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Antioxidant Activity and Chemical Profile of Fiddler Crabs as a Form of Self-Defense Against Various Anthropogenic Activities Along Urban Rivers

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ABSTRACT

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Fiddler crabs utilize bioactive compounds for defense against environmental stressors. The study aimed to determine the antioxidant activity, bioactive compound profile of fiddler crab extracts as a form of self-defense against various anthropogenic activities along urban rivers. The fiddler crabs (*Uca spp.*) were collected from the Tanjung Api-Api Port area and Sungsang Village, located in Banyuasin Regency, South Sumatra, Indonesia. Fiddler crab samples were extracted by maceration in ethanol. The antioxidant activity of the extracts was evaluated using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging assay. Bioactive compounds profile was determined by qualitative phytochemical screening, followed by gas chromatography-mass spectrometry (GC-MS). Fiddler crab extracts of samples obtained from both locations exhibited weak antioxidant activity with IC₅₀ values of 174.617 µg/mL and 190.786 µg/mL for crab extracts from Tanjung Api-Api area, and Sungsang village, respectively. Phytochemical screening of crab extract from Tanjung Api-Api area revealed the presence of alkaloid, triterpenoids, and saponins. GC-MS analysis identified hexadecanoic acid, trans-13-octadecenoic acid, (E)-9-octadecenoic acid ethyl ester, and cholesterol as the major bioactive compound groups in Tanjung Api-Api Fiddler crab extract. This findings suggest that fiddler crabs produce bioactive chemicals that could help combat oxidative stress caused by pollutants in urban rivers. Further research is needed to characterize these compounds in greater depth and explore their mechanisms of facilitating the adaptation of fiddler crabs to stressful environmental conditions.

Keywords: Antioxidant, Biochemical Profile, Fiddler Crabs, Anthropogenic, Urban Rivers.

Introduction

Increased urbanization and anthropogenic activity along urban rivers have led to a decline in environmental quality and aquatic ecosystem health.^{1,2} Water pollution, industrial waste discharges, and other chemical contaminants pose a serious threat to the organisms living in these ecosystems.^{3,4} Pollutants such as heavy metals, pesticides, and harmful organic compounds can enter aquatic systems.^{5,6} These pollutants can accumulate in sediments and aquatic organisms, causing cellular damage, reproductive impairment, and even death.⁷ Compounds like polycyclic aromatic hydrocarbons, polychlorinated biphenyls, and other industrial chemicals have the potential to induce oxidative stress in living organisms. This can result in inflammation, tissue injury, and disruption of normal physiological functions.⁸⁻¹⁰ Among aquatic organisms, crustaceans are important creatures exposed to environmental pollutants.¹¹⁻¹³ Crabs being one of the most dominant groups, tend to accumulate significant amounts of pollutants due to their close association with the substrate in contrast to pelagic fauna that live in the water column.¹⁴⁻¹⁶

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One genus that is often found in estuarine and estuary habitats is the fiddler crab.^{17,18} Fiddler crabs a type of semi-terrestrial crustacean are commonly found along the coasts of tropical, subtropical, and warm temperate regions worldwide.^{19,20} These crabs are resilient ecosystem components because they can adapt to a wide range of habitat conditions, polluted, brackish, and saline environments.²¹ They play important ecological roles, including nutrient cycling, organic matter decomposition, and as a food source for various predators (birds, fish, and marine mammals).^{22,24} Fiddler crabs are recognized as ecosystem engineers because of their influence on sediment composition and their impact on the biodiversity of mangrove ecosystems.²⁵ However, changes in water quality due to human activities have caused various challenges to their survival.^{26,27} Fiddler crabs play important roles in coastal ecosystems, including inorganic matter decomposition and as a food source for various predators.^{28,29} To survive in contaminated environments, fiddler crabs may have developed physiological and biochemical adaptations, including enhanced antioxidant responses and unique biochemical defense mechanisms.^{30,31}

Antioxidants are molecules that can scavenge free radicals, thereby preventing cellular damage caused by oxidative stress.^{32,33} In a polluted environment, the antioxidant defense system of fiddler crabs becomes very important to protect them from the damaging effects of chemical pollutants.^{34,35} In addition, biochemical compounds, which are natural chemical components in organisms, can play a key role in biological defense mechanisms.^{36,37} The biochemical profile of fiddler crabs, particularly their antioxidant and detoxification pathways, is crucial in mitigating oxidative stress and neutralizing pollutants. Flavonoids, terpenoids, and alkaloids are known for their antioxidant, anti-inflammatory, and other medicinal properties, which could help fiddler crabs adapt to polluted environments.³⁸⁻⁴⁰

Research on the antioxidant activity and biochemical profile of fiddler crabs in urban rivers can provide important insights into how these organisms adapt to environmental stresses caused by human activities. This knowledge is not only beneficial for fiddler crab species conservation, but it can also provide indicators of ecosystem health and potential pollution mitigation strategies. This study aimed to explore the antioxidant activity and biochemical profile of fiddler crabs as a form of self-defense against various anthropogenic activities along urban rivers. Understanding their biochemical adaptations allows us to better appreciate the complexity of interactions between organisms and their environment and develop more effective approaches to protecting and managing urban aquatic ecosystems.

Materials and Methods

Sampling area

Fiddler crabs were collected in December 2022 around the mangrove ecosystem area of Tanjung Api-Api Port and Sungsang Village, Banyuasin, South Sumatra (Figure 1). Tanjung Api-Api is surrounded by an extensive mangrove ecosystem that provides important habitats for various types of flora and fauna (fiddler crabs).^{32,41,42} In addition, Sungsang Village is surrounded by dense mangrove ecosystem, which are ideal habitats for fiddler crabs and various other marine species.⁴³⁻⁴⁵ The mangrove ecosystem at these two sites are important habitats for fiddler crabs (*Uca spp.*), which are known for their unique behaviors, such as burrowing in mangrove mud, and their important role in the ecosystem as bioindicators of environmental health. According to Marochi *et al.* (2022)⁴⁶, fiddler crabs usually inhabit mangrove habitats. Due to the uneven distribution of mangroves, understanding their connectivity and identifying local endemism is essential.



Figure 1: Map of sampling locations in Tanjung Api-Api Port area and Sungsang Village, Banyuasin District, South Sumatra, Indonesia.¹⁴⁸

Environmental quality measurement

The condition of the aquatic environment at the sampling site was measured using multiparameters, including dissolved oxygen (DO), salinity, pH, and temperature parameters.⁴⁷ Environmental parameters were assessed using a multiparameter device (Hanna HI 9829-01042, USA), and salinity was analyzed with a portable refractometer (ATC Portable, China).

Preparation of fiddler crabs

The sample preparation process was done according to the method described by Hamdi *et al.* (2020)⁴⁸ with modification. Fiddler crabs were cleaned from dirt using running water, followed by separation of the shell from the meat, and then oven-dried at 40°C. The dried sample was thereafter pulverized with the aid of an electric blender.

Determination of weight loss on drying

Briefly, samples were weighed before and after drying in an oven at 40°C until a constant weight was achieved. The percentage of weight loss was then calculated.

Extraction of fiddler crabs

The dried powdered sample (500 mg) was macerated in 2 L of ethanol (≥96% purity, Merck, Germany) at room temperature for 24 h. The extract solution was subsequently filtered through Whatman 40 filter paper (Whatman International Ltd, UK). The resulting extract was then subjected to evaporation using a rotary evaporator (DLAB RE100-Pro, China) at 40°C until the solvent has completely evaporated, yielding a concentrated paste. The percentage yield of the extract was calculated. This temperature is carefully selected to avoid degrading the compounds present in the extract.⁴⁹

Determination of antioxidant activity

The antioxidant activity of the Fiddler crab extract was determined using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging assay as previously described with slight modification.⁵⁰⁻⁵² DPPH stock solution (0.1 mM) was made by dissolving 0.002 g of DPPH crystals (Merck, Germany) in 50 mL of ethanol. Different concentrations (2000, 1000, 500, 250, 125, and 62.5 ppm) of the crab extract were prepared in ethanol, and 1 mL of the extract solution was added to 1 mL of 0.1 mM DPPH solution, followed by the addition of 1 mL of 96% ethanol in a vial. The mixture was vortexed, then incubated at room temperature in the dark for 30 minutes. The absorbance of the reaction mixture was measured at 517 nm using a UV-Vis spectrophotometer (Shimadzu 2100, Japan). Ascorbic acid at same concentrations as the extract was used as the reference standard. The percentage inhibition of DPPH radical was calculated using the formula below (Equation 1).

$$\% \text{ inhibition} = \frac{\text{blank abs} - \text{sample abs}}{\text{blank abs}} \times 100 \quad (1)$$

The antioxidant capacity of the extract was reported in terms of IC₅₀, which refers to the concentration in mg/mL of the extract required to reduce DPPH radical by 50%.^{53,54}

The IC₅₀ value was obtained from a linear regression equation (Equation 2) of the plot of sample concentration (x-axis) versus the percentage inhibition of DPPH radical (y-axis).⁵⁵

$$Y = ax + b \quad (2)$$

Phytochemical analysis

Fiddler crab extract was subjected to qualitative phytochemical tests for alkaloids, flavonoids, saponins, tannins, and terpenoids/steroids according to standard procedures.⁵⁶⁻⁵⁸

Gas chromatography-mass spectrometry (GC-MS) analysis

The chemical profile of fiddler crab extract was determined by GC-MS analysis as described previously.^{59,60} The GC-MS analysis was conducted using a Shimadzu QP2010 Plus (Shimadzu Corp., Japan), equipped with a Rxi-5ms capillary column (30 m × 0.25 mm i.d., 0.25 μm film thickness). Briefly, a 1 μL sample was injected into the column, with helium used as the carrier gas at a flow rate of 1 mL/min, and the split ratio was 1:5. The temperature program for the oven started at 50°C for an initial 5 minutes, followed by a gradual increase of 5°C per minute until 280°C was reached, and held for 5 minutes. The MS transfer line was maintained at 200°C. The ionization mode used was electron ionization at 70eV and source temperature of 280°C. Compound identification was assessed using Total Ion Count (TIC). The spectra of the separated compounds were compared with the database of the NIST Reference Spectra Library. The relative percentage composition of the identified compounds was estimated from the GC peak area percentage.

Results and Discussion

Environmental quality

The growth and development of fiddler crabs in estuary waters are ecologically influenced by the quality of the aquatic environment. Study on antioxidant activity in fiddler crabs must consider water quality because these factors have a direct effect on the physiological and biochemical conditions of animals. Temperature, salinity, pH, and DO not only affect the health and growth of marine organisms, but they also

determine their ability to produce and store bioactive compounds.⁵¹⁻⁶³ The aquatic environmental quality parameters including DO, pH, temperature, and salinity are presented in Table 1.

Table 1: Environmental quality of the sampling sites

Location	Environmental quality parameter			
	DO (mg/L)	pH	Temperature (°C)	Salinity (PSU)
Sungsang Village	6.83	7.13	31	12
Tanjung Api-Api Port	6.94	7.3	31.5	10

Based on environmental quality measurements, both sites showed DO levels > 5 mg/L. Most aquatic organisms depend on oxygen for survival and cannot endure for extended periods in water with DO levels below 5 mg/L.⁶⁴ Low DO levels significantly affect aquatic organisms,⁶⁶ influencing respiration rates and overall survival.⁶⁵⁻⁶⁷ DO is an important indicator for water quality, as aquatic organisms depend on oxygen for respiration.^{68,69} DO values in Sungsang Village and Tanjung Api-Api Port area indicate an environment that supports the survival of aquatic organisms such as fish and fiddler crabs.

The pH levels at both sites suggest neutral to mildly alkaline water conditions, with a pH range between 6.5 and 8.5 which is generally considered safe for most aquatic organisms.⁷⁰ The pH values at Sungsang Village and Tanjung Api-Api Port are within the ideal range, indicating that there is no significant acidic or alkaline contaminants at these two sites. The causes of drastic changes in pH are pollution sources such as industrial waste, domestic waste, and agricultural watercourses that contain hazardous chemicals.⁷¹⁻⁷³ The temperature at both sites was around 31°C. This temperature is within the range generally found in tropical waters. A stable water temperature that matches the thermal tolerance of aquatic organisms is essential for their physiological processes, including metabolism and reproduction.^{74,75} Extremely high or low temperatures can lead to thermal stress in aquatic organisms.^{76,77} Temperature stability is essential for the physiological processes of aquatic organisms, including metabolism and reproduction.⁷⁸ Elevated temperatures can accelerate metabolism, reduce oxygen availability, and affect sexual maturity. Salinity of Sungsang Village water sample was slightly higher (12 PSU) compared to that of Tanjung Api-Api Port (10 PSU). Both values indicate slightly brackish water conditions, which are common in estuarine habitats. Salinity affects the distribution and adaptation of aquatic organisms.⁷⁹ Results from previous studies have shown that fiddler crabs exhibit higher physiological tolerance to increased salinity levels, supporting their osmoregulatory capabilities.^{80,81}

Environmental quality is a key determinant of the survival and biological activities of fiddler crabs. Adequate DO enhances respiratory efficiency, a neutral to slightly alkaline pH stabilizes the chemical environment, temperature stability prevents thermal stress, and optimal salinity ensures osmoregulation. Monitoring these parameters is important because significant fluctuations could signal environmental changes due to anthropogenic activities.^{41,82}

Description of fiddler crabs

The fiddler crab has an intact exoskeleton with a robust carapace, large chelipeds, and specialized legs adapted for sandy or muddy environments (Figure 2). Fiddler crab males are characterized by a large and strong body, which is adapted for various functions, such as attracting females and defense. The carapace surface is hardened, featuring distinct textures and colour patterns that enhance camouflage and provide mechanical protection from predators and environmental stressors.



Figure 2: Body shape of the fiddler crab (*Uca spp.*). (A) Full body, (B) Claws, and (C) Carapace

Based on the observations from the present study, the fiddler crabs discovered were *Uca spp.* Commonly found in estuarine environments like salt marshes and mangroves, play a significant role in ecosystem engineering and are recognized for their distinct sexual dimorphism.⁸³ Male crabs have one large cheliped, while females have two equally-sized chelipeds.⁸⁴⁻⁸⁶ Male crabs use their large chelipeds to attract females and compete with fellow males, while female crabs invest more energy in reproduction than growth.⁸⁷

Fiddler crabs construct above-ground sediment structures made of mud or sand, located within or slightly above the tidal zone.⁸⁸ Male crabs use their large chelipeds for visual signals and other vibratory behaviors to repel intruders or attract females.^{83,89,90} Fiddler crab carapace and claw coloration have three main functions: thermoregulation, camouflage, and intraspecific communication.^{91,92}

Feeding behavior analysis reveals that fiddler crabs primarily consume organic material, including bacteria and microalgae, obtained from mangrove sediments.⁹³ Mud fiddler crabs actively separate detritus from mineral particles, contributing to sediment aeration and organic matter decomposition.^{93,94} Fiddler crabs face daily and seasonal variations in salinity, temperature, and environmental contamination, making them an attractive model for studying the biochemical mechanisms of environmental adaptation.^{85,97} Due to their territorial nature, and lack of mobility, fiddler crabs are vulnerable to chronic environmental pollution.⁹⁸ Exposure of fiddler crabs to extreme tidal conditions and elevated temperatures can induce dehydration, oxidative stress, and metabolic impairment, leading to reduced survival rates.^{99,100}

Characteristics of fiddler crab extract

The weight loss of fiddler crabs was higher in the samples collected from Tanjung Api-Api Port area with a percentage weight loss of 77.72%, while the samples from Sungsang Village had a percentage weight loss of 74.65% (Table 2).

Table 2: Weight loss of fiddler crabs

Location	Sample weight (g)		Weight loss (%)
	Wet	Dry	
Sungsang Village	200	50.7	74.65
Tanjung Api-Api Port	100	22.28	77.72

The weight loss is primarily due to the high water content of crabs. Environmental factors such as DO, pH, temperature, and salinity, as well as environmental stress from human activities, may have contributed to this difference. The lower salinity in Tanjung Api-Api Port may cause the crabs to absorb more water to maintain osmotic balance, resulting in higher weight shrinkage when dried. It has been opined that salinity fluctuations affect the physiology of aquatic organisms.¹⁰¹ In addition, slightly higher temperatures can increase

metabolism and water evaporation from the crab's body.^{99,102} Variations in pH and DO levels also influence crab adaptation and health, affecting physiological responses to environmental stress.¹⁰³ The fiddler crab extraction process using ethanol resulted in a higher extract yield (15.75%) in the crab sample collected in Tanjung Api-api port area compared to that of Sungsang Village sample which produced an extract yield of 13.75% (Table 3).

Table 3: Percentage yield of fiddler crab ethanol extract

Location	Sample weight (g)		Percentage yield (%)
	Dry powder	Crude extract	
Sungsang Village	20	2.75	13.75
Tanjung Api-Api Port	20	3.15	15.75

This difference is likely due to variations in environmental factors, such as water quality and food availability. Solvent type, extraction conditions (temperature, duration, solvent-to-sample ratio), and crab biochemical composition has been shown to significantly influence extraction efficiency.¹⁰⁴ For instance, ethanol as a polar solvent is widely used to extract bioactive compounds,^{105,106} and has been shown to be effectiveness in isolating various biochemicals in good yield.¹⁰⁷ Optimized extraction conditions enhance bioactive compound recovery, improving extract yield and chemical quality.^{108,109}

Antioxidant activity in fiddler crabs

The results of the antioxidant activity test on fiddler crabs from two different areas, namely Sungsang Village and Tanjung Api-api Port are presented in Figure 3. The crab samples from both locations were found to possess weak antioxidant activity based on their IC₅₀ values. The IC₅₀ values of the crab extracts from Sungsang Village and Tanjung Api-Api Port area were 190.786 µg/mL and 174.617 µg/mL.

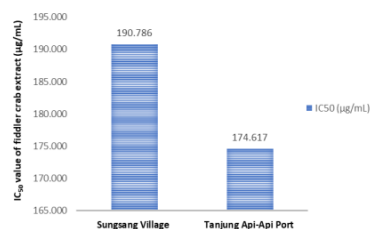


Figure 3: Antioxidant activity of fiddler crab ethanol extract

High IC₅₀ values suggest that a higher concentration of the extract is needed to inhibit 50% of DPPH free radicals, implying a lower level of antioxidant activity. These results may have been influenced by environmental factors such as pollution levels, pollutants, and habitat conditions. A previous report on the antioxidant activity of *Anadara granosa* from Sungsang village area revealed a strong activity with IC₅₀ value of 85 µg/mL.⁵³ As for the Tanjung Api-Api Port area, a weak antioxidant activity was found for mangrove species *Avicennia marina* with IC₅₀ value of 171.160 µg/mL, a moderate activity for *Bruguiera gymnorhiza* with IC₅₀ of 105.090 µg/mL, and a strong activity for *Sonneratia alba* with IC₅₀ of 28.064 µg/mL.³² The difference may be due to different species and changing environmental conditions.

The marked difference between the two areas may be due to variations in pollution levels and the types of pollutants present. Tanjung Api-Api Port is likely to have higher pollution levels due to intense port activities and vessel traffic, which can produce various pollutants, including heavy metals and toxic organic compounds.^{44,110} Changes in an

organism's antioxidant capacity have a significant impact and have been regarded as a marker for assessing environmental pollution in aquatic ecosystems resulting from human activities.¹¹¹

Fiddler crabs living in an area may be exposed to various pollutants that can induce oxidative stress and damage their natural antioxidant capacity. Previous research has reported that there has been heavy metal pollution in the Tanjung Api-api Port area, with lead (Pb) concentration in sediment ranging from 7.0104 to 11.8186 mg/kg, and copper (Cu) concentration ranging from 3.7127 to 4.5347 mg/kg.²⁷ Heavy metal contamination in biological and environmental samples has been widely studied due to its potential health risks. A study on RUZU bitters, a polyherbal extract with antidiabetic properties, reported the presence of heavy metals such as Cr (1.09 mg/L), Zn (0.10 mg/L), Fe (2.10 mg/L), Mn (0.23 mg/L), Cu (0.20 mg/L), Cd (0.06 mg/L), and others, but Pb and Cd were found to be absent.¹¹² Various studies have highlighted that oxidative stress in organisms, caused by pollutant exposure, can impair the immune function of mud crabs by damaging the hepatopancreas, triggering antioxidant enzyme activity, and affecting immune gene expression.¹¹³ A research report explained that exposure to heavy metals leads to the accumulation of reactive oxygen species (ROS) in marine decapods, surpassing the capacity of antioxidant enzymes to neutralize them.¹¹⁴ It has also been reported that the effects of persistent organic pollutants in the cellular defense mechanisms and physiological functions in crustaceans differ based on the compound, tissue, and species involved.¹³ In addition to pollutant-induced factors, variations in diet and the nutrient content of their habitat may also play a role in low antioxidant activity.¹¹⁵⁻¹¹⁷

Phytochemical constituents of fiddler crab extract

The crude ethanol extracts of fiddler crabs with the stronger antioxidant activity from both areas were subjected to phytochemical tests. From the results of the phytochemical screening, fiddler crabs from the Tanjung Api-api harbor contained a group of bioactive compounds, including saponins, terpenoids, and alkaloids (Table 4).

Table 4: Phytochemical compounds of fiddler crab ethanol extract from Tanjung api-api port area

Phytochemical	Inference
Alkaloids	+
Flavonoids	-
Terpenoids	+
Steroids	-
Saponins	+
Tannins	-

‘+’ indicates presence of phytoconstituents;

‘-’ indicates absence of phytoconstituents

These compounds are known to have various beneficial biological activities. Alkaloids are known to have various pharmacological effects including antimicrobial, anticancer, and antioxidant activities.^{118,119} Terpenoids are also recognized for their anti-inflammatory and anticancer activities.¹²⁰⁻¹²² On the other hand, saponins are reported to have antimicrobial, anti-inflammatory, and antifungal activities.¹²³⁻¹²⁵ The presence of these compounds in fiddler crabs indicates their potential as a source of biologically active compounds with applications in various medical and industrial fields.⁴⁴

However, the preliminary phytochemical tests were unable to detect the presence of flavonoids, steroids, and tannins in the crab extract from Tanjung Api-api harbor. Flavonoids are commonly present in a range of plants and are known to have strong antioxidant activity.^{126,127} The absence of flavonoids may be due to environmental factors or the type of diet of fiddler crabs in the Tanjung Api-Api Port area, which may not support flavonoid biosynthesis. Steroids and tannins were also not detected, although previous studies reported them to have important roles in various biological activities (anti-inflammatory and antimicrobial), this could be due to species-specific metabolic

variations or differences in extraction efficiency using ethanol as a solvent.¹²⁸⁻¹³⁰

16 **Compounds identified from the GC-MS analysis of fiddler crab extract**
GC-MS analysis was conducted on fiddler crab samples collected from the Tanjung Api-Api Port area, which demonstrated higher antioxidant activity compared to that of Sungsang Village. The following classes of compounds were detected; alcohols, aliphatic amines, lactones, alkaloids, sugars, esters, steroids, ketones, and organic fatty acids. The compounds identified were **4** determined by comparing the height of the chromatogram peaks and the mass spectra data of the chromatogram peaks with those in the WILEY 7 database library. The GC-MS analysis of the fiddler crab extract identified 13 secondary metabolites, with hexadecanoic acid and its derivatives, as well as unsaturated fatty acids such as trans-13-octadecenoic acid and (E)-9-octadecenoic acid ethyl ester, and cholesterol constituting the major compounds (Figure 4, Table 5). The presence of these compounds suggests that fiddler crabs from this pollution-exposed area have developed biochemical adaptations to harsh environmental conditions. In addition, these compounds have shown potentially significant biological activities. The presence of the compound 2-Piperidinone, which belongs to the alkaloid group,^{131,132} suggests that these crabs may have developed chemical defense mechanisms to fight predators or pathogens in polluted environments. Alkaloids are known to have antimicrobial and antiparasitic properties,^{133,134} which may help the crab defend itself in environmental conditions that may be rich in pathogenic microorganisms.

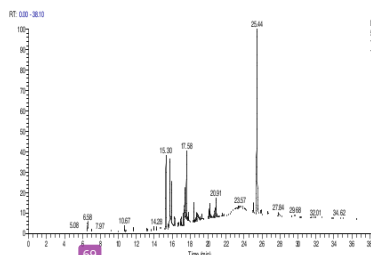


Figure 4: GC-MS chromatogram of fiddler crab extract from Tanjung Api-Api Port area

The presence of fatty acids such **28** hexadecanoic acid and its derivatives, as well as unsaturated fatty acids such as trans-13-octadecenoic acid and (E)-9-octadecenoic acid ethyl ester may suggest an adaptation of the crab to oxidative stress that may be caused by pollutants. These compounds are recognized for their anti-inflammatory and antioxidant **35** ities,¹³⁵⁻¹³⁷ and may help reduce cellular damage due to chemical and heavy metal pollutants that may be present in the harbor area. In addition, compounds such as arachidonic acid and eicosapentaenoic acid (EPA), which belong to the omega-3 fatty acid group, can help reduce cellular damage due to chemical pollution and heavy metals that may be present in the harbor area.^{138,139} These fatty acids also have an important role in reducing inflammation and maintaining cell membrane integrity,^{140,141} especially for crabs living in habitats that may be exposed to oil pollution and other chemicals. The high cholesterol content (40.32%) in this extract suggests an important adaptation in maintaining the composition and role of cell membranes under environmental stress conditions. Cholesterol helps to maintain cell membranes and protect cells from damage caused by pollutants and drastic environmental changes.^{142,143} Environmental conditions with high pollution levels due to port activities and ship traffic,^{144,145} may be the main factor that encourages fiddler crabs to produce these bioactive compounds. Contaminants like heavy metals, petroleum, and industrial chemicals can cause oxidative stress and

damage crab cells, so crabs must develop chemical defense mechanisms to survive.^{114,146,147} Overall, these results suggest that fiddler crabs in the Tanjung Api-Api Port area have developed complex biochemical adaptations to deal with challenging environmental conditions. Further research is needed to characterize these compounds in greater depth and explore their mechanisms of facilitating the adaptation of fiddler crabs to stressful environmental conditions.

Table 5: Compounds identified from the GC-MS analysis of fiddler crab extract from Tanjung Api-Api Port area

Ref.	Peak time	Area %	Name of compound	Compound group
	6.57	2.36	2-Piperidinone	Alkaloid
	15.3	5.94	Hexadecanoic acid, methyl ester	Methyl palmitate
	15.76	13.76	n-Hexadecanoic acid	Palmitic acid
	15.96	4.1	Hexadecanoic acid, ethyl ester	Ethyl palmitate
	17.4	9.11	trans-13-Octadecenoic acid	Fatty acid
	17.58	7.92	(E)-9-Octadecenoic acid ethyl ester	Fatty acid ester
	18.41	2.14	Arachidonic acid	Polyunsaturated fatty acid
	18.83	1.66	cis-5,8,11,14,17-Eicosapentaenoic acid	Omega-3 fatty acid
	23.57	1.44	Octadecenoic acid, 1,2,3-propanetriyl ester, (E,E,E)-	Triglyceride
	23.74	2.37	Hexadecenoic acid (hydroxymethyl)-1,2-ethanediyl ester	Glyceride
	25.03	2.14	1-Heptatriacanol	Alcohol
	25.44	40.32	Cholesterol	Sterol
	26.65	1.61	Ethyl iso-allocholate	Bile acid derivative

Conclusion

Fiddler crabs collected from Tanjung Api-api Port and Sungsang village were found to possess weak antioxidant activity. Phytochem **5** screening of the crab extract from Tanjung Api-api harbor revealed the presence of alkaloids, terpenoids, and saponins. GC-MS analysis further revealed the presence of hexadecanoic acid, trans-13-octadecenoic acid, (E)-9-octadecenoic acid ethyl ester, and cholesterol as major compounds in fiddler crab extract from Tanjung Api-api harbor. These findings suggest that fiddler crabs have developed complex biochemical adaptations as a defense mechanism against various anthropogenic activities along urban rivers. The presence of these bioactive compounds may also have helped the crabs mitigate oxidative stress caused by pollutants, underscoring the significant impact of human activities on **53** ic ecosystems and the adaptive responses of their inhabitants. Additional studies **70** required to thoroughly investigate the biological potentials of these compounds and their mechanisms of action in safeguarding against environmental stress.

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Conflict of Interest

The authors declare no conflict of interest.

Authors' Declaration

The authors hereby declare that 26 work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

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References

- Luo Z, Shao Q, Zuo Q, Cui Y. Impact of Land Use and Urbanization on River Water Quality and Ecology in a Dam Dominated Basin. *J Hydrol*. 2020; 584:124655.
- Anh NT, Can LD, Nhan NT, Schmalz B, Luo TL. Influences of Key Factors on River Water Quality in Urban and Rural Areas: A Review. *Case Stud Chem Environ Eng*. 2023; 8:100424.
- Gaur VK, Sharma P, Sirohi R, Awasthi MK, Dussap CG, Pandey A. Assessing the Impact of Industrial Waste on Environment and Mitigation Strategies: A Comprehensive Review. *J Hazard Mater*. 2020; 398:123019.
- Garg S, Chowdhury ZZ, Faisal ANM, Runjit NP, Thomas P. Impact of Industrial Wastewater on Environment and Human Health. In: Bhargava S, Prasad R, Prasad A, eds. *Industrial Wastewater Management and Treatment*. Springer; 2022. 197-209p. doi:10.1007/978-3-030-83811-9_10.
- Rozirwan R, Khotimah NN, Putri WAE, Fauziyah F, Aryawati R, Damiri N, Isnaini I, Nugroho RY. Environmental Risk Assessment of Pb, Cu, Zn, and Cd Concentrations Accumulated in Selected Mangrove Roots and Surrounding Their Sediment. *Biodiversitas*. 2023; 24:6733-6742.
- Khotimah NN, Rozirwan R, Putri WAE, Fauziyah F, Aryawati R, Isnaini I, Nugroho RY. Bioaccumulation and Ecological Risk Assessment of Heavy Metal Contamination (Lead and Copper) Build Up in the Roots of *Avicennia alba* and *Excoecaria agallocha*. *J Ecol Eng*. 2024; 25:101-113.
- Mustafa SA, Al-Rudaini AJ, Salman NM. Effect of Environmental Pollutants on Fish Health: An Overview. *Egypt J Aquat Res*. 2024; 50(2):225-233. doi:10.1016/j.ejar.2024.02.006.
- Mishra A, Kumari M, Swati, Kumar R, Iqbal K, Thakur IS. Persistent Organic Pollutants in the Environment: Risk Assessment, Hazards, and Mitigation Strategies. *Bioresour Technol Reports*. 2022; 19:101143.
- Barathi S, Gitanjali J, Rathinasamy G, Sabapathi N, Aruljothi KN, Lee J, Kandasamy S. Recent Trends in Polycyclic Aromatic Hydrocarbons Pollution Distribution and Counteracting Bio-remediation Strategies. *Chemosphere*. 2023; 337:139396.
- Venkatraman G, Giribabu N, Mohan PS, Mutiah B, Govindarajan VK, Alagiri M, Rahman PSA, Karsani SA. Environmental Impact and Human Health Effects of Polycyclic Aromatic Hydrocarbons and Remedial Strategies: A Detailed Review. *Chemosphere*. 2024; 351:141227.
- Behringer DC, Duermit-Moreau E. Crustaceans, One Health and the Changing Ocean. *J Invertebr Pathol*. 2021; 186:107500.
- Camacho-Jiménez L, González-Ruiz R, Yepiz-Plascencia G. Persistent Organic Pollutants (POPs) in Marine Crustaceans: Bioaccumulation, Physiological and Cellular Responses. *Mar Environ Res*. 2023; 192:106184.
- Rozirwan, Ramadani S, Putri WAE, Fauziyah, Khotimah NN, Nugroho RY. Evaluation of Calcium and Phosphorus Content in Scallop Shells (*Placuna placenta*) and Blood Cockle Shells (*Anadara granosa*) from Banyuasin Waters, South Sumatra. *Egypt J Aquat Biol Fish*. 2023; 27:1053-1068.
- Ngo-Massou VM, Din N, Kenne M, Dongmo AB. Brachyuran Crab Diversity and Abundance Patterns in the Mangroves of Cameroon. *Reg Stud Mar Sci*. 2018; 24:324-335.
- Wu F, Wang T, Li X, Zhao R, He F. Microplastic Contamination in the Dominant Crabs at the Intertidal Zone of Chongming Island, Yangtze Estuary. *Sci Total Environ*. 2023; 896:165258.
- Tang SZ, Song D, Bai SY, Huang XL, Chen ZX, Wang P, Qin DL. Trace Elements Accumulation and Health Risk Assessment of Chinese Mitten Crab (*Eriocheir sinensis*) From Monoculture and Rice-Crab Co-culture Mode. *J Food Compos Anal*. 2023; 123:105640.
- Peer N, Rajkaran A, Miranda NAF, Taylor RH, Newman B, Porri F, Raw JL, Mbense SP, Adams JB, Perissinotto R. Latitudinal Gradients and Poleward Expansion of Mangrove Ecosystems in South Africa: 50 Years After Macnae's First Assessment. *Afr J Mar Sci*. 2018; 40:101-120.
- Peer N, Miranda NA, Perissinotto R. Impact of Fiddler Crab Activity on Microphytobenthic Communities in a South African Mangrove Forest. *Estuar Coast Shelf Sci*. 2019; 227:106332.
- Shih HT, Ng PTL, Davie PJF, Schubart CD, Türkay M, Naderloo R, Jones D. Systematics of the Family Ocypodidae Rafinesque, 1815 (Crustacea: Brachyura), Based on Phylogenetic Relationships, With a Reorganization of Subfamily Rankings and a Review of the Taxonomic Status of *Uca* Leach, 1814, *Sensu Lato* and Its Subgenera. *Raffles Bull Zool*. 2016; 64:139-175.
- Pardo JCF, Stefaneli-Silva G, Christy JH, Costa TM. Fiddler Crabs and Their Above-Ground Sedimentary Structures: A Review. *J Ethol*. 2020; 38:137-154.
- Peer N, Rishworth GM, Miranda NAF, Perissinotto R. Biophysical Drivers of Fiddler Crab Species Distribution at a Latitudinal Limit. *Estuar Coast Shelf Sci*. 2018; 208:131-139.
- Reis A and Barros F. Tropical Saltmarshes Are Important to Juvenile Fiddler Crabs but not as Refuges from Large Predators or High Temperatures. *Mar Environ Res*. 2020; 161:105133.
- Banerjee K, Sahoo NR, Khemundu GR. Geoengineering Structures of Crabs and Their Role in Nutrient Cycling in Mangrove Ecosystem of Mahanadi Delta, Odisha, India. In: Mishra SB, Sharma KK, eds. *Environmental Processes and Management*. Springer; 2020. 155-200p. doi:10.1007/978-3-030-38152-3_10.
- Moslen M, Miebaka CA, Ombo PK. Anthropogenic Restructuring of Fiddler Crabs (*Uca tangeri*) Communities: A Solid Wastes Perspective. In: Kemah JAN, Nkembi JBN, eds. *Biodiversity in Africa: Potentials, Threats and Conservation*. Springer; 2022. 395-419p. doi:10.1007/978-981-19-3326-4_15.
- Costa T, de MM, Soares-Gomes A. Secondary Production of the Fiddler Crab *Uca rapax* From Mangrove Areas Under Anthropogenic Eutrophication in the Western Atlantic, Brazil. *Mar Pollut Bull*. 2015; 101:533-538.
- Apine E, Ramappa P, Bhatta R, Turner LM, Rodwell LD. Challenges and Opportunities in Achieving Sustainable Mud Crab Aquaculture in Tropical Coastal Regions. *Ocean Coast Manag*. 2023; 242:106711.
- Rozirwan, Saputri AP, Nugroho RY, Khotimah NN, Putri WAE, Fauziyah, Purwiyanto AIS. An Assessment of Pb and Cu in Waters, Sediments, and Mud Crabs (*Scylla serrata*) From Mangrove Ecosystem Near Tanjung Api-Api Port Area, South Sumatra, Indonesia. *Sci Technol Indones*. 2023; 8:675-683.
- Sun D, Yu M, Yu J, Li Y, Zhou D, Wang X, Lv Z, Li X, Wang S, Yang J. Responses of Soil Nutrient Contents and

- Eco-Stoichiometric Characteristics to Fiddler Crab Activities in Coastal Wetland of the Yellow River Delta. *Ecohydrol Hydrobiol.* 2022; 22:454–465.
29. Qin G, Lu Z, Gan S, Zhang L, Wu J, Sanders CJ, He Z, Yu X, Zhang J, Zhou J, Ding R, Huang X, Chen H, He H, Yu M, Li H, Wang F. Fiddler Crab Bioturbation Stimulates Methane Emissions in Mangroves: Insights into Microbial Mechanisms. *Soil Biol Biochem.* 2024; 194:109445.
 30. Capparelli MV, Bordon IC, Araujo G, Gusso-Choueri PK, de Souza Abessa DM, McNamara JC. Combined Effects of Temperature and Copper on Oxygen Consumption and Antioxidant Responses in the Mudflat Fiddler Crab *Minuca rapax* (Brachyura, Ocypodidae). *Comp Biochem Physiol C Toxicol Pharmacol.* 2019; 223:35–41.
 31. Silveyra GR, Silveyra P, Brown M, Poole S, Vatnick I, Medesani DA, Rodriguez EM. Oxidative Stress and Histopathological Effects by Microplastic Beads, in the Crayfish *Procambarus clarkii*, and Fiddler Crab *Leptuca pugilator*. *Chemosphere.* 2023; 343:140260.
 32. Rozirwan R, Hananda H, Nugroho RY, Apri R, Khotimah NN, Fauziyah F, Putri WAE, Aryawati R. Antioxidant Activity, Total Phenolic, Phytochemical Content, and HPLC Profile of Selected Mangrove Species from Tanjung Api-Api Port Area, South Sumatra, Indonesia. *Trop J Nat Prod Res.* 2024; 7:3482–3489.
 33. Bajaj S, Singh S, Sharma P. Role of Antioxidants in Neutralizing Oxidative Stress. In: Rahman MH, Chatterjee S, eds. *Nutraceutical Fruits and Foods for Neurodegenerative Disorders.* Elsevier; 2024. 353–378p. doi:10.1016/B978-0-443-18951-7.00020-7.
 34. Liu JD, Liu WB, Zhang CY, Xu CY, Zheng XC, Zhang DD, Chi CL. Dietary Glutathione Supplementation Enhances Antioxidant Activity and Protects Against Lipopolysaccharide-Induced Acute Hepatopancreatic Injury and Cell Apoptosis in Chinese Mitten Crab, *Eriocheir sinensis*. *Fish Shellfish Immunol.* 2020; 97:440–454.
 35. Yang X, Yu X, Sun N, Shi X, Niu C, Shi A, Cheng Y. Glyphosate-Based Herbicide Causes Spermatogenesis Disorder and Spermatozoa Damage of the Chinese Mitten Crab (*Eriocheir sinensis*) by Affecting Testes Characteristic Enzymes, Antioxidant Capacities and Inducing Apoptosis. *Toxicol Appl Pharmacol.* 2022; 447:116086.
 36. Anjali, Kumar S, Korra T, Thakur R, Arutselvan R, Kashyap AS, Nehela Y, Chaplygin V, Minkina T, Keswani C. Role of Plant Secondary Metabolites in Defence and Transcriptional Regulation in Response to Biotic Stress. *Plant Stress.* 2023; 8:100154.
 37. Kumar A, Nirmal P, Kumar M, Jose A, Tomer V, Oz E, Proestos C, Zeng M, Elobeid T, Sneha V, Oz F. Major Phytochemicals: Recent Advances in Health Benefits and Extraction Method. *Molecules.* 2023; 28(19):7001.
 38. Elbandy M. Anti-Inflammatory Effects of Marine Bioactive Compounds and Their Potential as Functional Food Ingredients in the Prevention and Treatment of Neuroinflammatory Disorders. *Molecules.* 2023; 28(14):5419.
 39. Banik BK and Das A. Anticancer Activity of Natural Compounds from Marine Plants. In: Kumar P, Rahman MH, eds. *Natural Products as Anticancer Agents.* Elsevier; 2024. 237–284p. doi:10.1016/B978-0-323-99710-2.00003-2.
 40. Kongolo Kalembe MR, Makhuvele R, Njobeh PB. Phytochemical Screening, Antioxidant Activity of Selected Methanolic Plant Extracts and Their Detoxification Capabilities Against AFB1 Toxicity. *Heliyon.* 2024; 10:e24435.
 41. Rozirwan, Muda HI, Ulqodry TZ. Short Communication: Antibacterial Potential of Actinomycetes Isolated from Mangrove Sediment in Tanjung Api-Api, South Sumatra, Indonesia. *Biodiversitas.* 2020; 21:5723–5728.
 42. Rozirwan R, Muhtadi M, Ulqodry TZ, Nugroho RY, Khotimah NN, Fauziyah F. Insecticidal Activity and Phytochemical Profiles of *Avicennia marina* and *Excoecaria agallocha* Leaves Extracts. *Ilmu Kelaut Indones J Mar Sci.* 2023; 28(2):148–160. doi:10.14710/ik.jms.28.2.148–160.
 43. Saputra A, Nugroho RY, Isnaini R, Rozirwan. A Review: The Potential of Microalgae as a Marine Food Alternative in Banyuasin Estuary, South Sumatra, Indonesia. *Egypt J Aquat Biol Fish.* 2021; 25:1053–1065.
 44. Rozirwan, Az-Zahrah SAF, Khotimah NN, Nugroho RY, Putri WAE, Fauziyah, Melki, Agustiani F, Siregar YI. Ecological Risk Assessment of Heavy Metal (Pb, Cu) Contamination in Water, Sediment, and Polychaeta (*Neoleanira tetragona*) From Coastal Areas Affected by Aquaculture, Urban Rivers, and Ports in South Sumatra. *J Ecol Eng.* 2024; 25:303–319.
 45. Rozirwan, Khotimah NN, Putri WAE, Fauziyah, Apri R, Isnaini, Nugroho RY. Investigating the Antioxidant Activity, Total Phenolics and Phytochemical Profile in *Avicennia alba* and *Excoecaria agallocha* Root Extracts as a Defence Mechanism Against Pollutants. *Farmacia.* 2024; 72:1216–1226.
 46. Marochi MZ, Tangerina MMP, Rodrigues RO, Laurenzano C, Vilegas W, Costa TM, Schubart CD. Phylogeographic Structure Within the Fiddler Crabs *Leptuca thayeri* and *Uca maracoani* (Brachyura, Ocypodidae) Along the Tropical West Atlantic. *Zool Stud.* 2022; 61:52.
 47. Rozirwan, Melki, Apri R, Nugroho RY, Fauziyah, Agusallim A, Iskandar I. Assessment of Phytoplankton Community Structure in Musi Estuary, South Sumatra, Indonesia. *AACL Bioflux.* 2021; 14(3):1481–1490.
 48. Hamdi M, Nasri R, Dridi N, Li S, Nasri M. Development of Novel High-Selective Extraction Approach of Carotenoproteins From Blue Crab (*Portunus segnis*) Shells, Contribution to the Qualitative Analysis of Bioactive Compounds by HR-ESI-MS. *Food Chem.* 2020; 302:125334.
 49. Onyebuchi C and Kavaz D. Effect of Extraction Temperature and Solvent Type on the Bioactive Potential of *Ocimum gratissimum* L. Extracts. *Sci Rep.* 2020; 10:14181.
 50. Rehman G, Gul N, Khan GN, Zaman K, Anwar Z, Kakakhel MA. Ethanolic Extract of *Allacanthos crab* Inhibits Cancer Cell Proliferation, Posses Anti-Inflammatory and Antioxidant Potentials. *Gene Rep.* 2020; 21:100907.
 51. Fajriaty I, Fidianny I, Kurniati NF, Fauzi NM, Mustafa SH, Adnyana IK. In Vitro and In Silico Studies of the Potential Cytotoxic, Antioxidant, and HMG CoA Reductase Inhibitory Effects of Chitin from Indonesia Mangrove Crab (*Scylla serrata*) Shells. *Saudi J Biol Sci.* 2024; 31:103964.
 52. Peddi P, PTSRK PR, Rani NU, Tulasi SL. Green Synthesis, Characterization, Antioxidant, Antibacterial, and Photocatalytic Activity of *Suaeda maritima* (L.) Dumort Aqueous Extract-Mediated Copper Oxide Nanoparticles. *J Genet Eng Biotechnol.* 2021; 19:131.
 53. Indrayanto G, Putra GS, Suhud F. Validation of In-Vitro Bioassay Methods: Application in Herbal Drug Research. *Profiles Drug Subst Excipients Relat Methodol.* 2021; 46:273–307.
 54. Sukweenadhi J, Yunita O, Setiawan F, Kartini, Siagian MT, Danduru A, Pratiwi, Avanti C. Antioxidant Activity Screening of Seven Indonesian Herbal Extract. *Biodiversitas.* 2020; 21:2062–2067.
 55. Salusu HD, Ariani F, Obeth E, Rayment M, Budiarmo E, Kusuma IW, Arung ET. Phytochemical Screening and Antioxidant Activity of Selekop (*Lepisanthes amoena*) Fruit. *Agrivita.* 2017; 39:214–218.
 56. Ijoma KI, Ajiwe VIE, Ndubuisi JO. Evidence-Based Preferential In Vitro Antisickling Mechanism of Three Native Nigerian Plants Used in the Management of Sickle Cell Disease. *Malays J Biochem Mol Biol.* 2022; 25:9–17.
 57. Bouabida H and Dris D. Phytochemical Constituents and Larvicidal Activity of *Ruta graveolens*, *Ruta montana* and *Artemisia absinthium* Hydro-Methanolic Extract Against

- Mosquito Vectors of Avian Plasmodium (*Culiseta longiareolata*). South Afr J Bot. 2022; 151:504–511.
58. Olasunkanmi AA, Fadahunsi OS, Adegbola PI. Gas Chromatography-Mass Spectroscopic, High Performance Liquid Chromatographic and In-Silico Characterization of Antimicrobial and Antioxidant Constituents of *Rhus longipes* (Engl). Arab J Chem. 2022; 15:103601.
 59. Yue Y, Zhang Q, Wang J. Integrated Gas Chromatograph-Mass Spectrometry (GC/MS) and MS/MS-Based Molecular Networking Reveals the Analgesic and Anti-Inflammatory Phenotypes of the Sea Slater *Ligia exotica*. Mar Drugs. 2019; 17(10):588.
 60. Rahim AC, Abu Bakar MF, Pidada—*Sonneratia caseolaris*. In: Siddiq M, Ahmed J, Lobo MG, eds. Exotic Fruits: Reference Guide. Academic Press; 2018. 327-332p. doi:10.1016/B978-0-12-803138-4.00043-5.
 61. Torres G, Charmantier G, Wilcockson D, Harzsch S, Giménez L. Physiological Basis of Interactive Responses to Temperature and Salinity in Coastal Marine Invertebrate: Implications for Responses to Warming. Ecol Evol. 2021; 11:7042–7056.
 62. Karthikeyan A, Joseph A, Nair BG. Promising Bioactive Compounds from the Marine Environment and Their Potential Effects on Various Diseases. J Genet Eng Biotechnol. 2022; 20:14.
 63. Xu S, Xiao Y, Xu Y, Su L, Cai Y, Qi Z, Liu Y, Chen Z, Lakshmikanand M. Effects of Seasonal Variations and Environmental Factors on Phytoplankton Community Structure and Abundance in Beibu Gulf, China. Ocean Coast Manag. 2024; 248:106982.
 64. Bozorg-Haddad O, Delpasand M, Loaiciga HA. Water Quality, Hygiene, and Health. In: Bozorg-Haddad O, ed. Economic, Political, and Social Issues in Water Resources. Elsevier; 2021. 217-257p. doi:10.1016/B978-0-323-90567-1.00008-5.
 65. Yang J. Predicting Water Quality Through Daily Concentration of Dissolved Oxygen Using Improved Artificial Intelligence. Sci Rep. 2023; 13(1):16259.
 66. Wang J, Zhou W, Zhao M, Guo X. Water Quality Assessment and Pollution Evaluation of Surface Water Sources: The Case of Weishan and Luoma Lakes, Xuzhou, Jiangsu Province, China. Environ Technol Innov. 2023; 32:103397.
 67. Xue Y, Ma Y, Long G, He H, Li Z, Yan Z, Wan J, Zhang S, Zhu B. Evaluation of Water Quality Pollution and Analysis of Vertical Distribution Characteristics of Typical Rivers in the Pearl River Delta, South China. J Sea Res. 2023; 193:102380.
 68. Wilson J, Ucham G, Beman JM. Climatic, Physical, and Biogeochemical Changes Drive Rapid Oxygen Loss and Recovery in a Marine Ecosystem. Sci Rep. 2019; 9(1):14605.
 69. Rozirwan, Iskandar I, Hendri M, Apri R, Supardi, Azhar N, Mardiansyah W. Distribution of Phytoplankton Diversity and Abundance in Maspari Island Waters, South Sumatera, Indonesia. J Phys Conf Ser. 2019; 1282(1):012012.
 70. Boyd CE. pH, Carbon Dioxide, and Alkalinity. In: Boyd CE. Water Quality: An Introduction. Springer; 2015. 153-178p. doi:10.1007/978-3-319-17446-4_8.
 71. Zhou X, Xu Z, Liu W, Wu Y, Zhao T, Jiang H, Zhang X, Zhang J, Zhou L, Wang Y. Chemical Composition of Precipitation in Shenzhen, a Coastal Mega-City in South China: Influence of Urbanization and Anthropogenic Activities on Acidity and Ionic Composition. Sci Total Environ. 2019; 662:218–226.
 72. Dewangan SK, Toppo DN, Kujur A. Investigating the Impact of pH Levels on Water Quality: An Experimental Approach. Int J Res Appl Sci Eng Technol. 2023; 11:756–759.
 73. Priya AK, Muruganandam M, Rajamanickam S, Sivarethinamohan S, Gaddam MKR, Velusamy P, Gomathi R, Ravindran G, Gurugubelli TR, Muniasamy SK. Impact of Climate Change and Anthropogenic Activities on Aquatic Ecosystem – A Review. Environ Res. 2023; 238:117233.
 74. Li S, Guo H, Chen Z, Jiang Y, Shen J, Pang X, Li Y, Li S. Effects of Acclimation Temperature Regime on the Thermal Tolerance, Growth Performance and Gene Expression of a Cold-Water Fish, *Schizothorax prenanti*. J Therm Biol. 2021; 98:102918.
 75. Kazmi SSUH, Wang YYL, Cai YA, Wang Z. Temperature Effects in Single or Combined with Chemicals to the Aquatic Organisms: An Overview of Thermo-Chemical Stress. Ecol Indic. 2022; 143:109354.
 76. Jawad LA and Jawad LA. The Effects of Thermal Pollution on the Aquatic Life in the Southern Marshes of Iraq. Coast Res Libr. 2021; 36:559–571.
 77. Osilla EV, Marsidi JL, Shumway KR, Sharma S. Physiology, Temperature Regulation. StatPearls. 2023.
 78. Audzijonyte A, Barneche DR, Baudron AR, Belmaker J, Clark TD, Marshall CT, Morrongiello JR, van Rijn I. Is Oxygen Limitation in Warming Waters a Valid Mechanism to Explain Decreased Body Sizes in Aquatic Ectotherms? Glob Ecol Biogeogr. 2019; 28:64–77.
 79. Rozirwan R, Bahrudin I, Barus BS, Nugroho RY, Khotimah NN. First Assessment of Coral Mussidae in Kelagian Island Waters, Lampung. In: Proceedings of the 9th International Symposium on Innovative Bioproducts and Bioengineering (ISIBIO) 2022: Strengthening Bioeconomy Through Applied Biotechnology, Bioengineering and Biodiversity. Vol 2972. IOP Publishing; 2023:040008.
 80. dos Santos CCM, da Costa JFM, dos Santos CRM, Amado LL. Influence of Seasonality on the Natural Modulation of Oxidative Stress Biomarkers in Mangrove Crab *Ucides cordatus* (Brachyura, Ucridae). Comp Biochem Physiol A Mol Integr Physiol. 2019; 227:146–153.
 81. dos Santos CCM, Ferreira JA, dos Santos CRM, Amado LL. Seasonal Modulation of Oxidative Stress Biomarkers in Mangrove Oyster (*Crassostrea gasar*) From an Amazon Estuary. Comp Biochem Physiol A Mol Integr Physiol. 2021; 257:110953.
 82. Fitriya Y, Rozirwan, Fitriani M, Nugroho RY, Fauziyah, Putri WAE. Gastropods as Bioindicators of Heavy Metal Pollution in the Banyuasin Estuary Shrimp Pond Area, South Sumatra, Indonesia. Acta Ecol Sin. 2023; 43(2):1129–1137. doi:10.1016/J.CHNAES.2023.05.009.
 83. Crane J. Fiddler Crabs of the World: Ocypodidae: Genus UCA. Princeton University Press; 1975.
 84. Swanson BO, George MN, Anderson SP, Christy JH. Evolutionary Variation in the Mechanics of Fiddler Crab Claws. BMC Evol Biol. 2013; 13:1–11.
 85. Fogo BR, Sanches FHC, Costa TM. Testing the Dear Enemy Relationship in Fiddler Crabs: Is There a Difference Between Fighting Conspecific and Heterospecific Opponents? Behav Processes. 2019; 162:90–96.
 86. Pena RC and Levinton J. Two Species of Fiddler Crab Show No Cost of Bearing a Sexually Selected Giant Claw in Predator Escape Behaviors. J Exp Mar Biol Ecol. 2021; 541:151570.
 87. Kristensen E. Mangrove Crabs as Ecosystem Engineers; With Emphasis on Sediment Processes. J Sea Res. 2008; 59:30–43.
 88. Mokhtari M, Ghaffar MA, Usup G, Cob ZC. Determination of Key Environmental Factors Responsible for Distribution Patterns of Fiddler Crabs in a Tropical Mangrove Ecosystem. PLoS One. 2015; 10:e0117467.
 89. Mowles SL, Jennions M, Backwell PRY. Multimodal Communication in Courting Fiddler Crabs Reveals Male Performance Capacities. R Soc Open Sci. 2017; 4:170068.
 90. Kim M, Park S, Lee HM, Kim T. Where the Fiddlers Sing: Fiddler Crabs Change Their Tunes Depending on the Context. Anim Behav. 2024; 207:37–45.

91. Christy JH and Salmon M. Ecology and Evolution of Mating Systems of Fiddler Crabs (Genus *Uca*). Biol Rev. 1984; 59:483–509.
92. Takeshita F. Color Changes of Fiddler Crab Between Seasons and Under Stressful Conditions: Patterns of Changes in Lightness Differ Between Carapace and Claw. J Exp Mar Biol Ecol. 2019; 511:113–119.
93. Neylan IP, Smith CS, Swanson ED, Fegley SR, Gittman RK. Interspecific and Intraspecific Interactions Between Fiddler Crabs *Minuca pugnax* (Mud Fiddler) and *Leptuca pugilator* (Sand Fiddler) Influence Species' Burrowing Behavior. J Exp Mar Biol Ecol. 2019; 517:40–48.
94. Riascos JM and Gomez N. A Bioengineer in the City—The Darwinian Fitness of Fiddler Crabs Inhabiting Plastic Pollution Hotspots. Environ Pollut. 2024; 335:122254.
95. Capparelli MV, Abessa D, McNamara JC. Effects of Metal Contamination *In Situ* on Osmoregulation and Oxygen Consumption in the Mudflat Fiddler Crab *Uca rapax* (Ocypodidae, Brachyura). Comp Biochem Physiol C Toxicol Pharmacol. 2016; 185–186:102–111.
96. Faria SC, Faleiros RO, Brayner FA, Alves LC, Bianchini A, Romero C, Buranello RC, Mantelatto FL, McNamara JC. Macroevolution of Thermal Tolerance in Intertidal Crabs from Neotropical Provinces: A Phylogenetic Comparative Evaluation of Critical Limits. Ecol Evol. 2017; 7:3167–3176.
97. Thurman CL, Faria SC, McNamara JC. Geographical Variation in Osmoregulatory Abilities Among Populations of Ten Species of Fiddler Crabs from the Atlantic Coast of Brazil: A Macrophysiological Analysis. J Exp Mar Biol Ecol. 2017; 497:243–253.
98. Capparelli MV, Gusso-Choucri PK, Abessa DM, de S, McNamara JC. Seasonal Environmental Parameters Influence Biochemical Responses of the Fiddler Crab *Minuca rapax* to Contamination *In Situ*. Comp Biochem Physiol C Toxicol Pharmacol. 2019; 216:93–100.
99. Principe SC, Augusto A, Costa TM. Differential Effects of Water Loss and Temperature Increase on the Physiology of Fiddler Crabs from Distinct Habitats. J Therm Biol. 2018; 73:14–23.
100. Levinton J. Thermal Stress: The Role of Body Size and the Giant Major Claw in Survival and Heat Transfer of a Fiddler Crab (*Leptuca pugilator*). J Exp Mar Biol Ecol. 2020; 530–531:151428.
101. Urbina MA and Glover CN. Effect of Salinity on Osmoregulation, Metabolism and Nitrogen Excretion in the Amphidromous Fish, Inanga (*Galaxias maculatus*). J Exp Mar Biol Ecol. 2015; 473:7–15.
102. da Silva Vianna B, Miyai CA, Augusto A, Costa TM. Effects of Temperature Increase on the Physiology and Behavior of Fiddler Crabs. Physiol Behav. 2020; 215:112765.
103. Thangal SH, Muralisankar T, Mohan K, Santhanam P, Venmathi Maran BA. Biological and Physiological Responses of Marine Crabs to Ocean Acidification: A Review. Environ Res. 2024; 248:118238.
104. Li J, Sobanika A. A Systematic Analysis of the Effect of Extraction Solvents on the Chemical Composition of Extraction Solutions and the Analytical Implications in Extractables and Leachables Studies. J Pharm Biomed Anal. 2023; 222:115081.
105. Tavakoli S, Hong H, Wang K, Yang Q, Gahruie HH, Zhuang S, Li Y, Liang Y, Tan Y, Luo Y. Ultrasonic-Assisted Food-Grade Solvent Extraction of High-Value Added Compounds from Microalgae *Spirulina platensis* and Evaluation of Their Antioxidant and Antibacterial Properties. Algal Res. 2021; 60:102493.
106. Rozirwan, Nanda, Nugroho RY, Diansyah G, Muhtadi, Fauziyah, Putri WA, Agusalam A. Phytochemical Composition, Total Phenolic Content and Antioxidant Activity of *Anadara granosa* (Linnaeus, 1758) Collected from the East Coast of South Sumatra, Indonesia. Baghdad Sci J. 2023; 1–8.
107. Erharuyi O and Falodun A. Free Radical Scavenging Activities of Methanol Extract and Fractions of *Picralima nitida* (Apocynaceae). J Appl Sci Environ Manag. 2012; 16:291–294.
108. Chen DQ, Ji WB, Granato D, Zou C, Yin JF, Chen JX, Wang F, Xu YQ. Effects of Dynamic Extraction Conditions on the Chemical Composition and Sensory Quality Traits of Green Tea. LWT. 2022; 169:113972.
109. Shen L, Pang S, Zhong M, Sun Y, Qayum A, Liu Y, Rashid A, Xu B, Liang Q, Ma H, Ren X. A Comprehensive Review of Ultrasonic Assisted Extraction (UAE) for Bioactive Components: Principles, Advantages, Equipment, and Combined Technologies. Ultrason Sonochem. 2023; 101:106646.
110. Putri WAE and Purwiyanto AIS. Cu and Pb Concentrations in Water Column and Plankton of Downstream Section of the Musi River. J Ilmu Teknol Kelaut Trop. 2016; 8:773–780.
111. Roy S, Sarkar DJ, Chakraborty N, Mondal K, Das BK. Bioaccumulation of Polystyrene Microplastics and Changes in Antioxidant and AChE Pattern in a Freshwater Snail (*Filopaludina bengalensis*) From River Ganga. Aquat Toxicol. 2023; 263:106697.
112. Chapter K and State L. Antioxidant Evaluation, Acute Toxicity Screening and Heavy Metal Analysis of a Poly Herbal Mixture. ChemSearch J. 2022; 13:111–119.
113. Yifei Y, Zhixiong Z, Luna C, Qihui C, Zuoyuan W, Xinqi L, Zhexiang L, Fei Z, Xiujuan Z. Marine Pollutant Phenanthrene (PHE) Exposure Causes Immunosuppression of Hemocytes in Crustacean Species, *Scylla paramamosain*. Comp Biochem Physiol C Toxicol Pharmacol. 2024; 275:109761.
114. Frías-Espiciueta MG, Bautista-Covarrubias JC, Osuna-Martínez CC, Delgado-Alvarez C, Bojórquez C, Aguilar-Juárez M, Roos-Muñoz S, Osuna-López I, Píez-Osuna. Metals and Oxidative Stress in Aquatic Decapod Crustaceans: A Review with Special Reference to Shrimp and Crabs. Aquat Toxicol. 2022; 242:106024.
115. Corino C, Prost M, Pizzi B, Rossi R. Dietary Plant Extracts Improve the Antioxidant Reserves in Weaned Piglets. Antioxidants (Basel). 2021; 10:1760.
116. Pruteanu LL, Bailey DS, Grădinaru AC, Jäntsch L. The Biochemistry and Effectiveness of Antioxidants in Food, Fruits, and Marine Algae. Antioxidants (Basel). 2023; 12:1240.
117. Zhang Y, Cheng W, Di H, Yang S, Tian Y, Tong Y, Huang H, Escalona VH, Tang Y, Li H, Zhang F, Sun B, Huang Z. Variation in Nutritional Components and Antioxidant Capacity of Different Cultivars and Organs of *Basella alba*. Plants. 2024; 13:1–15.
118. Fang Y, Li H, Ji B, Cheng K, Wu B, Li Z, Zheng C, Hua H, Li DF, Y. Renieramycin-Type Alkaloids from Marine-Derived Organisms: Synthetic Chemistry, Biological Activity and Structural Modification. Eur J Med Chem. 2021; 210:113092.
119. SG L, Sethi S, BK P, Nayak SL, MM. Ornamental Plant Extracts: Application in Food Colouration and Packaging, Antioxidant, Antimicrobial and Pharmacological Potential—A Concise Review. Food Chem Adv. 2023; 3:100529.
120. Ge J, Liu Z, Zhong Z, Wang L, Zhuo X, Li J, Jiang X, Ye XY, Xie T, Bai R. Natural Terpenoids with Anti-inflammatory Activities: Potential Leads for Anti-inflammatory Drug Discovery. Bioorg Chem. 2022; 124:105817.
121. Kuete JRN, Kepdieu RVT, Teponno RB, Kuete V. Terpenoids, Steroids, and Saponins From African Medicinal Plants as Potential Pharmaceuticals to Fight Cancers, and Their Refractory Phenotypes. In: *Advances in Botanical Research*. Academic Press; 2024. doi:<https://doi.org/10.1016/bs.abr.2024.02.011>.
122. Rozirwan R, Siswanto Ade, Khotimah NN, Nugroho RY, Putri WAE, Fauziyah F, Apri R, Hartoni H. Anti-

- inflammatory Activity and Phytochemical Profile from the Leaves of the Mangrove *Sonneratia caseolaris* (L.) Engl. for Future Drug Discovery. *Sci Technol Indones.* 2024; 9:502–516.
123. Grabowska K, Wróbel D, Żmudzki P, Podolak I. Anti-inflammatory Activity of Saponins from Roots of *Impatiens parviflora* DC. *Nat Prod Res.* 2018; 34:1581–1585.
 124. Li L, Wei M, Yu H, Xie Y, Guo Y, Cheng Y, Yao W. Antifungal Activity of Sapindus Saponins Against *Candida albicans*: Interruption of Biofilm Formation. *J Herb Med.* 2023; 42:100776.
 125. Gitanjali J, Dinesh Ram DS, Kavitha R, Amalan V, Alahmadi TA, Alharbi SA, Kandasamy S, Shanmuganthan R, Vijayakumar N. Antimicrobial, Antioxidant, Anticancer, and Antithrombotic, Competency of Saponins From the Root of *Decalepis hamiltonii*. *Environ Res.* 2023; 231:116096.
 126. Li Y, Chen Y, Chen J, Shen C. Flavonoid Metabolites in Tea Plant (*Camellia sinensis*) Stress Response: Insights from Bibliometric Analysis. *Plant Physiol Biochem.* 2023; 202:107934.
 127. Galatro A, Lucini Mas A, Luquet M, Fraga CG, Galleano M. Plants as a Source of Dietary Bioactives: Flavonoids and Basis for Their Health Benefits. *Asp Mol Med.* 2024; 4:100048.
 128. Nadaraja NS, Amiranashvili SH, Merlani M, Kakhabrishvili ML, Barbakadze NN, Geronikaki A, Petrou A, Porotkov V, Ciric A, Glamoclija J, Sokovi M. Novel Antimicrobial Agents' Discovery Among the Steroid Derivatives. *Steroids.* 2019; 144:52–65.
 129. de Melo LFM, de Queiroz Aquino-Martins VG, da Silva AP, Oliveira Rocha HA, Scortecchi KC. Biological and Pharmacological Aspects of Tannins and Potential Biotechnological Applications. *Food Chem.* 2023; 414:135645.
 130. Dembitsky VM. Biological Activity and Structural Diversity of Steroids Containing Aromatic Rings, Phosphate Groups, or Halogen Atoms. *Molecules.* 2023; 28:6159.
 131. Lei Y, Li B, Lia X, Xing X, Feng P, Zhao B, Xu S. Isolation and Total Synthesis of Dysidone A: A New Piperidone Alkaloid from the Marine Sponge *Dysidea* sp. *RSC Adv.* 2023; 13:29316–29319.
 132. Dua YD, Wang S, Dua HW, Chang XY, Chen XY, Li YL, Shu WD, Y. Organophotocatalysed Synthesis of 2-Piperidinones in One Step Via [1 + 2 + 3] Strategy. *Nat Commun.* 2023; 14:5339.
 133. Daley S, Cordell GA. Alkaloids in Contemporary Drug Discovery to Meet Global Disease Needs. *Molecules.* 2021; 26(13):3800. doi:<https://doi.org/10.3390/molecules26133800>.
 134. Mitra S, Prova SR, Sultana SA, Das R, Nainu F, Emran TB, Tareq AM, Uddin MS, Alqhtani AM, Dhama K, Simal-Gandara J. Therapeutic Potential of Indole Alkaloids in Respiratory Diseases: A Comprehensive Review. *Phytomedicine.* 2021; 90:153649.
 135. Aparna V, Dileep KV, Mandal PK, Karthe P, Sadasivan C, Haridas M. Anti-inflammatory Property of N-Hexadecanoic Acid: Structural Evidence and Kinetic Assessment. *Chem Biol Drug Des.* 2012; 80:434–439.
 136. Liu Y, Shen N, Xin H, Yu L, Xu Q, Cui YL. Unsaturated Fatty Acids in Natural Edible Resources, a Systematic Review of Classification, Resources, Biosynthesis, Biological Activities and Application. *Food Biosci.* 2023; 53:102790.
 137. Coniglio S, Shumskaya M, Vassiliou E. Unsaturated Fatty Acids and Their Immunomodulatory Properties. *Biology (Basel).* 2023; 12:1289.
 138. Hariyanto TI and Kurniawan A. Appetite Problem in Cancer Patients: Pathophysiology, Diagnosis, and Treatment. *Cancer Treat Res Commun.* 2021; 27:100336.
 139. Shahrzaman M, Hossain S, Ahmed T, Kabir SF, Minhajul Islam M, Rahman A, Sazedul Islam M, Sultana S, Rahman MM. Chapter 7 - Biological Macromolecules as Antimicrobial Agents. In: *Biological Macromolecules*. Elsevier; 2022:165–202. doi:<https://doi.org/10.1016/B978-0-323-85759-8.00007-5>.
 140. Jabbehari S and Handa JT. Oxidative Stress as a Therapeutic Target for the Prevention and Treatment of Early Age-Related Macular Degeneration. *Surv Ophthalmol.* 2021; 66:423–440.
 141. Sethwala AM, Goh I, Amerena JV. Combating Inflammation in Cardiovascular Disease. *Heart Lung Circ.* 2021; 30:197–206.
 142. Pauker K, Kráľová Lesná I, Poledne R. Cholesterol in the Cell Membrane-An Emerging Player in Atherogenesis. *Int J Mol Sci.* 2022; 23:13653.
 143. Su C, Li J, Zhang M, Pan L, Wang Y, Ding Y, Chen Z, Lu M. Dietary Cholesterol Enhances Osmoregulation, Antioxidant Defenses and Immune Response of *Litopenaeus vannamei* to Alleviate the Macromolecular Damage Induced by Salinity Stress. *Aquaculture.* 2023; 563:738861.
 144. Mueller N, Westerby M, Nieuwenhuijsen M. Health Impact Assessments of Shipping and Port-Sourced Air Pollution on a Global Scale: A Scoping Literature Review. *Environ Res.* 2023; 216:114460.
 145. Ducruet C, Polo MB, Sene MA, Lo Prete M, Sun L, Itoh H, Pigné Y. Ports and Their Influence on Local Air Pollution and Public Health: A Global Analysis. *Sci Total Environ.* 2024; 915:170099.
 146. de Jesus WB, Mota Andrade T, Soares SH, Pinheiro-Sousa DB, de Oliveira S, Rosana S, Torres HS, Protazio GS, da Silva DS, Santos DMS, de Carvalho Neta A, Vieira, Benjamin LA, Carvalho Neta R and Nonata F. Biomarkers and Occurrences of Heavy Metals in Sediment and the Bioaccumulation of Metals in Crabs (*Ucides cordatus*) in Impacted Mangroves on the Amazon Coast, Brazil. *Chemosphere.* 2021; 271:129444.
 147. Cheng CH, Ma HL, Deng YQ, Feng J, Jie YK, Guo ZX. Oxidative Stress, Cell Cycle Arrest, DNA Damage and Apoptosis in the Mud Crab (*Scylla paramamosain*) Induced by Cadmium Exposure. *Chemosphere.* 2021; 263:128277.
 148. Google Earth. Google Earth Program. 2024.

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