



Risk assessment of invasive species freshwater crayfish (*Cherax quadricarinatus*) in Lake Laut Tawar, Aceh

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ABSTRACT

This study aims to assess the distribution of *Cherax quadricarinatus* based on depth and evaluate its invasiveness using a risk assessment in Lake Laut Tawar, Central Aceh. The study was conducted at five stations representing various lake activities: Station 1 (One-One), Station 2 (Bewang), Station 3 (Gegarang), Station 4 (Mendale), and Station 5 (Dedalu). The methodology involved direct observation in the field followed by laboratory analysis. The results showed that 284 individuals were caught, consisting of 138 females and 146 males, with carapace lengths ranging from 20 to 76 mm. No consistent distribution of male and female carapace lengths was observed across all stations. The abundance of *Cherax quadricarinatus* in Lake Laut Tawar was classified as very abundant (>20%) at One-One and Bewang stations, both at a depth of 5 meters. In conclusion, *Cherax quadricarinatus* significantly dominates the lake ecosystem, as indicated by its relative abundance at different depths across the study sites. This species also shows a high potential for invasion in freshwater lakes, highlighting the need for effective management strategies.

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Introduction

Lake Laut Tawar (DLT) is located in Takengon, Central Aceh. The utilization of the lake in terms of regional economic development is very important because DLT is included in the National Priority Lake Phase II for the 2015-2019 period (KLH, 2014). This lake hosts a variety of fisheries resources, including 2 endemic species, namely depik fish (*Rasbora tawarensis*) and comrade fish (*Poropuntius tawarensis*) (Muchlisin *et al.*, 2010). One of the problems that are thought to be a threat to other species in Lake Laut Tawar is the introduction of invasive species (Muchlisin *et al.*, 2009). Based on Kamal *et al.*, (2021), one of the invasive species that entered DLT is crayfish (*Cherax quadricarinatus*). The Parastacidae family is a freshwater crayfish native to Papua New Guinea and Australia (Crandall & A, 2008). The crayfish (*Cherax quadricarinatus*) (von Martens, 1868) or red claw is a crustacean native to river catchments in northern Australia and southeastern Papua New Guinea (Lawrence and

Jones 2002). It has a larger body, dark blue to green carapace, maximum weight of males 500 grams and females 400 grams and has a wide tolerance even outside its natural habitat, making it an excellent species for aquaculture (Ghanawi & Saoud 2012).

In the most recent comprehensive assessment of *C. quadricarinatus* distribution Haubrock *et al.*, (2021) documented its presence in approximately 67 countries or territories, with established wild populations noted in 22 countries across all continents except Antarctica. The species spreads primarily through human activities like trade, aquaculture, and the aquarium industry. Once introduced, it thrives in warmer freshwater lakes due to its adaptability and lack of natural predators. Currently, confirmed feral populations exist in regions outside their native range, including Australia, various African countries (Mozambique, Namibia, South Africa, Swaziland, Zambia, and Zimbabwe), several countries in the Americas (Costa Rica, Ecuador, Jamaica, Martinique, Mexico, Puerto

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Rico, and the United States), Asian nations (Indonesia, Israel, Malaysia, Singapore, Taiwan, and Thailand), and in Europe (specifically in Spain, Slovenia, and Hungary in thermal waters).

This species can endure shallow dissolved oxygen conditions as low as one ppm. However, when humidity is high enough for crayfish to moisten their gills, they can engage in aerial respiration (Guo et al., 2019). Furthermore, if the dissolved oxygen levels in pond water decrease below one ppm, red claw crayfish will typically relocate to pond edges where oxygen levels are generally higher. In severe cases, they may even migrate. In Australia and other regions, redclaw crayfish are known to host various disease-causing organisms, including protozoans, bacteria, and viruses (Longshaw, 2011; Saoud et al., 2013). Among these, *White Spot Syndrome Virus* (WSSV) is particularly virulent in crustaceans, and *C. quadricarinatus* appears susceptible and capable of horizontally transmitting it to shrimp species (Soowannayan and Phanthura, 2011). *Cherax quadricarinatus Iridovirus* (CQIV), identified in China, can be fatal to crayfish (Li et al., 2017). Additionally, *C. quadricarinatus* is vulnerable to *Yellow Head Virus* (YHV), which has potential impacts on shrimp if transmitted (Soowannayan et al., 2015). Several other viruses have been isolated from *C. quadricarinatus*, including *Cherax Giardiavirus-like Virus* (CGV), *Spawner-Isolated Mortality Virus*, *Gill Parvovirus*, *Reoviridae viruses*, *Reo-like Virus*, *Cherax quadricarinatus Parvo-like Virus* (CqPIV), and *Penaes merguensis Densovirus* (PmergDNV), all of which pose significant concerns for aquaculture species (Saoud et al., 2013).

C. quadricarinatus has 5 pairs of walking and swimming legs. The difference between male and female lobsters can be seen in the walking legs. The gonopore in males is convex on the 5th walking leg, while in females, there is a small circular hole on the 3rd walking leg (FAO, 2008). *C. quadricarinatus* enters Indonesian waters through aquaculture activities (Edgerton, 2003). Damora et al., 2023 stated that *C. quadricarinatus* entering the waters of Lake Laut Tawar was also caused by aquaculture activities. The development of crayfish in DLT continues to increase, as seen from lobster production, which has an increasing production trend from year to year. The characteristics of invasive species are that they have the ability to develop quickly and are able to withstand high tolerance (Rodriguez, 2006). Human activities are the main cause that facilitates the introduction of alien species by intentionally or unintentionally introducing species outside the native habitat of a species. This leads to the destruction of biodiversity and can harm native species and disrupt

ecosystem processes. The higher an alien species enters the ecosystem, the higher the chance of it becoming invasive (Leprieur et al., 2014).

However, there is currently no information on the relative abundance of *C. quadricarinatus*, and how invasive this species is in Lake Laut Tawar. This study aims to analyze the distribution of carapace length size relative abundance (*C. quadricarinatus*) based on depth and assess invasive species through the cumulative scoring method in Lake Laut Tawar, Central Aceh. The existence of crayfish resources in an ecosystem needs to be managed properly so that these resources can be utilized optimally and appropriately and do not interfere with the existence of other species.

Materials and Methods

Location and time of research

This study was conducted in June 2023 at Lake Laut Tawar, Central Aceh. Sampling locations were carried out at 5 stations based on activities in the lake, namely One-One, Bewang, Gegarang, Mendale, and Dedalu (Figure 1). Sample analysis was conducted at the Fish Health Laboratory, Lukup Badak Fish Seed Center, Central Aceh District.

1. Station One-One : located in Lut Tawar Sub-district, is a floating net cage area.
2. Bewang station : located in Bintang sub-district, has little human activity around the waters.
3. Gegarang Station : located in Bintang Sub-district, is a fishing area around the waters.
4. Mendale station : Kebayakan sub-district, surrounding waters are anthropogenic activities from Takengon city.
5. Dedalu Station : Lut Tawar Sub-district, is the outlet of Lake Laut Tawar.



Figure 1. Maps showing the location research of *C. quadricarinatus* in Lake Laut Tawar, Aceh.

Research Methods

Sampling of *C. quadricarinatus* was carried out using traps measuring 20 cm x 30 cm at different depths at each station: One-One, Bewang, and Mendale stations at depths of 5, 10, and 15 m; Gegarang and Dedalu stations at depths of 1, 2, and 3 m. The difference in depth is because Gegarang station is a fishing area where no fishermen set traps for lobster, while Dedalu station is the lake outlet, and the maximum depth is only up to 3m. The time for placing the traps was in the afternoon, around 17.00 WIB, and it was lifted the next day at 09.00 WIB. The method used in this study is direct observation, namely systematic observation and recording of the object under study, followed by laboratory analysis to produce the required data. Observations were conducted at the Fish Health Laboratory, Lukup Badak Fish Seed Center, Takengon, Central Aceh.

Data analysis

The data obtained during the study was analyzed using the following formula:

Carapace length size distribution

The length distribution of crayfish (*C. quadricarinatus*) carapaces caught during the study is presented in frequency form. To determine the number of length class intervals and class intervals were calculated using the frequency distribution formula referring to [Jin et al., \(2015\)](#) :

$$Fi = ni/N \times 100$$

Description:

Fi : length frequency

Ni : number of lobsters in the i-th length class

N : total number of lobsters

Relative Abundance

The relative abundance of *C. quadricarinatus* is defined as the percentage of the number of individuals to the total number of individuals, with the equation ([Krebs, 1972](#)).

$$Kr = ni / N \times 100$$

Description:

Kr : Relative abundance (%)

Ni : Number of individuals of the i-th species

N : Total number of individuals of the species.

Abundance criteria (%)

0 : None

1-10 : Less abundant

11-20 : Abundant

>20 : Very abundant

Assessment of invasiveness of aquatic species (*Cherax quadricarinatus*)

Risk assessment is a stage of risk analysis that involves a systematic approach to drawing conclusions and assessing the likelihood and impact of the introduction or spread of invasive species. This assessment is quantitative using a scoring method. The assessment of potential hazards consists of four categories which include:

1. Potential for introduction and spread
2. Ecological impact
3. Economic impact
4. Impact on human health

The risk category for SAI (Invasive Alien Species) refers to the results of scoring with provisions referring to the 2017 Fish Quarantine and Quality Control and Fishery Product Safety Agency (BKIPM) with three levels of risk, namely:

1. Low Risk Level

The risk of SAI fish is categorized as low if the range of scoring results is less than or equal to 30.

2. Medium Risk Level

The SAI risk of a fish group is categorized as medium if the range of scoring results is between 31 - 60.

3. High Risk Level

SAI fish group risk is categorized as high if the range of scoring results is between 61 - 100.

Risk assessment to obtain risk levels uses the following formula:

$$\text{Score (f and k = 1,2,...,n)} = \text{Value} \times \text{Weight}(\%) \quad (1)$$

$$\text{Total score} = \text{Score (1)} + \text{Score (2)} + \dots + \text{Score (n)} \quad (2)$$

Where:

F: factor

k: category

n: number of factors

Water quality measurement

Water quality measurement in Lake Laut Tawar includes physical and chemical parameters as supporting data. Physical parameters are temperature (°C) using a digital thermometer and TDS (mg/L) measured using a TDS meter. Chemical parameters include pH with a pH meter measuring conductivity (µS/cm) using an EC meter. Both of these water quality parameters were measured *in situ*.

Results

Carapace length size distribution

The size distribution of crayfish carapace length ranges from 20- 76 mm. Based on the observation station, the highest size class of *C. quadricarinatus* is found at One-One station with a size class of 33-39

mm, while the lowest size class is found at Mendale station with a size class of 51-57 mm. The highest percentage of female *C. quadricarinatus* was found at Bewang station, with a size class of 39-45 mm, and the lowest at Mendale station, with a size class of 51-57 mm (Figure 2)

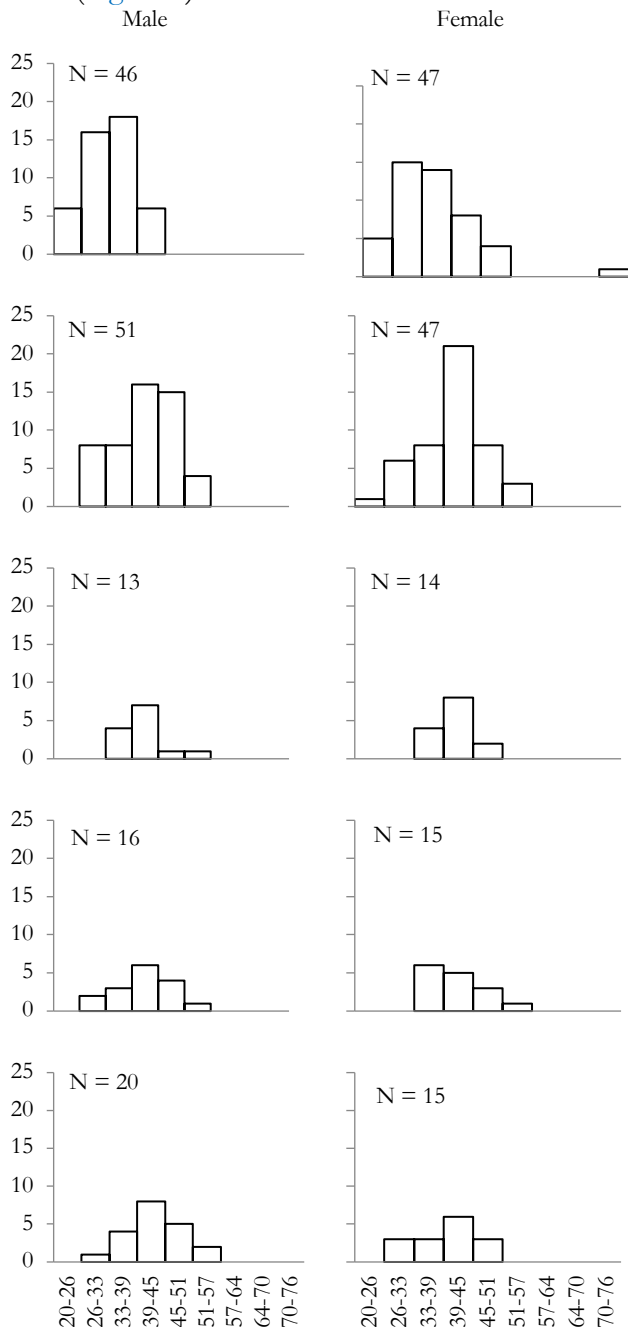


Figure 2. Distribution of male and female *C. quadricarinatus* by station in Lake Laut Tawar, Central Aceh.

Relative Abundance

Based on the results of *C. quadricarinatus* in Lake Laut Tawar, Central Aceh, 284 individuals, 138 female and 146 male lobsters, were found. *C. quadricarinatus* was obtained from catches using traps with different depths at each station with the intention of representing the size of the lobster. The

depths used were 1 m, 2 m, and 3 m at the Gegarang and Dedalu stations, while depths of 5 m, 10 m, and 15 m at One-One, Bewang and Mendale stations. The difference in depth is because Gegarang station is a fishing area, so that no fishermen set traps at a depth of > 3 m, while Dedalu station is the outlet of the Lake where the depth is < 5 m. Catch based on depth is one of the variables used to determine the presence of *C. quadricarinatus* in DLT waters.

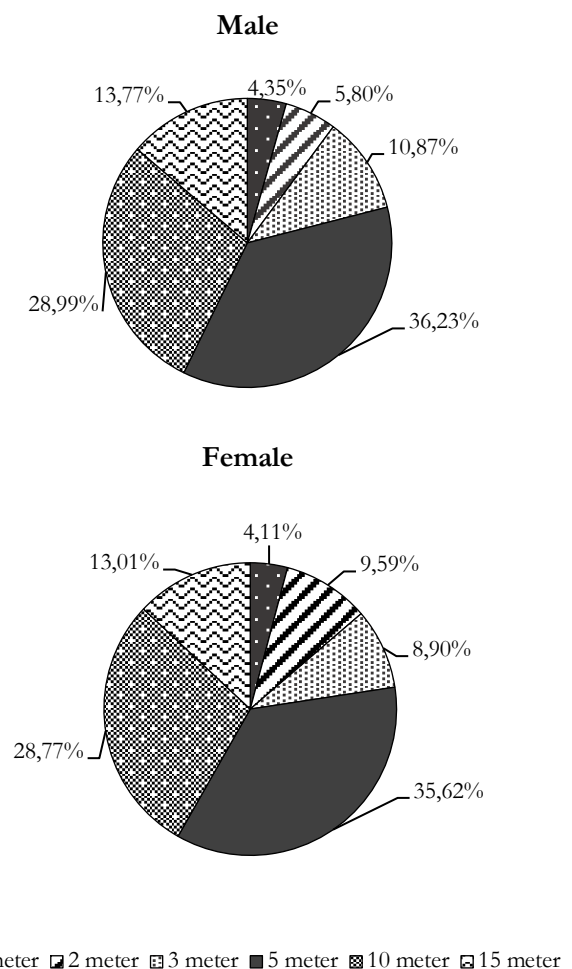


Figure 3. Relative abundance of *C. quadricarinatus* by depth.

The relative abundance of both male and female lobsters based on depth showed that the highest percentage of the catch was at 5 m depth 36.23% males and 35.62% females while the lowest was at 1 m depth 4.35% males and 4.11% females (Figure 3). Based on the observation station, the highest relative abundance of males was found at Bewang station 34.93%, and the lowest was found at Gegarang station 8.90%. The highest percentage of female relative abundance was found at One-One and Bewang stations 34.06% and the lowest at Gegarang station 10.14% (Figure 4).



Figure 4. Relative abundance of *C. quadricarinatus* based on observation stations

Table 1. Identification of Potential Hazards as Invasive Alien Species *Cherax quadricarinatus*

No	Potential hazards	Answer	Description
1	Predators?	Yes	<i>C. quadricarinatus</i> predates small fish and shrimp and even cannibalizes its species (Marufu et al., 2018).
2	Competitors?	Yes	<i>C. quadricarinatus</i> forms a population in Lake Eyre with more aggressive interactions and poses a risk of decline of native <i>Cherax destructor</i> species (Georgia et al., 2022).
3	Dominate a habitat?	Yes	<i>C. quadricarinatus</i> is widely considered an invasive species and has established wild populations in several tropical and subtropical countries, including Jamaica and Singapore (Ahyong and Yeo 2007; Belle and Yeo 2010). In this study, <i>C. quadricarinatus</i> had spread throughout all parts of Lake Laut Tawar.
4	Rapid reproductive cycle?	Yes	<i>C. quadricarinatus</i> is a relatively fastgrowing species specific to various freshwater environments (Doupe et al., 2004). According to Tropea et al. (2010) <i>C. quadricarinatus</i> can reproduce three to five times a year.
5	Fast growth?	Yes	<i>C. quadricarinatus</i> is large and growing, where weight gain is about 50-90 grams in 8- 12 months, but can be more in 117 days with a weight of 65-90 grams (Thompson et al., 2004).
6	Adaptive/highly tolerant of various environmental conditions?	Yes	<i>Cherax quadricarinatus</i> is classified as mesohaline because its adult species can survive at low temperatures (20°C) and the highest salinities. However, at salinities (up to 10 g/L), growth rates and energy reserves decrease (Prymazok et al. 2012). This crayfish is able to live in waters with water temperatures ranging from 10 - 31°C (Haubrock et al. 2021). The temperature in DLT ranges from 22-27°C with an average pH of 6.5-7 (This study).
7	Organism omnivorous?	Yes	The leading food of <i>C. quadricarinatus</i> is macrophytes, macroinvertebrates, and detritus (Marufu et al., 2018).
8	Organisms able to hybridize?	Yes	Hybridization of <i>C. quadricarinatus</i> males with <i>Cherax albetstisii</i> females resulted in high heterozygosity compared to hybridization of <i>C. quadricarinatus</i> females with <i>Cherax albetstisii</i> (Kusmini et al., 2010).
9	Organism cause health problems/carry harmful diseases that negatively affect the fish itself or other species?	Yes	There are several types of viruses and bacteria found, such as <i>Cherax quadricarinatus</i> Bacilliform virus (CqBV), <i>Cherax quadricarinatus</i> parvolike virus (CqPIV) (Edgerton et al., 2000), <i>Cherax quadricarinatus</i> reolike virus (CqRV) (Edgerton et al., 2000) which causes

No	Potential hazards	Answer	Description
10	Organism cause human health problems?	No	chronic mortality in <i>Cherax quadricarinatus</i> , Totiviruses (Poulos et al., 2006). Coxiella cheraxi bacteria, infecting gill tissue and hepatopancreas (La Fauce & Owen, 2007), Aeromonas sp., Bacillus sp., Pseudomonas sp., which are found in the shell of <i>Cherax quadricarinatus</i> (Suprpto et al., 2016). To date, there have been no studies/reports on the dangers of this species to humans, either in terms of disease or physical injury.

Table 2. Risk Assessment of Freshwater Crayfish (*C. quadricarinatus*) as an Invasive Alien Species

No	Factor	Value			Total Score
		Category	Value	Weight	
Income and Deployment Potential					
1	Breeding rate (productivity)	Slow breeding, low fecundity, and not mass-cultivated	30		
		Slow breeding, moderate fecundity, and potential for mass cultivation	60	10	10
		Fast breeding, high fecundity, and potential for mass cultivation	100		
2	Ability to spread beyond its natural habitat (tolerance and adaptation to waters in Indonesia)	Does not disperse outside its natural habitat. Requires specialized habitat	30		
		Dispersal occurs but within a limited area. This species is capable of living in 2-3 ecotypes or niches	60	10	10
		There is widespread dispersal over a large area outside of its natural habitat	100		
3	Potential entry via transportation (direct or indirect)	Potential income through transportation routes is rare	30		
		Potential income through transportation routes often occurs	60	8	4.8
		Potential income through transportation routes routinely occurs	100		
4	Regulations to prevent entry and transportation	Some regulations strictly prevent the entry and circulation of fish	30		

Description : (0-30) low risk level, (31-60) medium risk level, (61-100) high risk level.

No	Factor	Value			Total Score
		Category	Value	Weight	
5	Regulations to prevent entry and transportation	There are regulations governing the entry and exit of fish, but they still need to be effective.	60	6	3.6
		There are no regulations that strictly prevent the entry and circulation of fish	100		
	Distribution or presence in an area	Not yet present in any region/island in Indonesia	30	5	5
		It is only found in some parts/islands of Indonesia	60		
		It has spread to almost all regions/islands in Indonesia	100		
Ecological Impact					
6	Eating habits	Food types are limited	30	7	4.2
		All-consuming and greedy	60		
7	Impact on the genetic integrity of native species/potential for hybridization	All-consuming, voracious, and predator	100	6	6
		No impact on genetic integrity to native species / no potential for hybridization	30		
		Hybridize with one or more native species and produce sterile offspring that may reduce the reproduction of native species	60		
		Hybridize with one or more native species and produce fertile offspring that can compete with native species.	100		
Economic Impact					
8	Impact on capture fisheries industry/production	No impact or little impact on the capture fisheries industry/production	30	8	4.8
		Some impacts have the potential to reduce the capture fisheries industry/production	60		
		Some impacts derail the capture fisheries industry/production	100		
Impact on fish health					
9	Impact on fish health	No effect on fish health	30	4	2.4
		There is an impact on fish health through the pathogenic agents carried, causing fish illness and mortality in relatively low numbers	60		
		There is an impact on fish health through the pathogenic agents carried, causing high levels of fish sickness and mortality	100		
Impact on human health					
10	Impact on human health	No effect on human health	30	3	0.9
		Causes physical injury (claws, shells from zebra mussels, catfish hooks)	60		
		It is a disease vector for humans or as a disease organism (Zoonosis). It may also cause the death of individuals (toxic).	100		
Total Score					54,1 Medium risk

Description : (0-30) low risk level, (31-60) medium risk level, (61-100) high risk level.

The assessment of potential hazard identification, prepared by identifying 10 aspects according to BKIPM (Agency for Fish Quarantine, Quality Control, and Safety of Fishery Products) 2017. The identification results show that in Lake Laut Tawar, there are 9 potential hazards presented in (Table 1), and in aspect 10 there has been no research on the dangers of *C. quadricarinatus* that interfere with human health. After identifying potential hazards, then proceed to the risk assessment stage, where this assessment has 15 aspects and has different scores from the 5 categories, resulting in a total score of 72.6% (Table 2). These results indicate that the level of danger and risk of *C. quadricarinatus* in Lake Laut Tawar has a high risk and must be managed.

Physical and Chemical Processes

Factor Parameters Measurements of physico-chemical parameters in Lake Laut Tawar were carried out at each station. Based on Table 3, it is known that each parameter has different numbers. The highest temperature is found at station II, which is 28.9°C while the lowest temperature is found at Mendale station, which is 27.2°C.

In addition to temperature, water pH is also one of the important parameters in determining water quality and can be used in measuring the primary productivity of an aquatic ecosystem. According to Hakim (2007), the optimum pH for crayfish is 7-9. Based on the results of the study, the pH value in Lake Laut Tawar ranged from 7.61-7.78. This value is still suitable for fish and crayfish life. According to Romimohtarto (2001), a good pH range to support the life of aquatic organisms is around 6-8.

Table 3. Aquatic Environmental Conditions

Parameters	Research Station				
	1	2	3	4	5
Temperature (°C)	28.6	28.9	28.3	27.2	28.4
pH	7.62	7.78	7.75	7.56	7.61
TDS (mg/L)	84	75	79	88	80
Conductivity (μS/cm)	168	148	155	169	164

The highest TDS (Total Dissolve Solid) concentration value is found at station IV (Mendale) with a value of 88 mg/L. The lowest TDS concentration value is found at station II (Bewang); at this location, there is still little human activity. Conductivity (Electrical Conductivity / DHL) is the ability of water to conduct electricity. The highest water conductivity is found at station IV

(Kebayakan), while the lowest is found at station II (Bewang).

Discussion

The factor causing the high distribution of *C. quadricarinatus* at One-One station is that the surrounding waters are an area of floating net cages. Damora et al., 2023 explained that *C. quadricarinatus* is thought to enter DLT waters after being released from floating nets. This explains that *C. quadricarinatus* breeds and forms populations in this area. Rocks also dominate the substrate at the location. According to Souty-Grosset et al., (2006), *C. quadricarinatus* prefers abundant rocky habitats in caves for exploration, foraging, and providing shelter during molting. Freshwater crayfish, in their natural habitat, live in shelters such as rock crevices and tree roots (Lukito & Prayugo, 2007). Fish farming activities in floating net cages (KJA) produce residual feed and metabolic waste from cultured fish, which will enter the water and decompose through decomposing CO₂, NO₃⁻, and PO₄³⁻, affecting water fertility. If in reasonable concentrations, this can be utilized as an indicator of phytoplankton growth, and phytoplankton can be used as natural food by other species, such as *C. quadricarinatus*. According to Lagler (1972), a species in nature has a close relationship with its food and can survive if food availability is sufficient. Habitat complexity also dramatically affects the abundance of an organism. In the case of Bewang the combination of abundant phytoplankton (due to stable nutrient levels) and minimal human disturbance creates an environment where food availability is consistent and reliable. This leads to higher populations of lobsters, as they have a steady food supply from the lower trophic levels (like zooplankton and small invertebrates) that depend on phytoplankton. This observation aligns with Nurfadillah et al., (2012), who noted that the One-One and Bewang areas exhibit the highest phytoplankton concentrations.

The abundance of a species is strongly influenced by the sustainability and ecological balance of its ecosystem. To investigate factors affecting the vertical distribution of *C. quadricarinatus*, lobster catches were made at different depths. Relative abundance refers to the proportion of each species within the total community of organisms (Campbell, 2010). The analysis showed that *C. quadricarinatus* was most abundant at a depth of 5 meters, comprising more than 20% of the total population, consistent with previous observations. In contrast, at a depth of 15 meters, the abundance of *C. quadricarinatus* was

significantly lower, indicating that depth plays a critical role in its vertical distribution.

The risk assessment of *C. quadricarinatus* in Lake Laut Tawar, according to BKIPM 2017, with a total score of 54,1%, is included in medium risk level. Gherardi (2010) states that a species that enters an ecosystem, either intentionally or unintentionally, is said to be invasive if the species spreads, is able to reproduce in large numbers, and has a variety of sizes in the ecosystem. It can be concluded that *C. quadricarinatus* in Lake Laut Tawar poses a threat to endemic species.

Measurement of water quality is done to determine the condition of the waters, and can affect the life of an organism. Parameters that significantly affect the physical and chemical properties of water are temperature and pH. Water temperature is strongly influenced by sunlight entering the seas. According to Amri (2013), the temperature is good for the life of organisms between 25-30°C. Water temperature is one of the important factors in the distribution of organisms. Temperature affects the growth of crayfish, whereas in research by Guerrero et al., (2013), it was shown that a temperature of 28°C produces a high biomass weight. According to Akbar (2008), the optimal temperature for crayfish growth ranges from 26-26.9°C.

The degree of acidity or pH is influenced by the concentration of carbon dioxide and ions that are acidic or basic. Organisms are more tolerant of waters with pH values close to neutral values. According to Khairuman (2013), a good pH for organisms is 6-8.

TDS (Total dissolved solids) concentration is dependent on the conductivity value. Conductivity is a measure of the capacity of a liquid to conduct an electric charge. TDS (Total dissolved solid) is a water quality parameter that shows the number of particles in organic and non-organic materials in a body of water. (Safitri et al., 2022). The unit of measure for TDS is ppm (part per million) or equivalent to milligrams per liter (mg/L). The higher the TDS value, the reduced penetration of sunlight into the waters, which inhibits the photosynthesis process and decreases the level of water productivity (Rahadi et al., 2020). According to Nurhayati & Utomo (2018), the trigger for increasing TDS levels in water is protein content, detergents, or household waste disposal activities (anthropogenic). The connection between conductivity and *C. quadricarinatus* lies in the crayfish's capacity to tolerate different concentrations of dissolved ions in freshwater. This adaptability enables the species to thrive in a variety of environments, ranging from low to moderately high

conductivity levels (Ghanawi et al., 2012). However, if conductivity levels become too low or too high, they can negatively impact the crayfish population by influencing water quality, oxygen levels, and the overall health of the ecosystem.

Conclusion

The conclusion of this study is that the distribution of *C. quadricarinatus* in Lake Laut Tawar has significantly dominated the entire lake area, as seen from the level of relative abundance based on depth found at each research location. The presence of *C. quadricarinatus* also has the potential for medium invasiveness in Lake Laut Tawar, so that an effective management strategy is needed.

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