International Journal of Agriculture and Biosciences 2025 14(6): 1388-1396.
https://doi.org/10.47278/journal.ijab/2025.118

RESEARCH ARTICLE
eISSN: 2306-3599; pISSN: 2305-6622

Population Dynamics of *Geosesarma* sp: A New Species of Vampire Crab from the Menoreh Mountains of Java, Indonesia

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ABSTRACT

This research provides new records of the *Geosesarma* sp. population dynamics in the Meneoreh Mountains, Kulon Progo, Indonesia, since this crab was first discovered. This research aims to find out the latest information about population dynamics, which includes size distribution and sex ratio, growth patterns through the relationship between carapace width (CW) and body weight (BW), recruitment patterns, growth performance, and mortality of *Geosesarma* sp. The research was carried out from June 2023 to May 2024. The research location is in the Menoreh Mountains (07 °44.874'LS, 110°08.066'E) which is divided into three stations. The results showed that the sex ratio of the three stations was 1:0.4, 1:0.58, 1:0.6; The size distribution of males is more dominant than females, where at Station 1 the male CW size ranges from 9.7–11mm, and 6.9–8.2mm for females, Station 2 ranges from 8.9–9.7mm, Station 3 shows the CW is 7.5–8.4mm, and 6.5–7.4mm. The CW-BW relationship shows that the growth pattern of male crabs is positive allometric (b > 3), and that of female crabs is isometric. The growth coefficient shows a slow growth pattern (K<2). Station 1 showed that male experienced peak recruitment in July (18.56%), while females experienced peak recruitment in October (20.13%); at Station 2 in June (17, 34%) and May (20.38%); while station 3 in May was 16.89% and 24.06%. Crab mortality is caused by natural death and minimal fishing exploitation.

Keywords: Vampire Crab; *Geosesarma*; Population Dynamics; Freshwaters Crabs.

Article History
Article # 25-211
Received: 23-Apr-25
Revised: 25-Jun-25
Accepted: 07-Jul-25
Online First: 28-Jul-25

INTRODUCTION

Java Island in Indonesia holds biodiversity for a number of vampire crabs of the genus *Geosesarma* (Ng et al., 2015; Ng and Wowor, 2019, 2024; Hernawati, 2019; Mahendra, & Nuryanto 2024; Kurniawan et al., 2025). The genus *Geosesarma* is one of the semi-terrestrial crabs that has its own uniqueness in ecology and morphology. One of the interesting species is *Geosesarma* sp. from the Menoreh Mountains. This species is a land crab endemic to Java Island, Indonesia. It was first found on the slopes of the Menoreh Mountains, Kulon Progo Regency with distinctive characteristics in carapace, chelae, and ambulatory legs (article in preparation). The decline in the quality of aquatic ecosystems increases the risk of population decline of *Geosesarma* sp. in the Menoreh Mountains region. This shows the importance of effectively managing and protecting native species in freshwater areas (Jordan et al., 2020). This study has relevance in conservation aspects, as environmental changes can affect the population of this species (Ng & Wowor, 2018).

Research on vampire crabs on the island of Java is still limited, but several studies have been conducted to understand the differences between new species of vampire crabs (Ng et al., 2015; Ng and Wowor, 2019, 2024), understand the diversity of crab species (Hernawati, 2019), and understand crab diet (Kurniawan et al., 2025). Although there have been many studies of vampire crabs on the island of Java, data related to the population dynamics of vampire crabs (*Geosesarma* sp.) on the slopes of the Menoreh Mountains do not yet exist. In crabs, detailed studies on observations of biological aspects of species in the form of growth, recruitment patterns, and mortality are very important in stock assessment for fisheries and aquatic habitat management schemes (Nawer et al., 2023).

Cite this Article as: Aji MT, Saputra SW, Purnomo PW and Sabdaningsih A, 2025. Population dynamics of *Geosesarma* sp: a new species of vampire crab from the Menoreh Mountains of Java, Indonesia. International Journal of Agriculture and Biosciences 14(6): 1388-1396. https://doi.org/10.47278/journal.ijab/2025.118

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This study is a new record of the population dynamics of the vampire crab *Geosesarma* sp. Menoreh Mountains in Java, Indonesia. Observing the current condition of the carrying capacity of the Menoreh Mountains ecosystem on the island of Java as a natural habitat for *Geosesarma* sp. crabs, structured descriptive information on population dynamics is needed, which is expected to indicate the viability of the ecosystem. This study aims to determine the latest information in the past year regarding population dynamics, including size distribution and sex ratio, growth patterns through the relationship between shell width and crab weight, recruitment patterns, growth rates, and mortality of *Geosesarma* sp. crabs in the Menoreh Mountains.

MATERIALS & METHODS

Times and Study Area

The research was carried out for one year, from June 2023 to May 2024. The data taken represented two seasons in the tropical region, namely the rainy and dry seasons, to get a comprehensive picture of the life cycle of *Geosesarma* sp. in the Menoreh Mountains throughout the year. The research location is in the endemic habitat of *Geosesarma* sp. in the Menoreh Mountains, Jatimulyo Village, Girimulyo District, Kulon Progo Regency (07°44.874'S, 110°08.066' E), with a land height range of 620-720 meters above sea level. The location next to *Geosesarma* sp. is presented in Fig. 1. The Menoreh Mountains are a wet forest ecosystem located in the highlands. The characteristics of the Menoreh mountains are a landscape of agricultural resources and sample tree vegetation typical of tropical forests with the availability of several water sources and streams (Reinhart et al., 2023); this is by the specifications for the habitat characteristics of freshwater crabs (Yousefi et al., 2022). Access to location penetration and species availability information from residents is a crucial consideration in accessing research sample objects.

Sampling Techniques

A sampling of *Geosesarma* sp. was carried out using the Transect technique, namely by making a transverse path on land measuring 1x1m2. The transect has been modified according to the needs for sampling freshwater crabs with the addition of PVC pipe dividers to attract crabs to gather. The sampling location points are based on their natural habitat, where tropical freshwater crabs can live in the mountains and are usually found in river water areas, waterfalls and wetlands. They are semi-terrestrial (Hanifah et al., 2018), with water quality suitable for slow and fast flow (Popoola and Udoh, 2020) so that it is not far from water sources. Several species of small freshwater crabs and juveniles live around water flows, while in the adult phase, males and females dig holes away from the water flow (Mvogo-Ndongo et al., 2017). By studying this, the sampling location will be able to explore all sizes and genders of *Geosesarma* sp. in the Menoreh Mountains. The sampling location points are based on the location of the water source flow; station 1 is closer to the water source flow, station 2 is further away from the spring source flow, and station 3 is furthest from the water source flow.

Geosesarma sp. collected in the previously made transect is placed in a sterile container and labeled according to the station of origin. Sex identification was carried out directly at the sampling station, referring to the sex diagnosis of male and female *Geosesarma* sp. (Ng and Wowor, 2019). Carapace width was measured using a vernier caliper with an accuracy of 0.1mm, which covers the widest part along the lateral dorsal lying line on the crab carapace (Barlas and Yilmaz, 2020), while body weight was weighed using a digital scale with an accuracy of 0.1 grams.

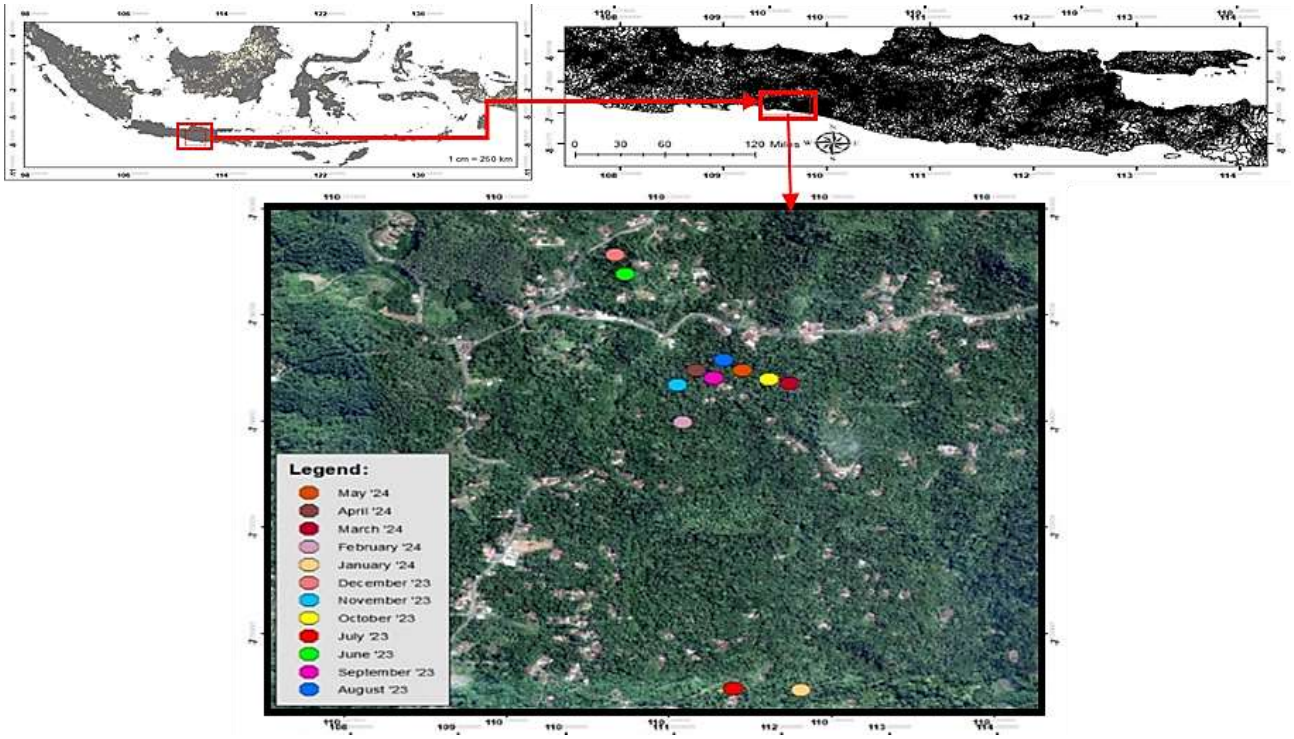

Fig. 1: Study Area Map.

Data Analysis

Size Distribution

The distribution of crab size requires crab carapace width data which is used to determine the carapace width composition of the captured crabs. The crab carapace width data is used to determine the distribution or frequency distribution (Ihsan et al., 2021).

Relationship between Carapace Width (CW) and Body Weight (BW)

Analysis of the relationship between carapace width and weight helps understand growth types in crustaceans (Islam et al., 2024), including the *Geosesarma* sp. species. The relationship between carapace width (CW) and body weight (BW) uses the following equation (Rouf et al., 2021).

$$W = aL^b$$

Where: W is BW in grams; L is CW in centimeters; a and b are constants. Log-transformed BW and CW values were calculated for linear regression analysis (log BW = log a + b × log CW). The growth allometry results are based on the b value: b = 3 means isometric growth, b > 3 means positive allometric growth and b < 3 means negative allometric growth (Ragheb, 2023).

Growth Performance

The growth parameter index can be estimated using the following Von Bertalanffy Growth Function equation growth model (Portella et al., 2024):

$$L(t) = L\infty\ (1 - e^{-K(t-t0)})$$

Where: Lt: length of fish at age t (unit of time); L∞: maximum theoretical length (asymptotic length); K: coefficient of growth (per unit time); t0: theoretical age when length equals zero. Growth parameters, including asymptotic carapace width (CW∞) and growth coefficient (K), were estimated with the ELEFAN I program in the FiSAT II program (Islam et al., 2024). The t0 parameter of the growth equation is determined using the Empirical (Pauly, 1982) equation:

$$\log(-t0) = 0{,}3922 - 0{,}2752\ (\log cW\infty) - 1{,}038\ (\log K)$$

Where: cWL∞ - asymptotic CW (cm); K - coefficient of growth rate (years); t0 - theoretical age of fish when the length is zero (years).

Recruitment Patterns

In this study, the recruitment pattern of *Geosesarma* sp. crab was analyzed using the FAO ICLARM (FiSAT II) stock assessment tool. The assessment tool can determine the time series recruitment structure using carapace width frequency distribution data to calculate the peak number each year. The calculation includes estimating all CW frequency distribution data onto a one-year time scale based on the Von Bertalanffy model (Pauly, 1982) using the NORMSEP (Normal Separation) procedure in FISAT II. In addition, the estimation results are obtained by entering the values of CW, K, and t0 (Asrial et al., 2020).

Mortality

Empirical natural mortality (M), total mortality (Z) and capture (F) in mortality and exploitation were calculated using the FiSAT II program. Mortality due to fishing (F) is calculated as the difference between Z and M (M = Z − M), and overexploitation (E) is calculated as the ratio between F and Z (E = F/Z) (3). The annual average air temperature in the region, namely 22℃ in the study period, was used for recruitment analysis by the FISAT II program.

RESULTS & DISCUSSION

Carapace Width (CW) Distribution

This study is a new record, and the first time related to the population dynamics of vampire crabs *Geosesarma* sp. in the Meneoreh Mountains Slope area, Kulon Progo, Indonesia. Vampire crabs on the slopes of the Menoreh Mountains inhabit terrestrial areas not far from water sources. This research shows that Stations 1, 2 and 3 have varying carapace width distributions between males and females, as shown in Fig. 3.

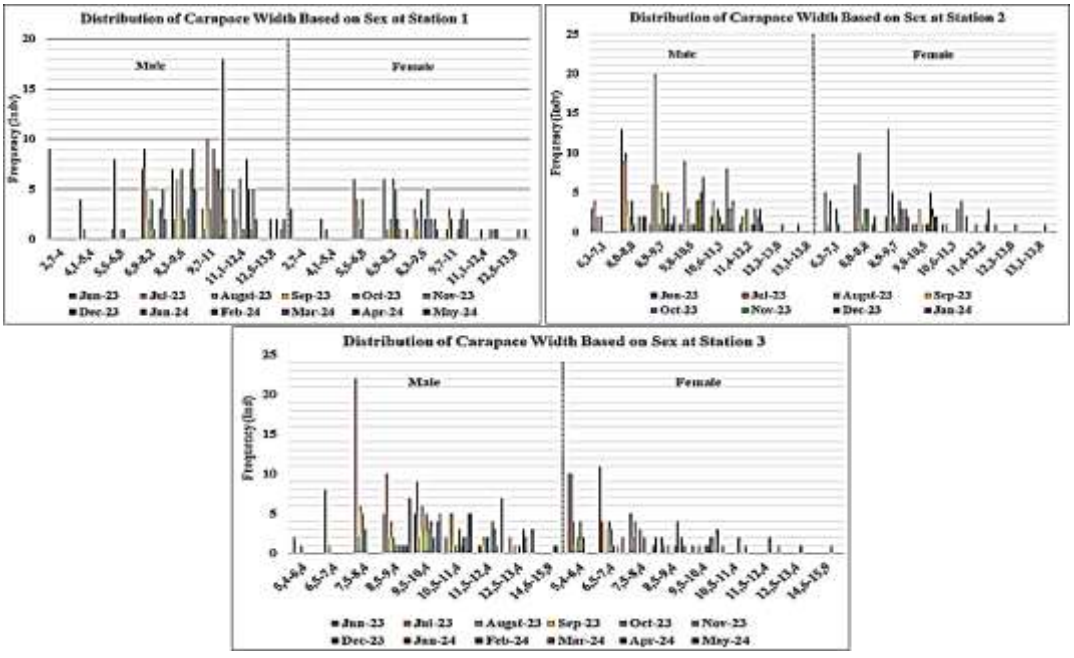

Fig. 3: Histogram of CW Distribution Based on Sex at Reaserch Stations.

The results show that Stations 1 and 2 have eight classes of shell width distribution while Station 3 has nine classes of shell width distribution. The number of *Geosesarma* sp. influences the differences in the distribution classes for the width of the shellfish caught from each station. The number of male crab catches at Station 1 was the largest of the three stations, dominated by a carapace width of 9.7–11mm (18 indv). Furthermore, at station 1, females had the lowest number of catches of the three stations and were dominated by a carapace width of 6.9–8.2mm (6 indv). At Station 2, the number of male and female crab catches was the same, dominated by a carapace width of 8.9-9.7mm (males 20 ind. and females 13 indv). Then, at Station 3, the number of male crab catches was dominated by sizes 7.5–8.4mm (22 indv), and at Station 3, females were dominated by sizes 6.5–7.4mm (11 indv). The research results show that the peak fishing season for the three stations is different. Sampling location 1 in April (43 indv), sampling location 2 in February (34 indv), and sampling location 3 in July (71 indv).

The observations of carapace width (CW) show the maturity level of *Geosesarma sp.* in the Menoreh Mountains, Indonesia. *Geosesarma* sp. at Station 3 has a larger CW size distribution than the CW sizes at Station 1 and 2. This shows that the life cycle of *Geosesarma* sp. is increasingly moving away from water sources as its size increases. Freshwater crabs have migratory behavior and move towards land areas along river flows (Kobayashi and Archdale, 2021). Wetland is the most suitable growth area for freshwater crabs to explore food and shelter areas away from predators (Uzunmehmetoğlua et al., 2019). Young crabs are often found in Station 1, which has the characteristics of wet, humid land and is close to water sources. This area is a reproduction and nursery area for the *Geosesarma* sp. species in the Menoreh Mountains. This is the same habit in several freshwater crab species, such as adult Sartoriana spinigera, often digging holes in wetland zones suitable for reproductive areas (Akther et al., 2024). Research results show that the life cycle of *Geosesarma* sp. starts from a small size living in a habitat close to a water source; as the crab matures, it will move towards moist land to look for food sources until it loses its positive rheotaxis ability (Kobayashi and Archdale, 2021).

Sex Ratio

Variations in the sex ratio in a crab species depend on reproductive activity and migration patterns in an ecosystem (Young and Elliott, 2020). The Sex Ratio of *Geosesarma* sp. in the Menoreh Mountains are presented in Table 1.

Table 1: Sex Ratio of *Geosesarma* sp. from the Menoreh Mountains

Location	Sex	Number of Samples	CW (mm)		Presentation	Sex Ratio
			Min	Max	(%)	
Station 1	Male	224	2.7	13.5	71	1; 0.4
	Female	90	3.3	13.8	29	
Station 2	Male	204	6.3	13.6	63	1; 0.58
	Female	119	6.6	15.3	37	
Station 3	Male	203	5.4	14.4	64	1; 0.6
	Female	113	7.3	15.4	36	

The study results show that the total samples collected were 953 individuals from 3 observation stations with the same characteristics as a total of 12 observation stations. Station 1 found a sample size of 71% males and 29% females, then sampling location 2 was 63% males and 37% females, and sampling location 3 was 64% males and 36% females. The sex ratios collected from the three sampling locations were 1, 2, and 3, respectively, namely 1:0.4, 1:0.58, and 1:0.6. This shows that the male population is more dominant than the female population of *Geosesarma* sp. in Menoreh Mountains. An imbalance in the sex ratio in crab species can be caused by an imbalance in the number of samples and spatial and temporal distribution of reproductive activity (Oh and Lee, 2020). The sex ratio parameter in this study shows that the availability of males is more dominant in size and number; this will influence population dynamics in reproductive recruitment patterns so that the availability of *Geosesarma* sp. seeds in the Menoreh Mountains will increasingly decrease. In crustaceans, the dominance of males and females in specific sizes and numbers is caused by factors that trigger ecological dynamics (Ewers-Saucedo, 2019), and the structure of reproductive patterns throughout the year (Lycett et al., 2020).

Relationship between Carapace Width (CW) and Body Weight (BW)

Observations of the growth patterns of *Geosesarma* sp. in the Menoreh Mountains were carried out by analyzing the relationship between CW and BW for one year, where the results showed variations in the size of CW and BW. Station 1 has male and female CW sizes ranging from 2.7–13.5mm and 3.3 – 13.8mm, while the BW of males and females ranges from 0.05 – 1.6g and 0.06 – 1.6g. Different results were obtained at station 2: male and female CW ranged from 6.3 – 13.6mm and 6.6 – 15.3mm and male and female BW ranged from 0.18 – 1.5g and 0.1 – 1.7g. The size of male and female CW ranges from 5.4 – 14.4mm and 7.3 – 15.4mm, male and female BW ranges from 0.1 – 2.2g and 0.2 – 1.9g observed at station 3. The "b" value shows the relationship between the CW and BW of *Geosesarma* sp. at each observation station, as presented in Fig. 4.

The research results show variations in the value (b) at each observation station. Male and female *Geosesarma* sp. at Station 1 has the equations $W=0.0021682CW^{2.445(b)}$ and $W=0.0015378CW^{2.537(b)}$. The growth pattern of males and females is negative allometric (b<3). At Station 2, male and female crabs have the equation $W=0.0003709CW^{3.240(b)}$ and $W=0.0003900CW^{3.151(b);}$ this shows that the growth pattern of male crabs is positive allometric (b>3), and female crabs are isometric (t count < t table). The growth pattern of male crabs is positive allometric (b>3) and female is isometric (t count < t table) at Station 3, with the equation values $W=0.0003607CW^{3.236(b)}$ and $W=0.0004864CW^{3.053(b)}$. The results of studies at three observation stations show that the growth pattern of male crabs is positive allometric and that of female crabs is isometric, as seen from the dimorphism of male crabs being more significant than that of female crabs. This condition shows that male crabs are more effective in utilizing energy metabolism (Su et al., 2022), thereby increasing somatic growth. The reproductive metabolism process is a priority for energy use in female crabs (Fazhan et al., 2021). The observation results also showed that at station 1, male and female crabs showed

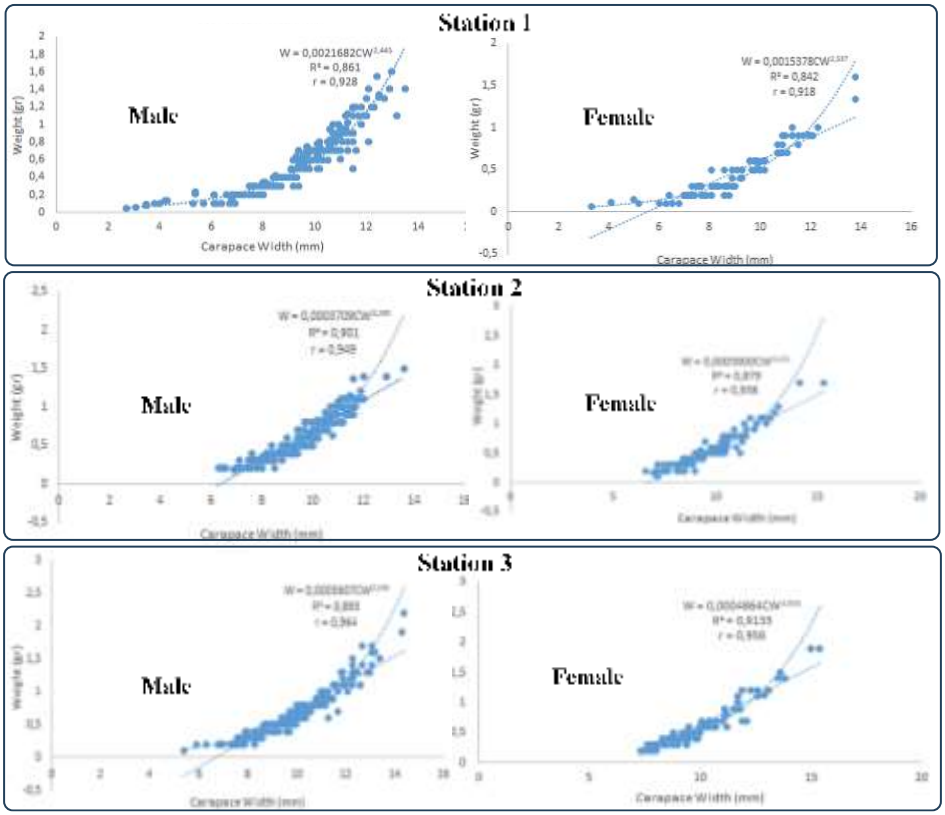

Fig. 4: Relationship between Carapace Width (CW) and Body Weight (BW) of *Geosesarma* sp.

negative allometric growth characteristics with a b value of <3. Sex-based differences in growth patterns are frequently observed in many decapods, attributed to molting at puberty, resulting in a sharp increase in the slope of the allometric growth graph (Lee et al., 2024).

Growth Performance

The results of observations of *Geosesarma* sp. growth at Station 1 showed rapid growth in males aged 0-2 years and young females of the same age. At station 2, young *Geosesarma* sp. experienced rapid growth in males aged 0-3 years, while in females aged 0-2 years, the same results were also seen at station three. The results of the Von Bertalanffy growth function (VBGF) analysis are presented in Fig. 5.

The equation for the Von Bertalanffy growth function (VBGF) of male and female *Geosesarma* sp. at Station 1 is $cWt=13.13[1- e^{(-1.1(t+0.181)}]$ and $cWt=13.75[1- e(- 0.79^{(t+0.252)}]$. The asymptotic carapace width (CW∞) of males and females obtained was 13.13mm and 13.75mm. The K value of male *Geosesarma* sp. was 1.1, and the theoretical age (t0) was -0.181years; for females, it was 0.79 and the theoretical age (t0) was -0.252years. At station 2 *Geosesarma* sp., males and females have the equation VBGF $cWt=12.50[1- e^{(-0.51(t+).0.407)}]$ and $cWt=15.02[1- e^{(-0.73(t+0.267)}$. The asymptotic carapace width (CW∞) of males and females obtained was 12.50mm and 15.02mm. K value for males is 0.51, and the theoretical age (t0) is -0.407years; for females, it is 0.73; and the theoretical age (t0) is -0.267years. Male and female *Geosesarma* sp. at station 3 have the equation VBGF cWt =14 .07[1- $e^{(-0.35(t+0.582)}$] and cWt =16.07[1- $e^{(-0.77(t+0.248)}$]. Asymptotic carapace width (cW∞) in males and females obtained were 14.07mm and 16.07mm long. The K value in males is 0.35, the theoretical age (t0) is -0.582years, and in males, it is 0.77, and the theoretical age (t0) is -0.248years.

Reviewing the research results, most K values for males and females from all observation stations are less than 1 (K<1), indicating that the growth rate of *Geosesarma* sp. in the Menoreh Mountains is relatively slow. Several freshwater crab species were also observed to have slow growth rates (K<1), namely the *Sodhiana iranica* (Sharifian et al., 2017). The general observation results are that the K value shows that the growth rate of males is faster than that of females (P<0.05). Male crab species focus on body growth, while female crabs use more energy to develop internal reproductive organs (Lee et al., 2024). In the first phase, young crabs rapidly grow (Yesilyurt et al., 2022). The growth curve of *Geosesarma* sp. shows that after experiencing rapid growth, the growth of male and female *Geosesarma* sp. slows until it reaches maximum CW. In some crab species, namely *Cronius rubber*, growth increases in the first phase between the ages of 0.5 and 1 year in males and between 0.4 and 0.8years in females (Portella et al., 2024). After that, in the second phase, the growth speed decreased, but not too slowly. Crab growth is slow and stagnant in the third phase until it reaches its maximum size. This shows that the *Geosesarma* sp. crab will proliferate in the initial phase in less than one year and then experience a decline in the following year, which aligns with the energy requirements for body metabolism, reproduction, and ability to adapt to the environment.

Recruitment Patterns

Estimating *Geosesarma* sp. recruitment patterns using FISAT II, the data used are cW∞, K and t0. The results of this analysis can show the percentage of crab recruitment every month for 1 year. The results of the percentage of male and female crabs are presented in Fig. 6.

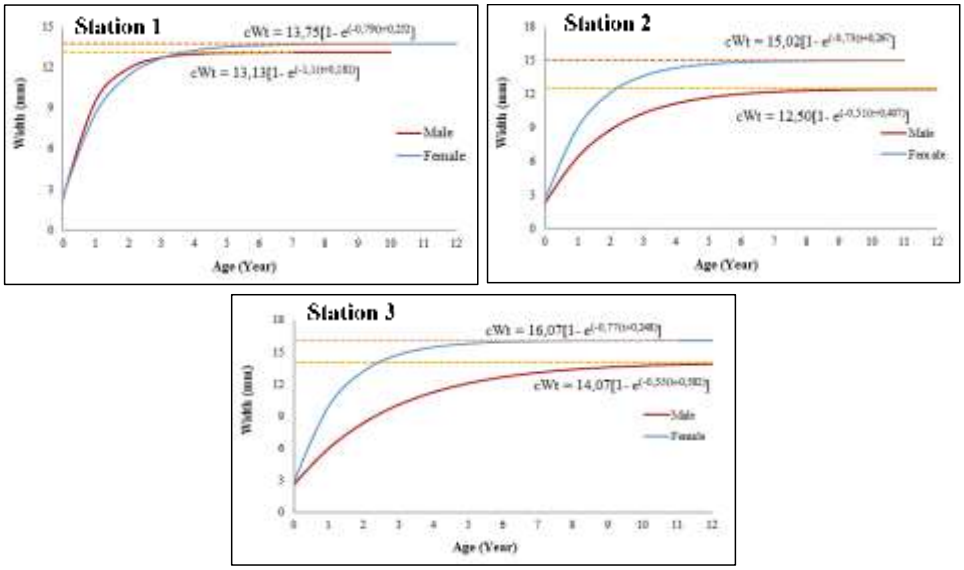

Fig. 5: Growth Curve of *Geosesarma* sp. Based on Sex at Reaserch Stations.

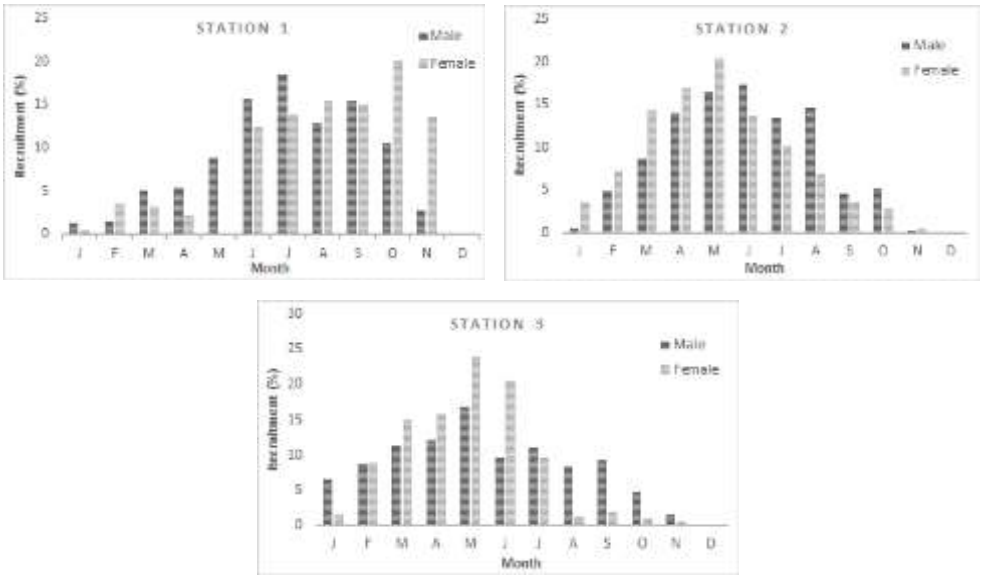

Fig. 6: Recruitment Patterns Based on Sex at Stations Research.

Fig. 6 shows that the recruitment patterns of male and female *Geosesarma* sp. at each research station are similar. At Station 1, it was observed that male *Geosesarma* sp. experienced peak recruitment in July (18.56%), while females experienced peak recruitment in October (20.13%). Station 2 shows that June is the peak recruitment for male crabs at 17.34%, while female crabs experience peak recruitment in May at 20.38%. The results were not much different from observations at station 3, where May was the peak of male recruitment at 16.89%, while for females in May, it was 24.06%. The research results show that the reproductive period of *Geosesarma* sp. from all observation stations is in the dry season from February to April, and the recruitment phase of *Geosesarma* sp. is during the transition from the dry to the rainy season, namely May - July.

Recruitment patterns in some species can function in estimating the annual reproductive phase (Nawer et al., 2023). The results of this research explore that *Geosesarma* sp. experiences a period of gonad maturation to reproduce in the dry season. In crustaceans, relatively warm high temperatures improve gonad quality (Ren et al., 2021). Several species of freshwater crabs in tropical regions have shown that warm temperatures can increase reproductive productivity in female crabs by digging holes during egg incubation (Taddei et al., 2015). In the rainy season in tropical areas where the temperature is relatively cool, this will increase the hatchability of eggs, producing many juvenile crabs in an ecosystem. This is because temperatures that increase more than the natural temperature will reduce the success of egg hatching (Chou et al., 2019). Climate change and increased larval productivity are some of the factors that influence crab recruitment patterns (Emond et al., 2015). This is what causes *Geosesarma* sp. in tropical regions to experience an increase in recruitment percentage during the transition from the dry to the rainy season.

Mortality

Analysis of mortality rates is essential in the ecosystem's population dynamics of crab species. The study of mortality data showed that mortality due to capture (F) of male and female *Geosesarma* sp. on the slopes of the Menoreh Mountains was lower than natural mortality (M). This situation shows that the species is not overexploited in that area (F<0:50). A comparison graph of *Geosesarma* sp. mortality in the Menoreh Mountains is presented in Fig. 7.

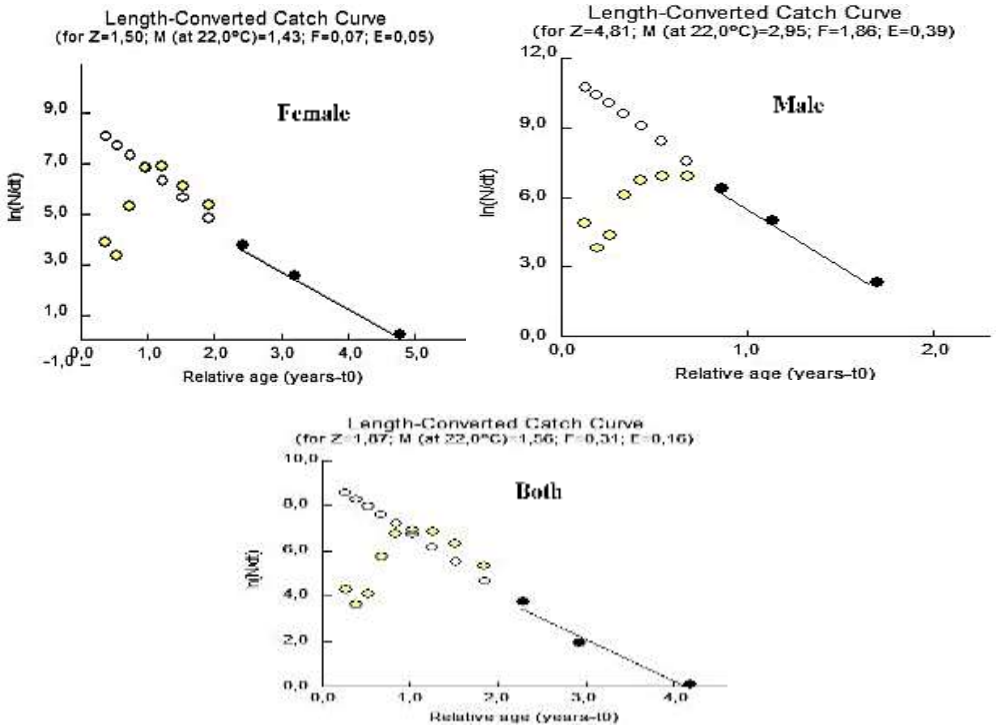

Fig. 7: Mortality graph of *Geosesarma* sp. in Menoreh Mountains.

The mortality rate of a species is influenced by the total mortality rate (Z), natural mortality rate (M), and mortality rate due to fishing (F) (Indarjo et al., 2020). Fig. 6 shows that the fishing exploitation rate for males is 1.86, for females 0.07, and 0.31 for both. Compared with the natural mortality rate (M) for males 2.95, and females 1.43 and 1.56, the fishing exploitation rate is relatively low. The natural mortality (M) of male crabs is higher than that of female crabs. This is due to the larger body size of male crabs because they use more energy for somatic growth (Fazhan et al., 2021) and the crab's more varied colors attract the attention of predators, making it difficult to carry out camouflage strategies (Dyer and Stevens, 2024). This shows that the shelling of this species in the Menoreh Mountains ecosystem is more dominantly caused by natural death caused by decreased environmental carrying capacity and limited lifespan compared to explosive fishing activities. Pollutants in the form of biochemicals captured by aquatic organisms will be distributed to all body organs (Mustafa et al., 2019), thereby impacting the risk of death. Besides that, several species of freshwater crabs have experienced population declines due to internal intraspecific competition and cannibalism (Fadlaoui and Melhaoui, 2019). This is reinforced by the low exploitation value (E) of male and female on the slopes of the Menoreh Mountains.

Conclusion

This study provides essential information on the population dynamics of *Geosesarma* sp. in the Menoreh Mountains, which shows that the size distribution of male *Geosesarma* sp. is more dominant than females, with an average sex ratio of 1:0.5. The growth pattern of male *Geosesarma* sp. is positive allometric, and that of females is isometric as seen from the dimorphism in males which is more significant than in female crabs. The growth performance of *Geosesarma sp.* could be faster, as evidenced by the K value for male and female crabs from all research stations is almost all less than 1 (K<1). The reproductive period of *Geosesarma* sp. throughout the research station is in the summer (February – April), with the recruitment of *Geosesarma* sp. in the transition from dry to the rainy season (May – July). The reproductive period of *Geosesarma* sp. from all research stations is in the summer (February – April), with the recruitment of *Geosesarma* sp. in the transition from hot to rainy season (May – July). Crab mortality is caused by natural death and minimal fishing exploitation (F). Information on the dynamics of the *Geosesarma* sp. population in the Menoreh Mountains needs to be developed through habitat identification based on water and soil quality throughout the year so that it can be used to design a domestication-based conservation model so that the availability of this crab can be maintained and does not depend on natural exploitation.

DECLARATIONS

Funding: This research received financial support from Beasiswa Pendidikan Indonesia, BPI (The Indonesian Education Scholarship). Pusat Pelayanan Pembiayaan dan Asesmen Pendidkan Tinggi, PPAPT (Center for Higher Education Funding and Assessment), Ministry of Higher Education, Science, and Technology of Republic Indonesia. Lembaga Pengelola Dana Pendidikan, LPDP (Endowment Fund for Education Agency), Ministry of Finance of Republic Indonesia, as funders of this research activity.

Acknowledgement: Our gratitude goes to Beasiswa Pendidikan Indonesia, BPI (The Indonesian Education Scholarship). Pusat Pelayanan Pembiayaan dan Asesmen Pendidkan Tinggi, PPAPT (Center for Higher Education Funding and Assessment), Ministry of Higher Education, Science, and Technology of Republic Indonesia. Lembaga Pengelola Dana Pendidikan, LPDP (Endowment Fund for Education Agency), Ministry of Finance of Republic

Indonesia, as funders of this research activity. Thanks to all academicians of the Faculty of Fisheries and Marine Science, Diponegoro University, and the Department of Aquaculture, Faculty of Agriculture, Tidar University, for their academic support.

Conflict of Interest: The author(s) have no financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability: All the data are available inside the article.

Ethics Statement: Does not use protected or endangered species, so ethical approval is not required.

Author's Contribution: MTA conducted data collection and data analysis. SWS, PWP, and AS served as Promoters and Co-Promoters who are very instrumental in this research starting from research preparation to the process of preparing articles.

Generative AI Statement: The authors declare that no Gen AI/DeepSeek was used in the writing/creation of this manuscript.

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