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To cite this article: T F S Muji *et al* 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **934** 012081

Prevalence of Cymothoidae (Isopoda) Infestation in Bigeye Scad (*Selar crumenophtalmus*) from Batangas, Philippines

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Abstract. Cymothoid isopod research is relatively scarce in the Philippines, despite the local economic significance of bigeye scad as an inexpensive source of protein and other nutrients. Isopod parasitism has also been shown to have detrimental effects on their fish hosts. The current study aimed to define the host-parasite relationship between cymothoid isopod and bigeye scad by determining cymothoid isopod prevalence, intensity, and host-parasite length correlations in bigeye scad (*Selar crumenophthalmus*) hosts sourced from Batangas, Philippines. Fish samples were sampled from the Tagaytay City Market in Cavite, which sources fish directly from Batangas. Fish samples were immediately measured and inspected for isopods in the branchial and buccal cavities. Isopods found were extracted, measured, and preserved in ethanol for identification. The isopods were identified as cymothoid isopods and consisted mostly of *Norileca indica* specimens and one *Glossobius impressus*. Prevalence and mean intensity of cymothoid isopod infections in bigeye scad were 30% and 1.6, respectively. A possible correlation between isopod size and host size was speculated for non-ovigerous female isopods, but data for male and ovigerous female isopod specimens were inconclusive. The host-parasite size relationships between bigeye scad and isopods are less likely based on body size of either the host or the parasite and are more likely based on other factors such as host cavity size.

1. Introduction

Cymothoid isopods have been known to infect various kinds of fish, including the bigeye scad *Selar crumenophthalmus*. A small pelagic fish belonging in the family Carangidae, the bigeye scad has a wide distribution across tropical and subtropical waters [1]. It is a major source of food for predators in higher trophic levels and for humans as an inexpensive source of protein, especially for families with low socioeconomic status [2]. The bigeye scad is the third most produced commercial and marine fish in the country with more than 110,000 metric tons of the fish produced in 2018 [3]. Moreover, the value of bigeye scad production from both marine and commercial fishing exceeded 164.5 million USD in 2018, highlighting its importance in the economy. Of the provinces in Region IV-A, Batangas had the highest production with 743 metric tons of bigeye scad in 2018 [3]. The agriculture industry, which includes both farmers and fishermen, is the second biggest in the Philippines after the service industry. As of April 2020, 14.1% of employed people work in the agriculture industry, which is equivalent to almost five million people [4]. This shows its major role in the livelihood of Filipinos.

The family Cymothoidae parasitizes Elasmobranchii and Actinopterygii [5, 6]. The parasite drains nutrients from the host's haemolymph and blood [7]. There have been reports of a direct relationship

between parasite and host sizes [8], but it is the space in the host cavity for the parasite to grow that determines parasite size. Although the size of female isopods tends to correlate with host size, this is due to the female isopod infecting its host early so it could grow and prepare for reproduction [8]. On the other hand, variation in cymothoid prevalence [9, 10] depends on the month of the year or the season. The differences in parasite prevalence are attributed to the breeding season of the host fish. Moreover, isopod distribution is also affected by host population [10].

Parasitic isopod infestations have caused great damage to fisheries and aquaculture industries by reducing growth of many marine species [11]. Despite being a major threat to the fishing industry, there is only a small number of studies on the infection of cymothoid isopods in bigeye scads in the Philippines. Most recently, the first record of *N. indica* in bigeye scad has been reported [12]. The parasites were found in the branchial cavities of the fish; and a correlation was found between the length of the parasite and its non-ovigerous female and male hosts. Although other studies have also reported Cymothoidae infection in the Philippines, none were observed in bigeye scad and more importantly, the studies are outdated [13–15]. Since the fishing industry is a significant part of the Philippine economy, it is important to determine the scope of infection of these isopods in local waters. Hence, the aim of the present study was to determine cymothoid isopod prevalence, intensity, and host-parasite length correlations in Batangas-sourced bigeye scad hosts.

2. Materials and Methods

2.1. Sample collection

Sample collection and preparation was done over the course of a five-week collection period. Ten freshly caught bigeye scads were purchased weekly from the Tagaytay City Market, Santa Rosa Road, Barangay Francisco, Tagaytay City, Cavite, where freshly caught fish from Batangas fishermen were sourced. Convenience sampling method was employed. A total of 50 bigeye scad samples were collected [12], divided into five weekly sample sets (each designated labels according to date/s of purchase) of ten bigeye scads. Each bigeye scad was measured in length (mm) and designated an appropriate label. Each bigeye scad was then dissected to reveal buccal and branchial cavities which were examined for the presence of isopods.

Each isopod found was extracted with fine forceps, measured in length (mm), and designated a label based on the fish in which it was found. The isopods were preserved in individual vials filled with 70% ethanol and labelled accordingly. Each isopod was examined under a 25x magnification setup. The dorsal and ventral sides of each isopod were photo-documented.

Genera/species and sex (i.e., non-ovigerous female, NOF; ovigerous female, OF; male, M) of the isopods were individually determined with a dichotomous key [16].

2.2. Data analysis

After each isopod had been identified to the genus/species level and its sex determined, separate prevalence and mean intensity calculations were employed. The following were obtained: tally of isopods per fish (i.e., OF, NOF, M, and total number) based on the number of measurements recorded; mean lengths per sex of each isopod both per individual bigeye scad in which they were found and per sample set; and number of infected fish per sample set. Prevalence and mean intensity per genera were calculated for each sample set and for all samples. Prevalence and mean intensity of the cymothoid isopods were calculated using equations (1) and (2), respectively [17].

$$\textit{Prevalence} = (\textit{number of infected fish}/\textit{total number of fish}) \times 100\% \quad (1)$$

$$\textit{Mean intensity} = (\textit{total number of parasites}/\textit{total number of infected fish}) \quad (2)$$

The lengths of each sample set of fish and isopods (per sex) were plotted to observe for any correlations between host length and isopod length, which could suggest possible host-parasite growth relationships [12].

3. Results and Discussion

Fifty specimens of *S. crumenophthalmus* were collected and measured in five separate collection weeks. The lengths of bigeye scad samples ranged from 172 to 225 (202 ± 14) mm. A total of 25 isopods were found in the branchial and buccal cavities of 15 out of the 50 different specimens of bigeye scad.

The isopods were determined as cymothoid using the dichotomous key and identified up to the species level due to the clarity of detail of the key and the relatively stark distinctions between cymothoid genera. Isopods were analyzed per species level. Of the 25 isopods collected, three were OF, 11 were NOF, and 11 were M. Twenty-four isopods in the branchial cavities were identified as *Norileca indica*. One isopod in the buccal cavity was identified as *Glossobius impressus.* Cymothoid prevalence and mean intensity were calculated at 30% and 1.6, respectively.

The lengths of the 11 NOF and three OF isopods ranged from 21 to 33 (28 ± 4.4) mm and 20 to 26 (23 ± 3) mm, respectively. Female specimens were typically accompanied by the male counterpart of the species or were not accompanied at all, except for the unexpected occurrence of both *N. indica* and *G. impressus* females in one bigeye scad. The OF were distinguished from NOF by eggs or larvae inside the marsupia of the OF, although OF were found smaller than NOF (figure 1).

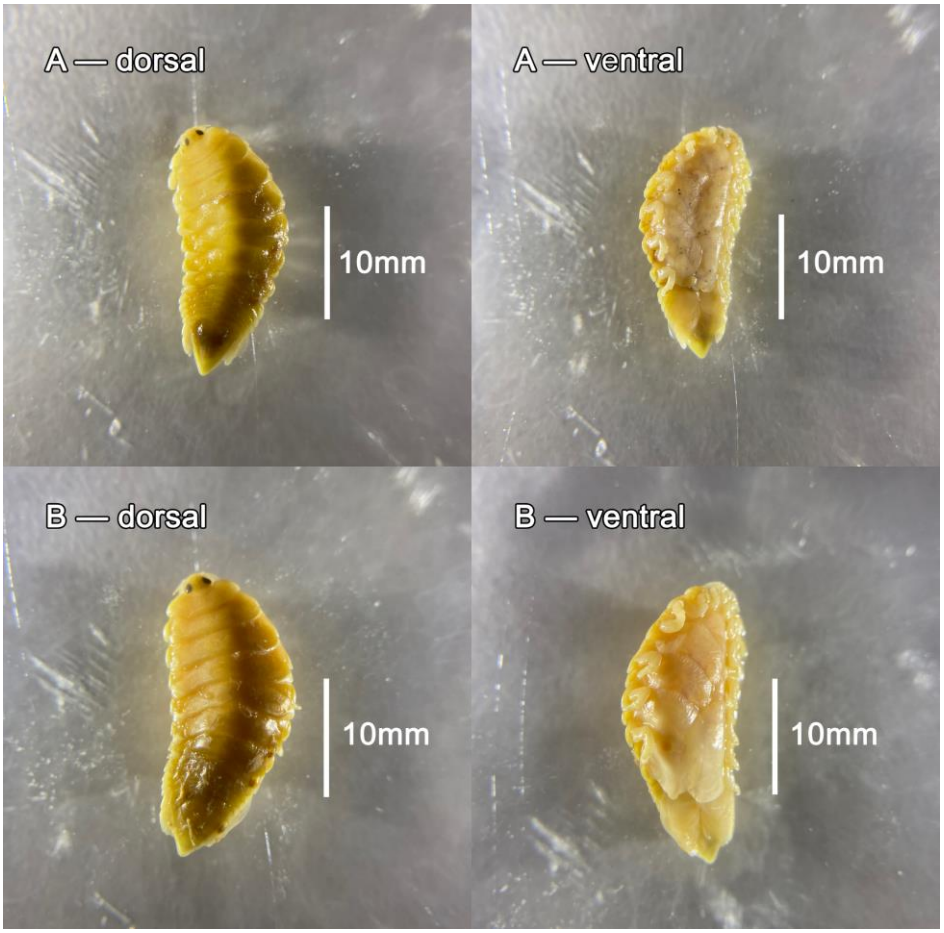

Figure 1. These are ovigerous (A) and non-ovigerous (B) female specimens of *N. indica* under 25x magnification.

The lengths of the 11 M isopods ranged from 12 to 17 (14 ± 1.7) mm. Male specimens were narrower, smaller, and symmetrical than female isopods (figure 2). Males always accompanied female isopods or were otherwise not present.

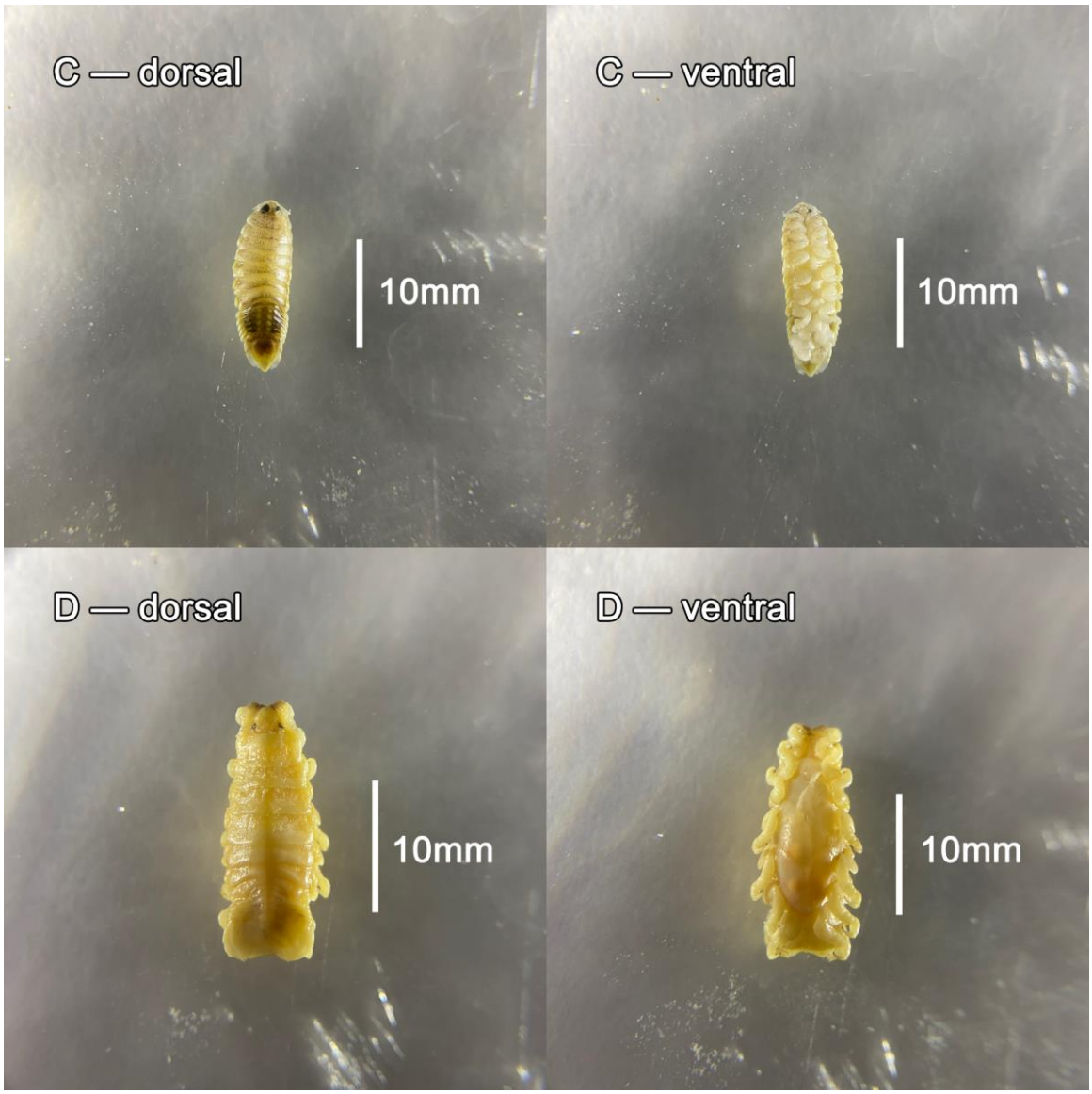

Figure 2. These are a male specimen of *N. indica* (C) and an ovigerous female specimen of *G. impressus* (D) under 25x magnification.

The collected *G. impressus* specimen was an OF measuring 20 mm in length. The *G. impressus* specimen was smaller, symmetrical, and less ovate when viewed dorsally compared to the female *N. indica* specimens.

All 10 bigeye scad samples from the third collection batch were infected with isopods, compared to only five out of 10 infected samples from the fifth collection batch. Female isopods from the fifth batch were larger than those of the third batch. All female specimens from the fifth batch were also found to be non-ovigerous.

There was a strong positive exponential correlation between NOF isopod and fish lengths. The M isopod length also showed a moderate positive parabolic correlation. There was no correlation between OF isopod and fish lengths due to scarcity in data. Overall, there was no correlation between isopod and bigeye scad lengths (figure 3).

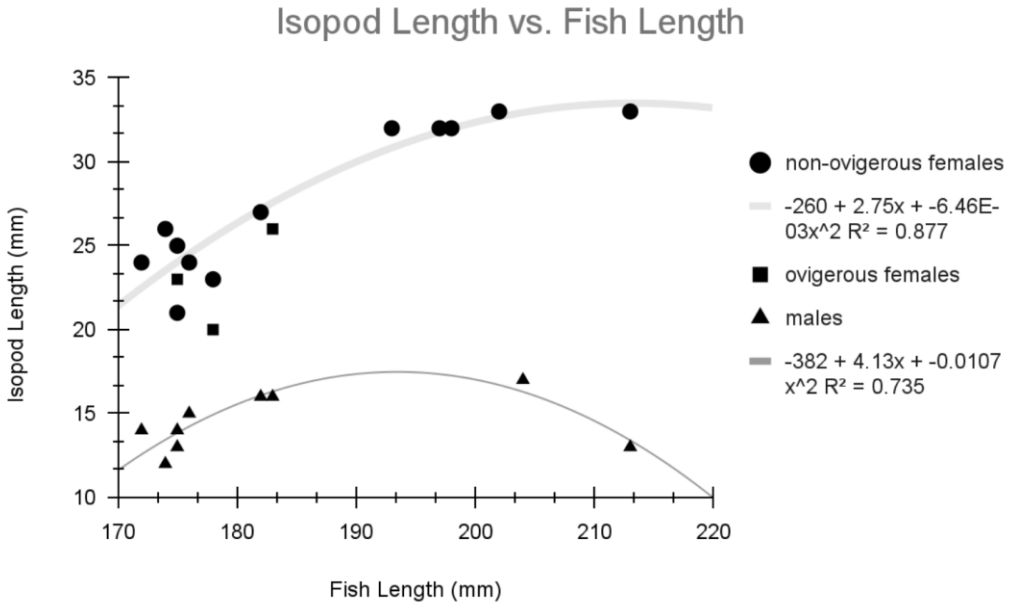

Figure 3. Correlations between bigeye scad and isopod lengths are shown here

To date, only one study has investigated the prevalence and mean intensity of *N. indica* infection in *S. crumenophthalmus* in the Philippines. There are, however, several other studies that have been conducted in neighbouring Southeast Asian countries [9, 12, 18–21]. In Iloilo, Philippines, a total prevalence of 40.7% and mean intensity of 10.5 from 81 total specimens of bigeye scad were calculated [12]. On the contrary, the present study calculated a lower prevalence of 30% and lower mean intensity of 1.6. Studies from other Southeast Asian countries showed varied prevalence and mean intensity, ranging from 1.64 to 85% and 1 to 1.6, respectively. Several studies have not included the number of infected fish or mean intensity, making it difficult to describe trends between countries beyond prevalence rates.

The differences in prevalence can be attributed to the variability of the populations of cymothoid isopods. Cymothoid populations are irregular [22]. However, the highest diversity of the isopods occurs in the Central Indo-Pacific Region, the area otherwise designated as Southeast Asia. Although cymothoid populations are variable, the breeding seasons of host fish were found to be consistent. Isopod prevalence rates are affected by the breeding season of host fish [10]. *Rastrelliger kanagurta*, the host fish of *N. indica*, breeds during the monsoon months from May to July. This caused the highest prevalence rates recorded in August since there was an increase in host population. The spawning season of bigeye scad was found to occur between April and September [23]. In the present study, the highest number of fish infected with isopods was from the third sample collection in September with a total of 18 isopods collected from 10 bigeye scad. Since the spawning season had already taken place during the time of the study, the increased host populations in September most likely provided the isopods greater chance to infect more fish. In another study, samples were collected in October, with juvenile recruitment to have taken place already, causing a greater increase in host population compared to that in September [18].

Host populations and its breeding season are not the only factors that can affect isopod prevalence. Aside from host populations, depth and movements of water were identified as abiotic factors that affect isopod prevalence [24]. Specifically, some isopods prefer shallower depths of water compared to others, while the flow rate of water affects binding strategies of the isopods to their hosts. Moreover, weather conditions can indirectly affect parasite prevalence since rains and flooding can both influence depth and movements of water. Unfortunately, since the specimens of bigeye scad were

sourced from the market and not directly from the port, it was not possible to include and analyze abiotic factors.

In terms of size relationships, a relatively strong positive exponential correlation between NOF isopod length and bigeye scad length is suggested. This indicates that as the length of fish increases, the length of the isopod increases at an exponentially decreasing rate up to a certain extent. The M isopod length, on the other hand, suggests a moderate positive parabolic correlation. Additionally, the OF length against fish length had three non-linear data points only, making it difficult to determine and conclude any type of correlation. While a positive correlation between isopod length and fish length has been observed in several studies, such is not immediately indicative of causation. Thus, cymothoid isopods do not choose their hosts based on size [8].

Overall, the lack of a correlation between isopod length and fish length is also evident in how the data points of the same sex have a relatively wide horizontal spread with little vertical spread in relation to each other. In terms of the affected cavity location in respective bigeye scad hosts, there also seemed to be no trend in relation to sex or length. The isopods choose their hosts based on space availability in the branchial cavity and therefore grow with the host [8].

4. Conclusion

A possible correlation between isopod size and host size was speculated for non-ovigerous female isopods, but data for male and ovigerous female isopod specimens were inconclusive. The host-parasite size relationships between bigeye scad and isopods are less likely based on body size of either the host or the parasite and are more likely based on other factors such as host cavity size.

Acknowledgments

J A Ragaza would like to acknowledge and thank Dr. Kharleezelle J. Moendeg for officially acting as the adviser of T F S Muji and J R Sorreta during her sabbatical leave. T F S Muji and J R Sorreta are grateful to Ms. Melchor "Aling Choy" Capacia for providing the bigeye scad samples for sale in the Tagaytay City Market.

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