernández, J.C.; Gómez-de Anda, F.R.; Reyes-Rodríguez, N.E.; Vega-Sánchez, V.; García-Reyna, P.B.; Campos-Montiel, R.G.; Calderón-Apodaca, N.L.; Salgado-Miranda, C. and **Zepeda-Velázquez, A.P. (2020).** Genera and species of the Anisakidae Family and their geographical distribution. *Animals*, **10**(12): doi:https://doi.org/10.3390/ani10122374

Bouree, P.; Paugam, A. and **Petithory, J.C. (1995).** Anisakidosis: Report of 25 cases and review of the literature. *Comparative Immunology, Microbiology and Infectious Diseases,* **18**(2): 75-84. doi: https://doi.org/10.1016/0147-9571(95)98848-C

Bozzola, J. (1999). Electron Microscopy: Principles and Techniques for Biologists, Vol. 670, Jones and Bartlett Publishers.

Bray, R. and **Justine, J.L. (2012).** A review of the Lepocreadiidae (Digenea, Lepocreadioidea) from fishes of the waters around New Caledonia. *Acta parasitologica / Witold Stefański Institute of Parasitology, Warszawa, Poland*, **57**: 247-272. doi: 10.2478/s11686-012-0039-0

Brunet, J.; Pesson, B.; Royant, M.; Lemoine, J.P.; Pfaff, A.W.; Abou-Bacar, A.; Yera, H.; Fréalle, E.; Dupouy-Camet, J.; Merino-Espinosa, G.; Gómez-Mateos, M.; Martin-Sanchez, J. and **Candolfi, E. (2017).** Molecular diagnosis of Pseudoterranova decipiens s.s in human, France. *BMC Infectious Diseases,* **17**(1): 397. doi: https://doi.org/10.1186/s12879-017-2493-7

Chaiphongpachara, T.; Adisakwattana, P. and **Suwandittakul, N. (2022).** Intraspecific genetic variation of *Anisakis typica* in Indian mackerel caught from the Gulf of Thailand, Samut Songkhram Province. *Sci. World J.,* **2022**(1): 2122619. doi: https://doi.org/10.1155/2022/2122619

Colwell, M.A.; Hurley, S.J.; Hall, J.N. and **Dinsmore, S.J. (2007).** Age-related survival and behavior of snowy plover chicks. *The Condor,* **109**(3): 638-647. doi: https://doi.org/10.1093/condor/109.3.638

Diaz Briz, L.M.; Martorelli, S.R.; Genzano, G.N. and **Mianzan, H.W. (2012).** Parasitism (Trematoda, Digenea) in medusae from the southwestern Atlantic Ocean: medusa hosts, parasite prevalences, and ecological implications. In: J. Purcell, H. Mianzan & J. R. Frost (Eds.), Jellyfish Blooms IV: Interactions with humans and fisheries (pp. 215-226). Dordrecht: Springer Netherlands, doi: https://doi.org/10.1007/978-94-007-5316-7_17

El-Betar, A.T. and **Osman, M.H. (2021).** Population structure of *Sardinella gibbosa* (Bleeker, 1849) with special reference to spawning ground in the Gulf of Suez, Egypt. *Egypt. J. Aquat. Biol. Fish.*, **25**(3): 353-365. doi: 10.21608/ejabf.2021.175579

Farghal, K.T.; Abou Zaid, M.M. and **Fouda, M.M. (2021).** Abundance, diversity, and distribution of coral reef fish families in the Egyptian Red Sea, at Hurghada, Egypt. *Egypt. J. Aquat. Biol. Fish.*, **25**(1): 541-554. doi: https://ejabf.journals.ekb.eg/article_147328.html

GAFRD (2017). General Authority for Fishery Resources Development, Ministry of Agriculture, Egypt. Annual report, Fish pro. Stat. Egypt.

Gibson, D.I.; Jones, A. and **Bray, R.A. (2002).** Keys to the Trematoda: Volume 1: CABI publishing.

Hoffman, G.L. (2019). Parasites of North American freshwater fishes: Cornell University Press.

Ivanović, J.; Baltić, M.Ž.; Bošković, M.; Kilibarda, N.; Dokmanović, M.; Marković, R.; Janjić, J. and **Baltić, B. (2017).** Anisakis allergy in human. *Trends Food Sci. &Tech.*, **59**: 25-29. doi: https://doi.org/10.1016/j.tifs.2016.11.006

Li, D.; Li, X.; Wang, Q. and **Hao, Y. (2022).** Advanced techniques for the intelligent diagnosis of fish diseases: A Review. *Animals*, **12**(21). doi: https://doi.org/10.3390/ani12212938

Looss, A. and **Cuffey, E. (1907).** Some parasites in the museum of the school of tropical medicine, Liverpool. *Ann. Trop. Med. Parasitol.*, **1**(1-5): 122-157. doi: https://doi.org/10.1080/00034983.1907.11719254

Lymbery, A.J. and **Cheah, F.Y. (2007).** Anisakid Nematodes and Anisakiasis. In: K.D. Murrell & B. Fried (Eds.), Food-Borne Parasitic Zoonoses: Fish and Plant-Borne Parasites (pp. 185-207). Boston, MA: Springer US, doi: https://doi.org/10.1007/978-0-387-71358-8_5

Madhavi, R. and **Triveni, L.T. (2012).** Community ecology of the metazoan parasites of the Indian mackerel *Rastrelliger kanagurta* (Scombridae) from the coast of Visakhapatnam, Bay of Bengal. *J. Parasit Dis.*, **36**(2): 165-170. doi: 10.1007/s12639-012-0097-0

Mahdy, O.A.; Abdelsalam, M.; Abdel-Maogood, S.Z.; Shaalan, M. and **Salem, M.A. (2022).** First genetic confirmation of Clinostomidae metacercariae infection in *Oreochromis niloticus* in Egypt. *Aquaculture Research*, **53**(1): 199-207. doi: https://doi.org/10.1111/are.15565

Nashaat, M.; Sabrah, M.M.; Shaaban, A.M.; Osman, H.M.; Geneid, Y.A. and **AbouElmaaty, E.E. (2023).** Morphological and SEM identification for mixed parasitic infestations in *Nemipterus japonicus* from the Western Gulf of Suez, Red Sea, Egypt. *Egypt. J. Aquat. Res.*, **49**(1): 67-73. doi: https://doi.org/10.1016/j.ejar.2022.10.004

Noga, E.J. (2010). Fish Disease: Diagnosis and Treatment: John Wiley & Sons.

Park, C.W.; Kim, J.S.; Joo, H.S. and **Kim, J. (2009).** A human case of *Clinostomum complanatum* infection in Korea. *Korean J Parasitol,* **47**(4): 401-404. doi: 10.3347/kjp.2009.47.4.401

Pravettoni, V.; Primavesi, L. and **Piantanida, M. (2012).** *Anisakis simplex*: current knowledge. *European Annals of Allergy and Clinical Immunology,* **44**(4): 150-156.

Rameshkumar, G. and **Ravichandran, S. (2010).** New host record, *Rastrelliger kanagurta*, for *Nerocila phaeopleura* parasites (Crustacea, Isopoda, Cymothoidae). *Middle East Journal of Scientific Research,* **5**(1): 54–56.

Rameshkumar, G. and **Ravichandran, S. (2015).** First occurrence of *Norileca triangulata* (Crustacea: Isopoda: Cymothoidae) from Indian marine fishes. *J. Parasit. Dis.,* **39**(1): 33-36. doi: https://doi.org/10.1007/s12639-013-0274-9

Ramudu, K. and **Rathod, J.L. (2023).** A temporal analysis of parasitic infections in Indian mackerel, *Rastrelliger kanagurta* (Cuvier, 1817) along the Western Coast of Karwar Bay, Karnataka: Employing a monthly assessment with histopathology. *J. Adv. Zoo.,* **44**: 465-472. doi: 10.17762/jaz.v44i3.497

Rijin, K.; Amruthavani, S.; Reshmi, M.; Drisya, O. and **Kappalli, S. (2020).** Copepod (Crustacea) infection on oil sardine, *Sardinella longiceps* Valenciennes, 1847 (Actinopterygii; Clupeidae)-First report. *Indian J. Geo-Mar. Sci.,* **49**(5): 911-914.

Rokkam, M. and **Lakshmi, T. (2011).** Metazoan parasites of the Indian mackerel, *Rastrelliger kanagurta* (Scombridae) of Visakhapatnam coast, Bay of Bengal. *J. Parasit. Dis.,* **35**: 66-74. doi: 10.1007/s12639-011-0028-5

Sethi, S.; Jithendran, K. and **Kannappan, S. (2013).** Co-infection of yellowtip halfbeak fish (*Hemiramphus marginatus*) with isopod and copepod parasites from the Coromandal Coast, India. *Fishery Technology,* **50**: 357-360. doi: http://eprints.cmfri.org.in/id/eprint/9641

Setyobudi, E.; Rohmah, I.; Syarifah, R.F.; Ramatia, L.; Murwantoko, M. and **Sari, D.W.K. (2019).** Presence of *Anisakis* nematode larvae in Indian mackerel (*Rastrelliger* spp.) along the Indian Ocean southern coast of East Java, Indonesia. *Biodiversitas J. Bio. Div.,* **20**(1): 313-319. doi: https://doi.org/10.13057/biodiv/d200136

Stern, N. and **Goren, M. (2015).** First record of the goldstripe sardinella (*Sardinella gibbosa* (Bleeker, 1849)) in the Mediterranean and reconfirmation for its presence in the Red Sea. *BioInvasions Records,* **4**: doi: 10.3391/bir.2015.4.1.08

Swiderski, Z. and **Georgiev, B. (2009).** Keys to the Trematoda. volume 3 (eds. R.A. Bray, D.I. Gibson and A. Jones) CABI Publishing, Wallingford, UK and the Natural History Museum, London, 824 pp. doi: 10.2478/s11686-009-0021-7.