IOP Conference Series: Earth and Environmental Science

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To cite this article: A Heirina *et al* 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **744** 012026

Ectoparasites of blue swimming crabs (*Portunus pelagicus*) from Demak and East Lampung, Java Sea Indonesia

A Heirina[1,*], M Krisanti[2], N A Butet[2], Y Wardiatno[2,4], S Köpper[6], A A Hakim[2] and S Kleinertz[3,5,*]

[1] Graduate Student of the Department of Aquatic Resources Management, Faculty of Fisheries and Marine Sciences, IPB University (Bogor Agricultural University), Jl. Agatis, Kampus IPB Dramaga, Bogor 16680, Indonesia
[2] Department of Aquatic Resources Management, Faculty of Fisheries and Marine Sciences, IPB University (Bogor Agricultural University), Jl. Agatis, Kampus IPB Dramaga, Bogor 16680, Indonesia
[3] Faculty of Fisheries and Marine Sciences, IPB University (Bogor Agricultural University), Bogor, Indonesia, Jl. Agatis Kampus IPB Dramaga, Bogor, Indonesia
[4] Environmental Research Center, IPB University, Kampus IPB Dramaga, Bogor 16680, Indonesia
[5] Aquaculture and Sea-Ranching, Faculty of Agriculture and Environmental Sciences, University of Rostock, Justus-von-Liebig-Weg 2, 18059 Rostock, Germany
[6] University of Prince Edward Island, Atlantic Veterinary College, Canada

*Corresponding author: aheirina25@gmail.com, sonja.kleinertz@uni-rostock.de

Abstract. Ectoparasites that infest *Portunus pelagicus* can have negative impacts on host health. This study aims to determine the infection patterns of ectoparasites of *P. pelagicus*, such as prevalences, intensities, and (mean) abundances in relation to its pathogenic impacts. A total of 93 crabs were sampled from fishermen in Demak and East Lampung from October 2019 to January 2020. Seven ectoparasite species, *Chelonibia testudinaria* (Crustacea), *Dianajonesia tridens* (Crustacea), *Octolasmis angulata, O. lowei, O. warwicki* (Crustacea), *Ostrea puelchana* (Mollusca) and *Thompsonia* sp. (Crustacea) were isolated. In Demak the ectoparasite with the highest prevalence was *O. angulata* of 81% with an intensity of 315. In East Lampung, *C. testudinaria* had the highest prevalence of 88% but with low intensity of 62. Both parasite species can have health impacts on their host, such as enhanced vulnerability to predators for *C. testudinaria* or reduced oxygen uptake for *O. angulata*. A total of 20,540 specimens of *Thompsonia* sp. were found within the East Lampung samples. This species can have a negative effect on their host's reproduction system. In the future, this knowledge will support enhanced sustainable use of this commercially important crab species and will increase our understanding of health impacts of ectoparasites on *P. pelagicus*.

Keywords: crustacean fisheries; crustacean health impacts; host-parasite interactions; *Octolasmis* spp.

1. Introduction

Parasites are ubiquitous components of the marine biodiversity that not only affect individual hosts, populations and communities, but can also play an important role in ecosystem functions and food web dynamics [1]. Host-parasite relationships, in which one partner benefits from the other, are complex and depend upon several factors. Initially, the (ecto) parasite will try to attach itself to the host and susceptibility and resistance of the host will determine whether or not infection will occur. Parasitic infection patterns can be expressed as prevalence, (mean) intensity or (mean) abundance [2, 3]. A factor that influences the abundance of small crabs is the presence or absence of parasites as parasites in blue swimming crabs (*P. pelagicus*) can impact host growth [4], interfere with the respiratory system, such as *Octolasmis* spp., or affect host reproduction, such as for *Sacculina granifera* and *Thompsonia* sp. [4–8].

Blue swimming crabs belong to the Portunidae family, which are widely consumed by humans because of their soft meat and good nutritional contents. They are widely distributed within the Indo-Pacific where they are highly valued for the national economy and export [9–11]. Importantly, Indonesia is one of the main distributors for blue swimming crabs [7, 12–14] and the main export destinations are the United States followed by Japan, the European Union and China. The decline in the crab population can be caused by overfishing as well as by several factors from the aquatic environment, such as physical and chemical factors and the presence of the parasite in or at the crabs [15]. To understand and overcome this problem, it is necessary to conduct research on ectoparasites that infect crabs. The aim of this study was to analyse parasitic infection patterns and their health impacts on blue swimming crabs by identifying and quantifying all present metazoan ectoparasites and analyse the results with regard to sampling location, impacts on crab health and crab fisheries.

2. Methods

2.1. Study area

This research was conducted using crabs from the East Lampung Coast (Labuhan Maringgai) and in Betahwalang, Demak Central Java from October 2019 to January 2020. The parasite identification process was carried out at the Macro Biology Laboratory, Department of Aquatic Resources Management, Faculty of Fisheries and Marine Sciences, Bogor Agricultural University (FPIK-IPB University). Ectoparasites were found on crabs from East Lampung waters mostly within muddy substrates. In Demak waters the crabs were found on sandy clay substrates, exclusively. Especially the study area in East Lampung was in close proximity to sand mining activities [16]. Further studies are needed to confirm or deny the assumption that negative impacts of mining activities on marine habitats could be indicated by using ectoparasite infection patterns.

2.2. Sample collection

Samples of the blue swimming crabs (*P. pelagicus*) were taken by field observation methods from two different locations (figure 1). Blue swimming crab samples (*P. pelagicus*) were obtained from traditional fishermen's catch using traps and gill nets. A total of 93 crab samples, consisting of 43 crab samples from Demak and 50 crab samples from East Lampung, were measured and examined in this study. The crabs were individually stored in single plastic bags at temperatures up to 4°C for transport, the isolated parasites were stored in a microtube containing 96% ethanol as a preservative [17].

2.3. Crab sample examination and measurements

The size, CW (carapace width in mm), ICW (internal carapace width in mm), CL (carapace length in mm), LMEL (left merus length of cheliped in mm), RMEL (right merus length of cheliped in mm) sex, and weight in g, were morphological characteristics of all crabs that were measured (table 1). Then the external parts of the crabs, such as carapace, swimming legs, walking legs, claws, and gills were examined to identify and isolate ectoparasites using a stereomicroscope (Zeiss Stemi DV4). Afterward, the external body parts were transferred to a petri dish filled with physiological NaCl solution (0.9%)

and were examined under the stereomicroscope [18, 19]. The isolated ectoparasites were counted, collected, and stored separately in glass vials containing 96% ethanol [17].

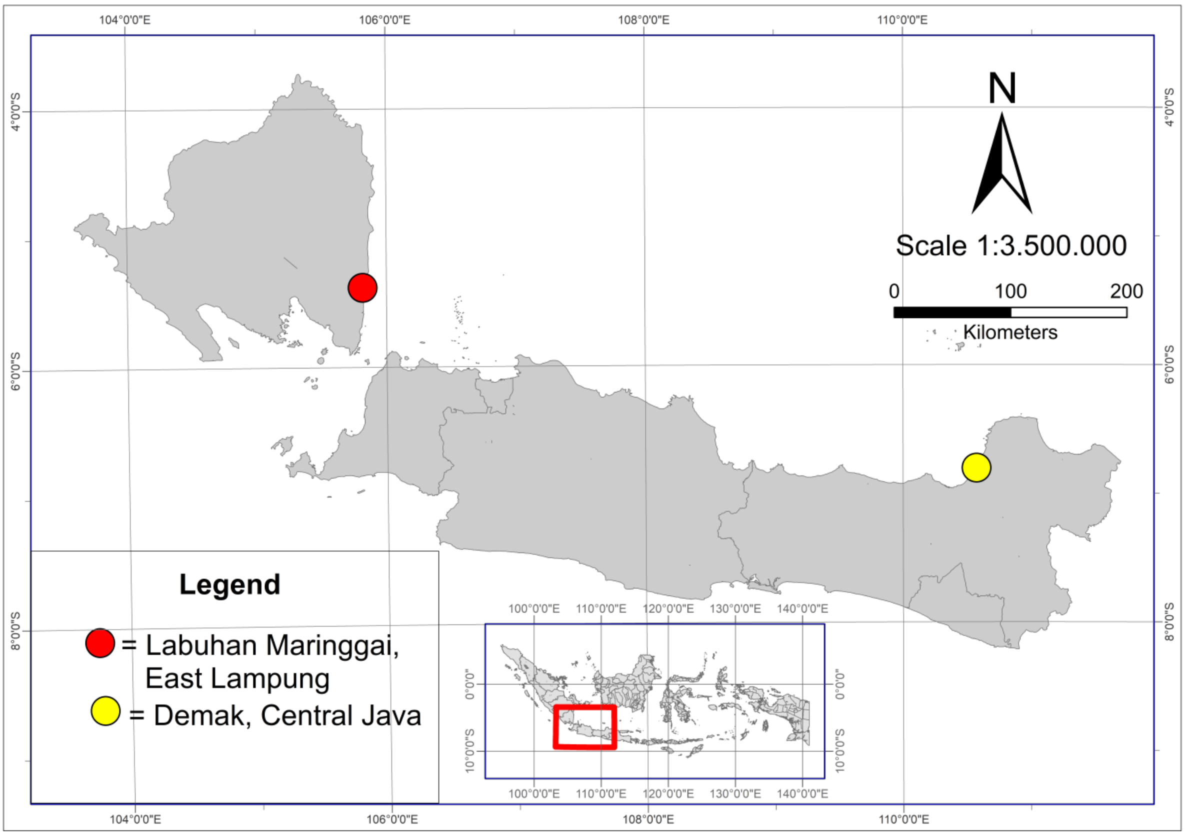

Figure 1. Sampling location (triangles) for examined crabs (*Portunus pelagicus*) from coastal waters of Demak, Central Java and Labuhan Maringgai, East Lampung.

Table 1. Morphological measurements of examined *Portunus pelagicus* from the two locations, including the number of samples (n), males (M), females (F). CL: carapace length in mm, CW: carapace width in mm, ICW: internal carapace width in mm, LMEL: left merus length of cheliped in mm, RMEL: right merus length of cheliped in mm, weights in g.

Locality	n	CL	CW	ICW	LMEL	RMEL	Weight	M	F
Demak	43	50.67 (34–89)	101.00 (74–140)	82.87 (56–116)	35.3 (21–72)	36.4 (21–73)	69.1 (23–183)	17	26
East Lampung	50	50.40 (25–93)	101.31 (10–188)	81.64 (16–162)	32.52 (22–83)	35.23 (22–83)	88.9 (10–397)	30	20

2.4. Data analysis
The calculations of the parasitological parameters, prevalence (P), intensity (I), mean intensity (mI) and mean abundance (mA) followed Bush *et al*. [20].

3. Results and discussion

3.1. Infection patterns
Parasitological indices of ectoparasites infecting blue swimming crabs in Demak and East Lampung are presented in table 2 and table 3, respectively. Seven ectoparasitic crustacean species (*Chelonibia testudinaria* (Linnaeus, 1758), *Dianajonesia tridens* (Aurivillius, 1894), *Octolasmis angulata*

(Aurivillius, 1894), *O. lowei* (Darwin, 1852), *O. warwicki* Gray, 1825, *Octolasmis* sp. (larval), *Thompsonia* sp., (genus *Thompsonia* Kossmann, 1872)) and one bivalve species (*Ostrea puelchana* d'Orbigny, 1842) were isolated (see figure 2). For *Octolasmis* sp. no further identification was possible due to their larval stage. In total 4,823 parasites were isolated from *P. pelagicus* from Demak waters (five taxa: *C. testudinaria*, *D. tridens*, *O. angulata*, *O. lowei*, *O. warwicki* and one unidentified taxa *Octolasmis* sp.) and from Lampung waters 21,430 parasites specimens were isolated (six taxa: *C. testudinaria*, *D. tridens*, *O. angulata*, *O. warickii*, *Os. puelchana* and *Thompsonia* sp.) (see table 2 and 3). The ectoparasite infection patterns in Demak waters were for some isolated parasites lower than those from East Lampung waters, especially in terms of intensity and mean abundance with the highest intensity value of 315 and a mean abundance of 68.88 for *O. angulata*. In East Lampung waters the highest intensity was 137–2740 and the highest mean abundance was 410.8 for *Thompsonia* sp. (see table 2 and table 3). Only the infection with the different *Octolasmis* species shows an adverse pattern, see discussion below.

Table 2. Ectoparasites in blue swimming crabs (*Portunus pelagicus*, n=43) in Demak, Central Java. I: Intensity, mI: mean Intensity, mA: mean Abundance.

Parasites	P (%)	I	mI	mA	Host infection site
Chelonibia testudinaria	49	1–9	3.14	1.53	carapace, abdomen, claws, swimming legs
Dianajonesia tridens	30	1–168	25.69	7.77	gills chamber, mouth parts, carapace, eyes, antenna
Octolasmis angulata	81	1–315	84.63	68.88	gills
Octolasmis lowei	40	1–158	60.12	23.77	gills
Octolasmis warwicki	37	2–87	16.25	6.05	carapace, abdomen
Octolasmis sp.	58	1–43	9.56	5.56	gills

Table 3. Ectoparasites in blue swimming crabs (*Portunus pelagicus*, n=50) in Labuhan Maringgai, East Lampung.

Parasites	P (%)	I	mI	mA	Location in host
Chelonibia testudinaria	88	1–62	9.20	8.10	carapace, abdomen, claws, swimming feet
Dianajonesia tridens	2	5	5.0	0.10	gills chamber
Octolasmis angulata	6	1–33	12.0	0.72	gills
Octolasmis warwicki	2	4	4.0	0.08	abdomen
Ostrea puelchana	52	1–116	16.85	8.76	carapace, claws
Thompsonia sp.	48	137–2740	855.83	410.80	all external body parts

In Demak waters, there were five species of parasites with the highest intensity, for *O. angulata*, with 315 parasites/individual and a prevalence of 81%. *O. angulata* was only found to infect the gills. (see table 2). The ectoparasites that infect *P. pelagicus* in the waters of East Lampung were quite different compared to Demak. The highest prevalence value was found for *C. testudinaria* at 88% in East Lampung waters (see table 3). In East Lampung *Thompsonia* sp. infected *P. pelagicus* with an intensity of 2740 a prevalence of 48% a mean intensity of 855.83 and a mean abundance of 410.80 (see table 3). According to Irvansyah *et al*. [29], the presence of ectoparasites can be affected by stress and poor water quality so that it can reduce the immunity levels of the hosts.

There are 43 species of *Octolasmis* Gray, 1825 within the Pacific, the Atlantic Ocean, and the Indian Ocean [23]. 26 species of *Octolasmis* have been recorded in the South China Sea and they have been found attached to the gills of decapods, sea snakes, and corals [23]. There are ten species of parasites from the genus *Octolasmis* known in Southeast Asia to parasitize other organisms, namely, *O. angulata, O. bullata, O. cor, O. lowei, O. neptuni, O. tridens, O. warwicki* and there are several species that are still unidentified. These ectoparasites were found to infect almost all parts of the gills of *P. pelagicus* [24]. Yap *et al*. [21] argued that morphologically, *O. angulata* larvae have the same body size and lifestyle as *O. cor*, leading to difficulties in morphological identification at this larval stage.

To secure the survival of the individual *Octolasmis* sp. must complete its entire life cycle before the host molts. *Octolasmis* sp. were found to be attached to decapod gills that have a full life cycle occurring at their host gills [22, 23]. In previous studies, four species of *Octolasmis* were also found in *P. pelagicus* which originated from the waters of Kuala Terengganu [8]. Besides that, several previous studies also found the parasite *Octolasmis* sp. which infects several crab species from the genus *Portunus* in various areas, such as the Red Sea, Egypt [25], Moreton Bay, Australia [17], Hailing Bay, South China Sea [26]. This proves the wide zoogeographical distribution of these ectoparasites.

According to Herlinawati *et al*. [27] *Octolasmis* sp. is a parasite that can have an adverse effect on the respective host, such as absorbing nutrients and disrupting the host in the process of respiration. *Octolasmis* colonies that stick to the host for a long time can cause a heavy weight related burden so finally, it can lead to increased host mortalities [26] (isolated parasite species within this study are displayed in figure 2 (*Octolasmis angulata, O. lowei, O. puelchana, O. warwicki*) and figure 3 (*Chelonibia testudinaria, Dianajonesia tridens, Thompsonia* sp.). Within the present study, the above stated four different *Octolasmis* species were revealed. In Demak waters all these four species were found. *O. angulata* reached a prevalence of 81% and an intensity of 1–315 in this location. In contrast, in Lampung waters only two species of this genus were isolated *O. angulata* and *O. warwicki* with much lower prevalences and intensities. There are several studies about *Octolasmis* sp. found in the gills of different crustaceans, such as Palinuridae, Scyllaridae and Portunidae, especially *O. angulata* is known to infect the gills and can inhibit the respiration process and therefore hampers the oxygen uptake of these crustacean hosts [8, 17, 24, 28–30]. Therefore, we expect the health of the crabs from Demak waters to be more impacted by this parasite than those from Lampung waters with an increased risk for mortality of the host.

3.2. Morphological identification and infection sites of the isolated ectoparasites

Morphological identification depends on the shape of the calcareous plate [30, 31]. *O. angulata* has oval calcareous plates. *O. angulata* has a tapered carina, tergum, peduncle, and scutum (see figure 2). Carina coats the internal organs and the tergum serves as the mouth and the scutum as the intestine [24, 29, 32].

O. lowei is often found in crustacean gills and is characterized by a capitular length of 3.29 ± 0.29 mm, five capitular discs, two tergum, two scutum, and one carina (see figure 2) [24]. *O. lowei* are attached to decapod gills and live in shallow waters to a depth of 500 m [23].

O. warwicki Gray, 1825 (invalid name: *O. warwickii*) was found to infect the carapace of the examined blue swimming crabs and several other crustaceans (Portunidae and Calappidae) [33]. Yusa *et al*. (2010) stated that *O. warwicki* can reproduce hermaphroditically. This can be assumed to lead to a higher reproduction rate of these parasites and therefore lead to an increased infection pattern for *O. warwicki*. *O. warwicki* has a larger size compared to the other *Octolasmis* species. *O. warwicki* has a capitular length of 6.06 ± 0.74 mm with five complete capitular discs and has two tergum and two scutum and one carina (see figure 2). *O. warwicki* is commonly found in the exoskeleton of decapods, one of them from the family Portunidae [23, 28, 34].

Chelonibia testudinaria (invalid name: *C. patula*) sticks to the carapace of the crab. It is often found in claws and at the legs of the crab. Pasternak *et al*. [35] suggested that *C. testudinaria* also are attached to various marine organisms including whales and turtles, probably for transport. *C. testudinaria* has a diameter of up to 13 mm. According to Hudson and Lester [36], they reach a diameter of 13 mm and have a smooth, white and cone-shaped skin. High intensities of *C. testudinaria* infection can interfere with the host's ability to swim, resulting in increased vulnerability to predators [36].

Figure 2. Ectoparasites from *Portunus pelagicus*: A) *Octolasmis angulata*, B) *Oc. lowei*, C) *Os. puelchana*, D) *Oc. warwicki*. Ca = carina, Ci = cirri, P = penducle, S = scutum, T = tergum, (scale bars: 1mm each).

Figure 3. Ectoparasites from *Portunus pelagicus*: A) *Chelonibia testudinaria* (habitus with shells), B) *C. testudinaria* (habitus without shells), C) *Dianajonesia tridens,* D) *Thompsonia* sp., (scale bars: 1mm each).

Os. puelchana is an ectosymbiont belonging to the bivalve group which was found attached to *P. pelagicus* from East Lampung with a prevalence of 51% and an intensity of 116. According to Lima *et al*. [37], *Os. puelchana* is capable of living in or at various substrates and organisms, such as mangrove roots, corals, decapods, and other molluscs. The presence of *Os. puelchana* clams attached to the crabs can have a negative impact. Negative impacts are that it reduces host flexibility, affects buoyancy and movement of the host, making it more vulnerable to predators. In the study of Lima *et al*. [37] *Os. puelchana* was found to be attached to *Callinectes exasperates*, but it was demonstrated that *Os. puelchana* does not have a negative impact on these hosts, because it was only attached to about 20% of the carapace so it does not interfere with the movement, flexibility, and function of the host. Within the present study, the coverage of this parasite species was up to 50% of the carapace of the examined blue swimming crabs. This can already start to interfere with the hosts movement and flexibility [37, 47].

In contrast to several other ectoparasitic crustaceans, specimens of the genus *Thompsonia* sp. are very small and usually live in colonies on the host in large numbers. *Thompsonia* sp. are consisting of an evenly rounded, ovoid body, 0.9–1.3 mm long and 0.6–0.8 mm in diameter. All species of *Thompsonia* sp. often reach intensities of several hundred individuals infecting a single host [38, 39] and they infect almost the entire body surface of their hosts [5, 38].

D. tridens was found attached to the gill space, mouth, antennae, and the eye of the crabs (*P. pelagicus*). The same was observed by Jones *et al*. [23]. This crustacean ectoparasite is characterized by an average capitular length of 2.56 ± 0.25 mm with two scutums and a tergum and a carina (see figure 3).

According to Gavriletea [40], several negative environmental impacts are known to occur in areas within proximity of sand mining and exploitation activities. Depending on the mining type the introduction of toxic wastewaters, pollution to streams in general and ecosystem destruction can occur during the mining process, leading to biodiversity losses, soil erosion and water poisoning [40]. This could also have a negative impact on the blue swimming crabs, increasing their susceptibility to pathogens which can result in higher infection rates of ectoparasites, especially for *Thompsonia* sp.

Shields [17] found *C. testudinaria* infested *P. pelagicus* in the waters of Moretan Bay, Singapore with a prevalence value of 21.5%. Key *et al*. [41] also found *C. testudinaria* infesting blue crabs *Callinectes sapidus* with a prevalence of 66.7%. The to-date known health related impacts of the isolated ectoparasites that affect aquatic organisms are presented in table 4.

3.3. Pathogenic impacts of ectoparasites to the blue swimming crabs

All five isolated ectoparasite genera, within the present study, are documented to possibly cause pathogenic impacts to different crustacean hosts, including *P. pelagicus* [5, 6, 8, 26, 29, 36, 37, 39,41–47] (see table 4).

According to Gannon and Wheatly [45] parasites from the genus *Octolasmis* infecting *P. pelagicus's* gills have shown to have a negative impact on respiration in turn affecting the hosts' heart rates. Research done by Khattab [25] found that female *P. pelagicus* were more susceptible to *Octolasmis* ectoparasites. Of the total 180 samples of *P. pelagicus* from the study of Khattab [25], 90% of all isolated ectoparasites were *Octolasmis* with a prevalence of 92%. In this study, *O. angulata* mostly infects gill organs. *O. angulata* are known to usually be attached to the gills of various decapods [23]. *O. warwicki* is generally found on the dorsal side of the carapace of crabs. Infected crabs show changes in host behavior such as reduced molting intervals [26, 33]. As a result, crabs that fail to molt will be consequently more massively infected with ectoparasites like *Octolasmis* spp. which can lead to increased mortalities of the host [26].

According to Wahl and Mark [47], *O. puelchana* can have a negative impact on the host by increasing their weight and friction-reducing host flexibility. The continued growth of *O. puelchana* attached to the host's carapace until adulthood can affect the buoyancy and movement of the host, leading to an increased vulnerability to predators. At the juvenile stage, it is likely that *O. puelchana* has no negative impact on its host as it adheres to only about 20% of the carapace [37]. Within the present study, especially in Demak waters, we revealed higher prevalences for different *Octolasmis* species. *Oc. angulata* reached a maximum prevalence of 81%. Therefore, we assume that in this location an infection with the different *Octolasmis* species will lead to higher mortality rates of the blue swimming crabs.

The presence of *C. testudinaria* infections can cause an increase in host body weight and can reduce the ability to swim so that the host is more vulnerable to be attacked by predators [35,41]. Within the present study, *C. testudinaria* was isolated with highest prevalence up to 88% in East Lampung waters. With these high infection patterns, we can assume that pathogenic impacts most likely occur in the blue swimming crabs in this location and that the crabs are of higher vulnerability to predators in East Lampung waters than in Demak waters.

Thompsonia sp. can form a root-system-like attachment to its host. The presence of *Thompsonia* sp. can affect the crab's reproductive system leading to infertility. *Thompsonia* sp. are found to infect various hosts, such as stomapods, carideans, decapods, peracarids, and other cirripedes [5, 39]. Blue swimming crabs have often been infected with thousands of *Thompsonia dofleini* ectoparasites. In the present study, *Thompsonia* sp. were isolated only from East Lampung waters where *P. pelagicus* was infected with a high intensity of 2,740, a prevalence of 48%, mean intensity of 855.83 and a mean abundance of 410.80. Especially the high intensity leads to the conclusion that the infected crabs will probably show pathogenic health impacts in terms of infertility. This could potentially lead to different population patterns compared to blue swimming crab populations without or with lower infections of this parasite [39].

Table 4. Health-related impacts of crustacean ectoparasites that infect several aquatic organisms.

Parasites	Host	Health Impact	Citation
Chelonibia testudinaria	*Callinectes sapidus, Portunus pelagicus*	Increasing weight load, impaired swimming ability, restricted movement, making the host more vulnerable to predators.	[41–43]
Dianajonesia tridens	Mud crab (*Scylla* sp.), Portunid crabs, *Portunus pelagicus*	*Dianajonesia tridens* which occupy space in the gills will affect host respiration.	[8, 44,4 5]
Octolasmis angulata	*Scylla* sp., *P. pelagicus*	Affecting the respiration, hampers oxygen uptake.	[8, 29]
Octolasmis warwicki	*Portunus sanguinolentus*, *Portunus pelagicus*	Can increase the load of the host so that the host has difficulty moving and swimming. High-intensity infected hosts get less food and are vulnerable to predators.	[8, 26]
Octolasmis spp.	Mud crab (*Scylla* sp.), Portunid crabs, *Portunus pelagicus*	Affecting the breath, development and ingestion of hosts.	[6, 8, 29, 36, 44–46]
Ostrea puelchana	*Callinectes exasperatus*	Can reduce host flexibility, affect buoyancy and movement of the host, thus making the host more vulnerable to predators.	[37, 47]
Thompsonia sp.	*Portunus pelagicus*	Affects the crab's reproductive system so that the crabs become infertile.	[5, 39]

4. Conclusions

The magnitude of the infection, especially the intensity and mean abundance levels of the isolated ectoparasites, suggest that *P. pelagicus* are highly susceptible to ectoparasites in Indonesia. As a commercial species, they should be monitored with regard to parasite related health impacts. The total amount of isolated parasites from Demak waters were 4,823 specimens whereas the total amount of isolated parasites from East Lampung waters was about five times higher with 21,430 ectoparasite specimens. We suggest that this difference in infection patterns is probably related to the different muddy vs. sandy clay substrates in the two examined locations probably leading to different host ecologies. Another factor could be the sand mining activity near the Lampung study side, which could have negative environmental impacts and lead to the lower immune response in hosts and to higher ectoparasite infections.

To study ectoparasite infection patterns of commercially important crab species, like blue swimming crabs, will enhance the sustainable use of this fisheries resource in future. Different isolated ectoparasites within this study are known to have pathogenic impacts on their hosts health and therefore can adversely influence the crabs population patterns as well as their population dynamics, such as reproduction, growth rates and mortality rates. Impacts, such as decreased oxygen or food uptake and hampering of the crabs movement not only leaving the crabs more vulnerable to predators but also can lead to higher mortality rates and reduces the market value of this valuable export commodity.

Acknowledgments
We are grateful to the Ministry of Research and Technology for supporting this research. Based on Decree Number 6/E/KPT/2019 dated 29 March 2019 and Agreement/Contract Number 3/E1/KP.PTNBH/2019.

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