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Physical, chemical, and biological characteristics of crab (*Scylla* spp.) from East Kalimantan, Indonesia

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Abstract. *Fanggi, Hardi EH, Nikhlani A, Mahendra AP, Tarbiyah, Novita, Noerhidayanti F. 2023. Physical, chemical, and biological characteristics of crab (*Scylla *spp.) from East Kalimantan, Indonesia. Biodiversitas 24: 4998-5006.* Mud crab (*Scylla* spp.) is a direct export commodity to China from East Kalimantan, Indonesia. The majority of crabs are caught wild by traditional farmers in some districts. Early detection of crab quality is required to prevent the rejection of mud crab export products due to size, heavy metals, and infections. Fifteen samples from 15 farms in Balikpapan, Indonesia, were evaluated for physical parameters (weight, carapace width, sex, completeness of morphology, and identification of species), chemical parameters (Cu, Pb, Mg, Cd, and As), and biological parameters for the detection of White Spot Syndrome Virus (WSSV). The crab catches are from Kutai Kartanegara, Paser, and Penajam Paser Utara Districts. The physical examination of the crabs revealed a weight of 441.73±88.14 g, a carapace width of 11.92±0,59 cm, sexes of 14 males and 1 female, species including *Scylla serrata* (Forskål, 1775), *Scylla olivacea* (Herbst, 1796), *Scylla paramamosain* (Estampador, 1950), and *Scylla tranquebarica* (Fabricius, 1798), and 93.3% of the crabs had morphological completeness. The chemical examination of heavy metals, including Cu, Pb, Mg, Cd, and As, is still limited to fish products, while Fe has passed the quality standard, and WSSV has infected no crabs. The investigation found that 40% of East Kalimantan Province crab exports did not meet carapace width criteria. No WSSV pathogen was found in the samples. However, crab meat Fe concentration exceeded requirements.

Keywords: Fisheries products, heavy metals, morphological, mud crabs, WSSV

INTRODUCTION

According to Fujaya et al. (2014), the commercial potential of mud crabs, also known as *Scylla* spp., is considerable. This is because mud crabs produce a delectable fish product with high protein content. In addition, mud crabs (*Scylla* spp.) are a fishery commodity with significant economic value and can frequently be found along the coast of Indonesia (Tahmid et al. 2015). This is especially true for those mud crabs grown in mud and obtained through natural fishing in coastal waters, particularly estuaries and brackish water ponds (Triyanto et al. 2019; Akber et al. 2020). Currently, mud crabs from East Kalimantan, Indonesia, depend on natural catches (Nirmalasari et al. 2010). The lack of technological advancements in mud crab farming has contributed to this industry's imperfection.

Regarding the export destinations for mud crabs, particularly those originating from East Kalimantan, specifically China, it was previously necessary for the mud crab export products to transit through Surabaya or Jakarta, Indonesia. However, due to the diligent efforts of the Fish Quarantine Quality Control and Safety of Fishery Products (BKIPM) and airport managers, it has been confirmed that in 2021, East Kalimantan will have the capability to directly export mud crabs from Balikpapan, Indonesia, to Shanghai, China, with a monthly capacity of 150 tons. This development is expected to result in fresher products due to the reduced transit time (Antara Kaltim 2022).

According to the information above, Indonesia and East Kalimantan, in particular, have the potential to improve their crab export industry. However, as a resident of a country with enormous export potential, you should not focus solely on quantity but on quality regarding your concerns about exports. On June 30, 2022, there was a rejection of fishery export products that took place recently as a result of the Singapore Food Agency's (SFA) discovery that the amount of cadmium in shrimp imported by the Song Fish Dealer company was above the maximum limit, shrimp goods originating in Indonesia were removed from the market in Singapore. The survey findings indicate that anywhere between 22 and 24 percent of Indonesian fishery goods have been turned down for export in several different nations. The fact that pathogenic microorganisms, bio-contaminants, heavy metals, and parasitic diseases were found in some cases led to the dismissal of more than 450 patients' claims. In more specific terms, rejected fishery products include bivalve mollusks, which are rejected because of pathogenic microorganisms and biotoxins; cephalopod mollusks, which are rejected

because they contain heavy metals above the threshold; and crustaceans, which include shrimp, which contain residues of antibiotics, drugs, and heavy metals (CNN Indonesia 2022).

The current challenges aquaculture and fisheries face revolve around environmental concerns, including pollution, overfishing, and the impact of climate change. These factors have resulted in adverse effects on mud crabs, such as heightened stress levels, increased death rates, and a decline in overall crab quality (Fawzi and Husna 2021). According to Coates and Rowley (2022), stress and environmental stress are significant factors that render crabs more susceptible to microbial or parasitic attacks, ultimately leading to their demise. The adverse effects of pollution have been observed to significantly impact not only the well-being of crabs but also human health (Tirtadanu and Chodrijah 2018; Pratiwi et al. 2022). Hence, export commodities from fisheries must be accompanied by comprehensive documentation about microbiological contaminants and heavy metals. China serves as a recipient nation for mud crabs (*Scylla* spp.) originating from East Kalimantan, with a monthly cargo allocation of up to 150 tons. The Ministry of Fisheries in Indonesia has implemented laws on the exportation of crabs. These regulations specify that the carapace size of the crabs must not exceed 12 cm in width, and they must weigh a minimum of 30 g. Additionally, the crabs must adhere to the statutory limits for heavy metal contaminants, ensuring they do not surpass the permissible levels. Furthermore, the crabs must not exhibit any detection of White Spot Syndrome Virus (WSSV).

According to the Kepmen KKP RI No. 91/KEPMEN-KP/2018, the WSSV is a class one quarantine fish pest and diseases that cannot be disinfected or treated from its carrier media since the treatment technology has not been perfected. This means that the virus cannot be cured from its carrier media. This virus caused substantial mortality in numerous crustaceans, including mud crabs that were infected with it. Although some of the crabs infected with the virus did not develop infections, others served as intermediate hosts for the virus and transmitted it to other creatures, such as shrimp and fish (Patil et al. 2021). The accumulation of heavy metals in aquatic species' flesh is a well-documented phenomenon. Consequently, heavy metal contamination in fish and shrimp often arises from waters contaminated with heavy metals (Zhang et al. 2019). The subsequent clarification provided details that heavy metal pollutants, including copper (Cu), lead (Pb), cadmium (Cd), mercury (Hg), arsenic (As), and iron (Fe), must be present in fisheries products at levels that do not exceed the established standard threshold.

To mitigate the occurrence of rejected crab exports from East Kalimantan, it is imperative to promptly identify potential issues through the early detection of various factors. These factors encompass the physical attributes of crab morphology, such as size and intact organs, heavy metal contaminants (specifically Cu, Pb, Cd, Hg, As, and Fe) and pathogens (specifically WSSV). This detection process should be carried out at the fish quarantine and inspection agency. The collected research data can subsequently serve as valuable input for local governmental entities in assessing the distribution patterns of mangrove crabs within the waterways of Kutai Kartanegara (Kukar), Penajam Paser Utara (PPU), and Paser, Kalimantan, Indonesia. Additionally, this data can aid in evaluating the quality of mangrove crabs and identifying potential chances for their exportation as a valuable commodity.

MATERIALS AND METHODS

Study area

During the period spanning from December 2022 to January 2023, a collection of crabs was obtained from the districts of Kukar, PPU, and Paser, Kalimantan, Indonesia. These crabs were gathered from 15 farms located in Balikpapan District, East Kalimantan, and BKIPM officials randomly selected exported crabs. The fishing grounds for mud crabs in Kutai Kartanegara District encompass the sub-districts of Handil, Muara Badak, and Sungai Mariam. In North Penajam Paser District, mud crabs are captured in the Penajam Sub-district, while in Paser, the Grogot Sub-district serves as the fishing location. The process of crab identification was conducted at two different locations. The Fish Quarantine Quality Control and Safety of Fishery Products (BKIPM) Balikpapan, located at Colonel Syarifudin Yoes Street, No. 10 Ring Road Gunung Bahagia, South Balikpapan, was responsible for utilizing biological and physical parameters. On the other hand, the detection of heavy metals through chemical parameters was carried out at the Water Quality Laboratory, situated at the Faculty of Fisheries and Marine Sciences, Universitas Mulawarman, Samarinda, Indonesia. Both laboratories possess certifications from the Indonesian Accreditation Agency (KAN).

Research procedure and data analysis

Kepmen KKP RI No. 91/KEPMEN-KP/2018, issued by the Minister of Maritime Affairs and Fisheries, outlines the sample analysis procedures. To be eligible for export, mangrove crabs (*Scylla serrata* (Forskål, 1775)) must meet the following size requirements: carapace width of at least 12 cm; minimum weight of 150 g; absence of WSSV. The minimum size for exported lobsters (12 cm carapace width) and crabs (30 g for wild catch and 60 g for domestic shipment) is outlined in Kepmen KKP RI No. 16/KEPMEN-KP/2022, which is titled Amendments to Kepmen KKP RI No. 17/KEPMEN-KP/2021 concerning the management of lobsters (*Panulirus* spp.), crabs (*Scylla* spp.), and crabs (*Portunus* sp.). BKIPM Balikpapan inspectors randomly sampled products from 15 farms. All export crabs will be scrutinized, and those not measuring up will be swapped out for new ones. Physical, chemical, and biological standards must be met before exporting crabs. All physical characteristics (average weight, carapace width, sex, completeness of morphology using Avianto et al. 2013 and Paital and Chainy 2012 methods) and identification of the crab species (Abbas et al. 2016; Pati et al. 2023) were analyzed for 15 samples of crabs

(*Scylla* spp.) from 15 farms in Balikpapan, East Kalimantan. White spot syndrome virus (WSSV) was detected by polymerase chain reaction (PCR) and standard Kit IQ 2000 was used as a marker for this step of the biological characterization process. Crab samples, including gill and meat, were used for chemical analysis (Pb, Cu, Cd, Hg, As, and Fe) using Standard SNI 2354.5:2011.

RESULTS AND DISCUSSION

Physical characteristics

The research used a sample from 15 farms, one of whom was an exporter based in East Kalimantan. The study employed a random sampling technique to pick a representative sample of crabs, with one crab being taken from each farm. Based on the collected crab samples, three distinct fishing places were identified, namely Kutai Kartanegara District. Specifically, 8 samples were taken from Handil, 3 from Muara Badak, and 1 from Sungai Mariam. The study included two samples from the Grogot sub-district and one from the Penajam Paser Utara District, as shown in Figure 1.

Mud crab sample weight, carapace width, and fulfillment

The results of the weight crab sample are described in Table 1. The crab samples passed the criteria (> 30 g) based on Kepmen KKP RI No. 16/KEPMEN-KP/2022, which is 30 g. Additionally, the minimum carapace width seen was 12 cm. The crabs analyzed in this study ranged from 318-640 g, with an average weight of 441.73±88.14 g. The crab sample from Musriadi Farm exhibited the highest weight, measuring 640 g, while the one in UD Nur Fajar displayed the lowest weight, measuring 318 g. The carapace width ranged from 10.5 to 13.0 cm, and the findings on examining carapace width are presented in Table 2. According to the prevailing legislation, consuming or trading crabs exclusively is permissible if their carapace width exceeds 12 cm. This research showed that 60% of the crabs exhibited complete organs, characterized by intact organs, whereas the remaining 40% did not display such fulfillment.

Sex of mud crab

The sex of male and female crabs can be observed from the outer shape of the body. In male crabs, the sex organs are attached to the abdomen, forming a tapered triangle; in female crabs, the genital organs tend to be broadly triangular in shape and blunt in front (Mohanty et al. 2006; Paital and Chainy 2012). According to the data, the sex of crabs obtained from 15 samples contained 14 crabs with male sex (93%) and 1 crab with female sex (7%). Many male crabs were trafficked to prevent rejection due to the egg-laying process.

Completeness of mud crab sample morphology

The crab has both exterior and interior organ morphology. They have a hard shell covering their entire bodies, spines between their eyes, pincers (chelipeds), walking legs, and swimming legs. Complete morphological data on crabs is vital for trade. Missing appendages on mud crabs may be an indication of stress or an autonomic process brought on by fishing. Therefore, export rejection can result from organ failure in crabs. Data from 15 specimens showed that just one crab lacked all its appendages (Figure 2), while the others all had complete sets.

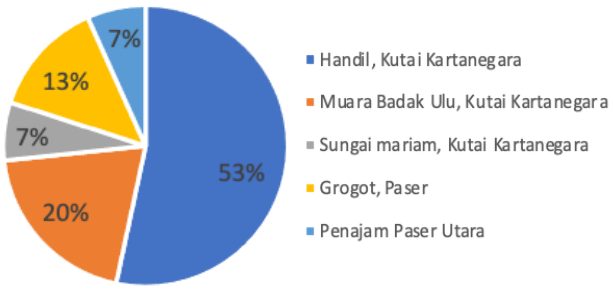

Figure 1. Crab (*Scylla* spp.) catch area

Table 1. Crab sample weight of mud crabs (*Scylla* spp.)

Code	Exported Farm	Crab Weight (g)	Carapace width (cm)	Comparability of crab morphology
A	CV Tiga A	549	12.5	Complete
B	Tsania Asia Raya	341	12.0	Complete
C	CV. DSA Buana Borneo	381	11.5	**Not**
D	Deddi Haryadi	448	12.0	Complete
E	UUP Lilis Ayu Df	494	12.0	Complete
F	PT. Sumber Laut Semesta	427	11.5	**Not**
G	Muhammad Firdaus	412	12.5	Complete
H	CV. Davira Bone	552	12.5	Complete
I	CV. Kaisar Multi Bisnis	368	11.8	**Not**
J	Bintang Laut	489	12.0	Complete
K	CV. Nur Abadi	403	12.0	Complete
L	Family Jaya	387	11.5	**Not**
M	UD. Nur Fajar	318	10.5	**Not**
N	Musriadi	640	13.0	Complete
O	CV. Hoky Laut	417	11.5	**Not**

Mud crab sample species

The mud crabs (*Scylla* spp.) export samples found in East Kalimantan can be classified into four distinct species: *S. serrata* (26.67%), *S. tranquebarica* (13.33%), *S. olivacea* (33.33%), and *S. paramamosain* (26.67%). The variations in basic morphology can be observed in Table 2.

Chemical parameters

Food safety was a crucial aspect in the production of fishery exports, with the primary concern being the presence of heavy metal pollution (Table 3), which contributed to the drop in export volumes. The assessment of heavy metal presence in crabs holds significance in determining the suitability of their exportation. The copper (Cu) concentration in crabs ranged from 0.033 to 0.205 mg/kg. The lowest Cu content was found in Hoky Laut and CV Tiga A crabs, measuring 0.030 mg/kg. Conversely, UD Nur Fajar Farm crabs had the highest Cu level, measuring 0.205 mg/kg. On average, the Cu content in mud crabs sourced from East Kalimantan was determined to be 0.114 mg/kg. The crabs captured inside the fishing district of Kutai Kartanegara exhibit the most minimal concentration of Cu, measuring at 0.099 mg/kg. Subsequently, the Paser region records a slightly higher Cu level of 0.11 mg/kg, while the PPU area demonstrates the greatest Cu concentration among the crabs, measuring at 0.21 mg/kg.

According to the findings of this study, the observed Pb levels in the crab samples indicate that 14 samples had concentrations below 0.034 mg/kg, while one sample had a concentration of 0.039 mg/kg. The farm with the lowest level of Pb was CV Tiga A, whereas the one with the highest was CV DSA Buana Borneo. The crabs captured inside the fishing district of Paser exhibit the lowest recorded concentration of Pb (0.030 mg/kg), with Kutai Kartanegara (0.033 mg/kg) and PPU (0.034 mg/kg) following suit. It is noteworthy that, akin to the Cu levels, the PPU region has the highest Pb concentration in the crabs.

The mercury (Hg) sample levels are below the suggested 1.0 mg/kg limit, as specified by the Indonesian National Standard (SNI) No. 7387. The measured Hg levels in all samples were less than 0.004 mg/kg. The crabs captured inside the East Kalimantan region exhibit a reduced concentration of mercury (Hg).

The cadmium (Cd) level in mud crab meat samples from the East Kalimantan catchment area was obtained, as shown in Table 3. The maximum limit of Cd contamination in food is 1.0 mg/kg. The Cd content in 15 samples was 0.001-0.002 mg/kg, 9 samples were at 0.001 mg/kg, and 3 samples were at 0.002 mg/kg. Crabs caught in the fishing district of Paser and PPU have the lowest Cd level (0.001 mg/kg) compared to Kutai Kartanegara (0.002 mg/kg). Table 3. shows East Kalimantan crab samples with As contamination. Cadmium buildup in crab meat was still below the threshold after assessing arsenic levels in 15 East Kalimantan mud crab samples. This was based on SNI No. 7387 2009's maximum arsenic (As) level of 1.0 mg/kg in crab flesh. The maximum arsenic content in 15 samples was found in farm UD. Nur Fajar (0.073 mg/kg), with 4 samples at <0.008 mg/kg. Kutai Kartanegara crabs had the lowest As level (0.018 mg/kg), followed by Paser (0.021 mg/kg) and PPU (0.073 mg/kg). Like Cu and Pb, crab meat's highest As level was in the PPU.

The iron (Fe) levels in 15 mud crab samples acquired from East Kalimantan waters showed that the accumulation of iron content in some crab meats exhibited relatively high findings. These results were determined by measuring the levels of Fe in the crabs' meat. This was determined using the maximum allowable level of heavy metal iron content recommended by SNI No. 7387 2009 (1.0 mg/kg). In 15 samples, the iron level was between 0.017 and 0.033 mg/kg, more than the acceptable limit; however, the Nur Fajar farm had the highest iron content, 24.59 mg/kg. In the same manner as the amounts of Cu, Pb, and As, the PPU area included the greatest level of Fe in the crab meat. Only two of the samples caught in the Kutai Kartanegara area have a low level of Fe in the crab meat (0.625 and 0.853 mg/kg), while the others have a high amount. On the other hand, the Fe levels in all of the area's crabs that have been captured are pretty high: 6.09 mg/kg for Paser, 10.11 mg/kg for Kutai Kartanegera, and 24.59 mg/kg for PPU. The PPU area also had the highest levels of copper and lead, while the crabs there had the highest iron levels.

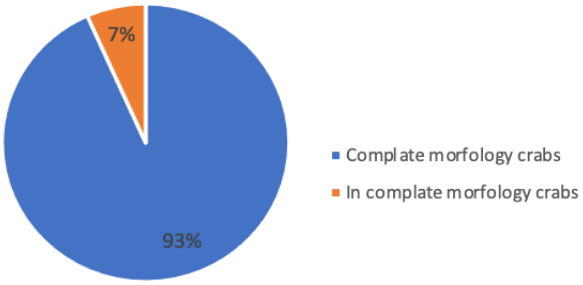

Figure 2. Completeness of mud crab (*Scylla* spp.) sample morphology from East Kalimantan, Indonesia catch

Table 2. Mud crab sample species

Species	Carapace end	Corpus	Percentation (%)
Scylla serrata	Tall and pointy	Two spines on the wrist, There are thorns	26.67
Scylla paramamosain	Rather tall and pointed	No thorns	26.67
Scylla olivacea	Low and rounded	One spine. No thorns	33.33
Scylla transqubarica	Rather low and rounded	There are thorns	13.33

Table 3. Heavy metal level in mud crabs (*Scylla* spp.) sample

Code	Exported Farm	Cu (mg/kg)	Pb (mg/kg)	Hg (mg/kg)	Cd (mg/kg)	As (mg/kg)	Fe (mg/kg)
A	CV Tiga A	0.033	0.019	0.004	-	0.017	0.625
B	Tsania Asia Raya	0.122	0.025	0.004	-	0.033	1.147
C	CV. DSA Buana Borneo	0.071	0.039	0.004	-	0.025	0.853
D	Deddi Haryadi	0.103	0.034	0.004	0.001	0.008	11.04
E	UUP Lilis Ayu Df	0.104	0.034	0.004	0.001	0.013	12.11
F	PT. Sumber Laut Semesta	0.073	0.034	0.004	0.001	0.008	10.2
G	Muhammad Firdaus	0.139	0.034	0.004	0.002	0.026	13.61
H	CV. Davira Bone	0.142	0.034	0.004	0.001	0.021	11.74
I	CV. Kaisar Multi Bisnis	0.069	0.034	0.004	0.001	0.008	10.82
J	Bintang Laut	0.112	0.034	0.004	0.002	0.016	12.14
K	CV. Nur Abadi	0.101	0.034	0.004	0.001	0.015	12.65
L	Family Jaya	0.146	0.034	0.004	0.002	0.023	13.22
M	UD. Nur Fajar	0.205	0.034	0.004	0.001	0.073	24.59
N	Musriadi	0.173	0.034	0.004	0.001	0.032	14.97
O	CV. Hoky Laut	0.03	0.034	0.004	0.001	0.008	8.33

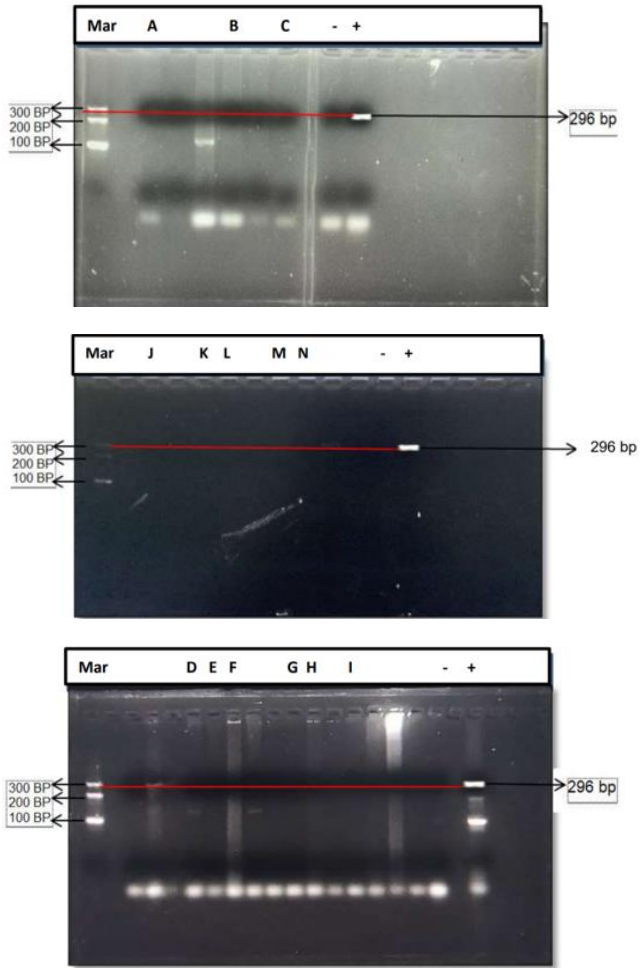

Figure 3. PCR detection of WSSF in gill mud crab (*Scylla* spp.) samples

The contamination of fishing products with microbiological infections was an additional issue due to exporting these products. There were almost 450 distinct isolates that were not accepted, and microbial pathogens were the cause of 65% of those rejections (Hardi 2023). The WSSV was discovered to be one of the viruses responsible for the highest rates of mortality and zoonosis in crabs (Ghittino 1972; Gauthier 2015). As a result, the rule for export products required that they be free from this infection. During a study of the biological parameters of all mud crabs (*Scylla* spp.), observation, and detection of WSSV using PCR with IQ 2000TM (2009), the existence of a band at 296 bp shows that the crab is not infected with WSSV. This conclusion was reached as a result of the findings of the study.

Figure 3. indicates that all samples were WSSV-negative since there was no 296 bp band. Fifteen crab samples with negative status suggest that East Kalimantan seas are not in WSSV emergency status, where BKIPM Lab analysts rarely find positive samples. Although this virus is rare, it must be detected before shipping since it is in HPIK Group 1, quarantine fish pests and diseases that cannot be sterilized from carrier media due to unmastered treatment technology. This virus requires extra attention and must be negative before shipping.

Discussion

The analysis of crab specimens intended for exportation via BKIPM Balikpapan, originating from three distinct districts within the East Kalimantan province, reveals many factors that may impede the success of the exportation process. As an illustration, it should be noted that not all specimens conform to the prescribed carapace width criterion of 12 cm as stipulated in Ministerial Decree No. KP. 16/KEPMEN-KP/2022. Furthermore, several crab specimens have elevated Fe levels beyond the established threshold limit.

The body of the crab species *Scylla* sp. is large, transverse, and somewhat convex at its carapace, but the surface is even. The carapace is made up of fused tergites and is serrated on the front with six teeth and on the front and sides with nine teeth on each side. On the anterior side of the body, this species has one set of antennae, antennules, and stalked eyes. Three regions make up the body: the cephalic region, the thoracic region, and the

abdominal region. The mouth is in the middle of the anterocephalic area, and its various components, including the mandible, maxillae, and others, are easily identifiable. This fact is similar to the findings of Paital and Chainy (2012). Based on Ohoiulun et al. (2020), the morphometrics of the carapace of *S. serrata* with the equation W = 0.375L-0.117 show that the mean crabs have a positive correlation value between weight and carapace weight; all samples in East Kalimantan were in normal condition.

Based on the findings of Syahdan et al. (2021) and Nirmalasari et al. (2010), it has been observed that the region of East Kalimantan exhibits the highest diversity of crab species. Four distinct species of the genus *Scylla* were identified in our study, specifically *S. serrata, S. paramamosain, S. olivacea*, and *S. transqubarica*. The decision to prohibit the high mangrove crab was influenced by the findings of Siringoringo et al. (2017) and Widianingsih et al. (2019), who highlighted the significance of the high mangrove ecology in this regard. The extensive mangrove habitats in East Kalimantan, particularly in the Mahakam Delta, are widely acknowledged in the literature (Indarjo et al. 2020; Hardi et al. 2022a,b). The Mahakam Delta harbors a significant abundance of mangroves.

Furthermore, according to Putri et al. (2022), *Scylla* spp. were found in marine habitats with a significant influence (89.22%) from the mangrove ecosystem. The survival of the *S. serrata* species is highly contingent upon the salt levels, which often fluctuate between three and four parts per thousand, as well as the abundance of mangrove trees within its habitat. The surrounding ecology heavily influences mud crabs' abundance, density, and diversity. The species *S. serrata*, as described by Vay (2001), is frequently observed in abundant quantities inside wetland environments characterized by mangrove forests. Conversely, the species *S. tranquebarica* is typically encountered in habitats consisting of sandy swamps.

The minimal crab carapace length for ingestion is 12 cm since research shows that crabs under 12 cm are juvenile. In this study, 60% of crab samples were complete, had complete organs, and weighed 441.73 ± 88.14 g. Srinivasagam et al. (2000) and Mohanty et al. (2006) found that *S. tranquebarica* has more data than *S. serrata*. Research shows the same thing. Different species have different digestive and feed metabolic physiologies. Crab catches over 12 centimeters in length are permitted in order to preserve the resource. Data on the carapace width of sample crabs indicates that forty percent do not meet export size requirements; therefore, evaluating the crabs and replacing those too small is necessary. The caught crabs should have reproduced, preserving the crabs in nature. Several elements sustain crabs, including water parameters, natural food, and mangrove habitat. Research suggests mangroves may filter, sediment, and feed crabs and other organisms. Mangrove crabs thrive in East Kalimantan's mangrove-dominated seas (Van Zwieten 2006; Troell 2009; Fawzi and Husna 2021). Article 19 of KP No. 16 of 2022 states that "any person who catches, cultivates, traffics, and/or releases lobster seeds (*Puerulus*), lobsters (*Panulirus* spp.), and crabs (*Scylla* spp.) in conditions that do not comply with the provisions as intended in Article 18 paragraphs (2), (3), and (4) is subject to administrative sanctions," which can result in the cessation of activities, the sealing of vessels exporters are on notice that they must adhere to these rules for every organism they ship abroad.

Crab samples have Cu toxicity from 0.02-1.00 mg/kg, and the WHO blood threshold is 0.8-1.2 mg/kg. At 1.0 mg/kg, FAO seafood quality standards for Cu (Zhang et al. 2019). From the threshold values above, no copper metal exceeded the maximum amounts in 15 mud crab samples. This value indicates that mud crabs in East Kalimantan waters are still safe and suitable for consumption. However, we should all be warned, especially the government, that Cu has been detected in East Kalimantan, which does not rule out the possibility that the levels will rise and cause various impacts, especially on fisheries and human biota.

SNI No. 7387 (2009) sets the maximum limit for heavy metal contamination in food at 0.5 mg/kg, so the Pb content in 15 mud crabs caught in East Kalimantan waters was within normal limits. This means all mud crab samples shipped by the Fish Quarantine and Inspection Department, notably to China, are safe to eat. However, human activities like settlements, factory waste, and others will increase the waste load, affecting water quality, so marine biota's heavy metal content may continue to rise and exceed the threshold (Siahaan et al. 2018). Even while heavy metal sources are increasing, their concentration in water might vary at any time. This relates to the water column activities these chemicals undergo. Water-heavy metal concentrations depend on temperature, salinity, currents, pH, and suspended particles. These factors' interactions affect water-heavy metal concentrations.

The maximum mercury (Hg) contamination level in fish and crustacean meat is recommended by SNI No. 7387 (2009). Crustaceans had 1.0 mg/kg of heavy metal pollution, and fish 0.5 mg/kg. The heavy metal mercury content in East Kalimantan waters suggests that consumption organisms are still safe to eat but in small amounts. It should be a warning to everyone, especially the government, that Hg has been detected in the region, which could lead to higher levels in the future and harm fisheries and human biota.

According to Nurdin (2012), the gills absorb heavy metals and water that disperse and move through the circulation, accumulating in the flesh. Hg enters by skin, breathing, and digestion. Methyl mercury exposure is highest in humans if crabs eat small fish infected with it and humans eat crabs (Budiasih et al. 2015). Crabs collect heavy metal Hg through their gills and store it in their tissues. Zhang et al. (2019) found that 70% of food-borne methyl mercury is absorbed into fish tissues and 10% through the gills. Speed of metabolism, size and type, alkalinity, and pH affect Hg absorption. Along with the demethylation process, temperature, contamination amount, time, source, and form of Hg, and organism life (Dayal et al. 2019).

From the threshold values above, no Cd metal exceeded the maximum limits in 15 mud crab samples. Even in small

quantities, mud crabs in East Kalimantan waters were safe and suitable for consumption due to their CD value. However, this should be a warning to all of us, especially the government, that Cd has been detected in East Kalimantan, which will not one day disappear and can have various impacts on fisheries and human biota.

Cadmium enters the environment as a result of human activities. Sources of cadmium pollution come from air pollution, glazed ceramics, cigarettes, well water, fungicides, fertilizers, and paints. Cadmium in water bodies can come from atmospheric deposits, dust, and industrial wastewater. Cadmium is cumulative and very toxic to humans because it can cause impaired kidney and lung function, increase blood pressure, and cause infertility in adult men (Nasution 2017).

Due to the low levels of arsenic (As) in this sample, the fish quarantine and inspection agency has determined that all mud crab samples shipped via their facilities, particularly to China, are safe for human consumption. The detection of As in East Kalimantan, even if only at low levels at first, should serve as a warning to all of us, notably the government, because it does not rule out the possibility that future levels may increase and can produce numerous repercussions, especially on fisheries and human biota. The high density of mud plants along the coast of East Kalimantan is responsible for the region's low As content. Despite the substantial pollution, muds are very resistant to metal contamination. Muds actively prevent excessive heavy metal influx, act as filters, and have unique treatment power at their roots, as shown above. The content of heavy metals in marine biota may continue to increase and accumulate to the point where it exceeds the threshold (Kusumawarni et al. 2014). This is because arsenic (As) in marine biota does not rule out the possibility that, as human activities increase (such as settlements, factory waste, and other activities), the waste load will increase significantly, negatively impacting water quality.

The high levels of Fe in the waters of East Kalimantan need to be a concern for all of us, especially the government, to deal with this because it can cause various negative impacts. The high Fe content in mud crab meat is thought to be due to the quality of the waters. The Fe in the water is thought to have originated from factory and domestic waste disposal and ship vehicles containing solid iron and corroded. In general, East Kalimantan is a coal and oil-producing province, which can affect water quality where transportation and industrial activities are mainly carried out in waters; it does not rule out the possibility of waste disposal originating from industrial activities and the dense mobility of vehicles that pass through the waters and leave heavy metals behind corroded iron.

Overconsumption of marine animals high in Fe, say Suryaningsih et al. (2018), is extremely dangerous to human health. Fe is an essential element for the development and survival of marine life. However, persistent absorption can lead to dangerous iron accumulation in the bodies of organisms. In the short term, symptoms of Fe metal poisoning include nausea, vomiting, diarrhea, and headaches. Based on our findings, crab meat has an elevated Fe content. How regulate crab, shrimp, and fish farming to reduce Fe pollution should be a top priority for the local government. The highest concentrations of Cu, Pb, and Fe contaminants in the crab meat were found in Paser and Kutai Kartanegara, where the PPU was the most active.

Since the 1990s, WSSV and Acute Hepatopancreatic Necrosis Disesase (AHPND) have been the primary causes of failure in the crab and shrimp aquaculture industries, respectively (Valente and Wan 2021; Xie et al. 2021), and the crab is an intermediate host for WSSV (Salehi 2010). Infectious WSSV could spread across the ecosystem if crabs are harboring it. This is one of the reasons why HPIK Group 1 includes WSSV. Several investigations (Patil et al. 2021; Hardi et al. 2022a,b) demonstrate that *Scylla* spp. can withstand the effects of WSSV. On the other hand, there are some signs that crabs that have been infected have become less active, and their growth has slowed down. This disease causes mortality, grows more slowly, and reduces the economic value (Andersen et al. 2000). Additionally, the sickness leaves the carapace of affected crabs looking dull and covered with white patches. This damage is brought about by the action of oclastic chitin, which is carried out by fungi, bacteria, and viruses. The amount of the pathogen's pathogenicity is highly impacted by environmental factors such as the low availability of natural food and low dissolved oxygen, which occur more frequently in settings with high salinity. The preceding discussion makes it abundantly evident that viral infections in *Scylla* spp. crabs are widespread and have a tight relationship to the parameters of their environment. All crab samples were WSSV-negative, indicated by the absence of a band that appeared at 296 bp. Fifteen crab samples with a negative status indicate that the waters of East Kalimantan are still not in WSSV emergency status. This disease cannot be disinfected from the carrier media because the treatment technology has not been mastered; therefore, this virus receives special attention and is a mandatory negative requirement before shipment. In this detection, the target organ taken is the crab's gills by cutting the carapace towards the gills, where the gills and stomach are the crab's digestive system, which is included in one of the WSSV target organs.

The conclusions of the research on the inventory of physical, chemical and biological parameters on mud crabs (*Scylla* spp.) exported to China from East Kalimantan are as follows: physical parameters include weight 318-640 g, carapace width 10.5 cm-13.0 cm, 14 males and 1 female, just 1 incomplete morphological completeness and 14 others complete and species of *Scylla* spp. from east Kalimantan that’s export commodity were include *S. serrata, S. olivacea, S. paramamosain* and *S. tranquebarica*, and dominance by *S. olivacea*. Chemical parameters include measuring Cu was 0.033-0.205 mg/kg, Pb was 0.019-0.039 mg/kg, Hg levels all <0.004 mg/kg, Cd levels 0.001-0.002 mg/kg, As <0.008-0.073 and Fe was 0.625-24.59 mg/kg. The Cu, Pb, Mg, Cd, and As levels were still below the threshold, while the Fe content had already passed above 1 mg/kg. The biological parameters of all samples were negative WSSV.

The research findings indicate that a significant proportion (40%) of the exported crabs from catches in East Kalimantan Province did not fulfill the specified carapace width criteria. Furthermore, no evidence of the WSSV pathogen was detected in the samples. However, it was observed that the Fe concentration in the crab meat exceeded the permissible standards. Based on these findings, the authors make the following recommendations: we need to diversify the fish consumption of marine biota with other healthy foods because the iron (Fe) content in mud crabs obtained from East Kalimantan waters has exceeded the threshold; we need to increase mud crab aquaculture to meet export needs; and we need to control the crabs caught in the wild and not catch the spawning crab broodstock to ensure the availability.

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