INTL J BONOROWO WETLANDS
Volume 13, Number 1, June 2023
Pages: 1-8

P-ISSN: 2775-8052
E-ISSN: 2775-8044
DOI: 10.13057/bonorowo/w130101

Population density and distribution patterns of *Austruca annulipes* (Ring-legged fiddler crab) in the mangrove of Bogowonto Estuary, Kulon Progo, Yogyakarta, Indonesia

RIZKY NUR FADILAH[1], INGGRID TRIFENA YULIA[1], ZHALZABILLA SHAFA ALFITRA[1], WINDA SAGITA ARMADHAN[1], RATNA WIDYANINGTYAS[1], DITA RAHMAYANI[1], DINDA PUTRI PERMATASARI[1], IGUSTITA[1], DIAN KUSUMA[1], SATRIA AJI PRAMBUDI[1], GAVRIEL ENOS BERLIN[1], ADITYA TRIYANTO[2,3], SUTARNO[2], MUHAMMAD INDRAWAN[1], MUH. SULAIMAN DADIONO[4], KHAIRUL ADHA BIN A. RAHIM[5], AHMAD DWI SETYAWAN[1,6,♥]

[1]Department of Environmental Science, Faculty of Mathematics and Natural Sciences, Universitas Sebelas Maret . Jl. Ir. Sutami 36A, Surakarta 57126, Central Java, Indonesia. Tel./Fax.: +62-271-663375, ♥email: volatileoils@gmail.com.
[2]Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Sebelas Maret. Jl. Ir. Sutami 36A, Surakarta 57126, Central Java, Indonesia
[3]Biodiversity Study Club, Faculty of Mathematics and Natural Sciences, Universitas Sebelas Maret. Jl. Ir. Sutami 36A, Surakarta 57126, Central Java, Indonesia
[4]Department of Aquaculture, Faculty of Fisheries and Marine Science, Universitas Jenderal Soedirman. Jl. Dr. Soeparno, Purwokerto Utara, Banyumas 53122, Central Java, Indonesia
[5]Faculty of Resource Science and Technology, Universiti Malaysia Sarawak. Jl. Datuk Mohammad Musa, 94300 Kota Samarahan, Sarawak, Malaysia
[6]Biodiversity Research Group, Universitas Sebelas Maret. Jl. Ir. Sutami 36A, Surakarta 57126, Central Java, Indonesia

Manuscript received: 26 December 2022. Revision accepted: 19 January 2023.

Abstract. *Fadilah RN, Yulia IT, Alfitra ZS, Armadhan WS, Widyaningtyas R, Rahmayani D, Permatasari DP, Igustita, Kusuma D, Prambudi SA, Berlin GE, Triyanto A, Sutarno, Indrawan M, Dadiono MS, Rahim KABA, Setyawan AD. 2023. Population density and distribution patterns of* Austruca annulipes *(Ring-legged fiddler crab) in the mangrove of Bogowonto Estuary, Kulon Progo, Yogyakarta, Indonesia. Intl J Bonorowo Wetlands 13: 1-8.* The mangrove forest ecosystem is a forest with coastal plant characteristics that are influenced by tides and tolerate high salt levels. Mangrove forests in Indonesia contain about 89 species of flora, and around 18% of their fauna are keystone species. Keystone species are species that play an important role in maintaining the balance of the ecosystem. *Austruca annulipes* (H. Milne-Edwards, 1837), or Ring-legged fiddler crab is one of the fauna species in the mangrove ecosystem, which has an important role in maintaining the balance of the food chain and nitrogen cycle, so the study of this species is very important for the sustainability of the ecosystem in mangrove area. This study aimed to determine the population density and distribution patterns of *A. annulipes* in the Mangrove Bogowonto Estuary Area, Kulon Progo, Yogyakarta, Indonesia. The research method was purposive random sampling using a 10m x 10m square plot. Furthermore, the identification of morphology and documentation of the activities of *A. annulipes* was carried out, and data were examined using calculations of crab density. Based on the research finding, the population density of *A. annulipes* is 0.9975 individuals/m^2. Calculating the Morisita Index of *A. annulipes* obtained a value of 1.38 with the category of clumped distribution patterns. Various factors influence this distribution, including abiotic factors such as soil moisture, temperature, air, salinity, and pH. In addition, the presence of vegetation has also affected the density of *A. annulipes* because it is used as a shelter and foraging among its roots.

Keywords: Behavior, coastal ecosystem, Crustacea, Morisita Index, morphology

INTRODUCTION

Indonesia is one of the countries with the highest levels of biodiversity in the world and ranks second after Brazil (Dahlia and Mukti 2021). However, biodiversity in Indonesia continues to experience declining significantly. The increase in population will be linear with increasing anthropogenic activities, which also increase human needs leading to the emergence of exploitation of various species, which could cause decreased biodiversity (Mujiono et al. 2021). The loss of biodiversity is a crucial problem because it has implications for the survival of other living things (Suryana and Antara 2021). Therefore efforts to protect and preserve biodiversity are important things to do in the future.

The mangrove forest ecosystem is one type of forest in the tidal area. Mangrove forests are a meeting place for two groups of fauna: terrestrial and aquatic (Hasan et al. 2020). Mangroves are described as the characteristics of plants that live in river mouths or on the coast, which are influenced by sea tides and tolerating on high salt levels (Ramadhan et al. 2022). Mangroves play an important role in absorbing carbon in the atmosphere, which positively impacts global climate stability. Meanwhile, mangroves have important value in terms of ecological aspects as habitats for various fauna, breeding grounds for various marine biota, shelters, nutritional sources for various living things, and preventing coastal abrasion (Zeng et al. 2021).

The existence of mangroves in Indonesia is recorded at the remaining 1.2 million hectares (Irma et al. 2020). Mangroves can be found between land and sea as well as along tropical and subtropical coasts. Therefore, the health condition of mangrove forests is the most important factor in ensuring the sustainability of forest functions and benefits. That can be observed by assessing indicators of forest health forest, namely the biodiversity of fauna and flora in mangrove forests (Sari et al. 2019). In Indonesia's mangrove forests, flora species reach about 89 species of plants consisting of 35 trees, 5 species of herbs, 9 species of shrubs, 29 species of epiphytes, and 2 species of parasites (Rahim and Baderan 2017). Meanwhile, mangrove fauna consists of vertebrates and invertebrates such as Crustaceans, Carideas, Mollusks, Echinoderms, Polychaeta, aves, reptiles, amphibians, mammals and primates, as well as fish vertebrates (Driptufany et al. 2021).

Approximately 18% of the total individual fauna are categorized as keystone species (Yudha et al. 2021). Keystone species are species that have an important role in the structure, function or productivity of a habitat or ecosystem (habitat, soil and seed disperser). The loss of this species will result in changes to other types of populations or ecosystems (Roberge and Angelstam 2004). For example, one keystone species in the mangrove forest is the *Austruca annulipes* (H. Milne-Edwards, 1837) or violin/fiddler crab, which males crab will grow larger. That is intended as a means of defense from enemies and to attract the females' attention. Meanwhile, the two claws of female crabs are small and function to eat and dig burrows or holes. The hole is the home of *A. annulipes* which can protect it from predators, salinity, temperature, and other crabs' attacks (Aprilyanto et al. 2017).

The mangrove ecosystem of Bogowonto Estuary is located in Pasir Mendit Hamlet, Jangkaran Village, Temon Sub-district, Kulon Progo District, Yogyakarta, Indonesia is operated as an ecotourism area with the trade names of Jembatan Api-Api Mangrove and Pasir Kadilangu Beach. This area was originally known as dunes, and mangrove lagoon ecosystems mostly converted to pond areas. That can be observed from the preference for the livelihoods of the local residents, who are dominated as fish farmers. The riverside area is heavily planted with mangrove forests, whereas the construction of bridges facilitates access through the mangrove areas. *Casuarina equisetifolia (cemara laut)* is one of the most dominant associated mangrove species. It can withstand the crashing of sea waves to preserve the environment and protect coastal areas to preserve the surrounding (Musrifah and Munir 2020). In addition to the various types of mangroves plant, some fauna, such as benthic fauna species, exist. Moreover, compared to other fauna, the benthic species is dominant while examining the composition of fauna in the mangrove ecosystem. The benthic fauna commonly found in the Mangrove Bogowonto Estuary area are crustaceans, mollusks, and mudskippers (Sari et al. 2019). This research examined *A. annulipes* because it dominates the Bogowonto Estuary Mangrove area. The existence and domination of this crab make the soil of the mangrove ecosystem fertile (Putriningtias et al. 2019). Mangrove forests are used to cultivate crabs and have a close relationship with environmental development, preserving mangroves and other habitats (Harini et al. 2019). Crabs in the mangrove ecosystem can be a bioindicator of whether the mangrove forest is functioning correctly. According to Kalor et al. (2018), crabs are keystone species in mangrove forests that can convert nutrients, increase mineralization, increase oxygen distribution in the soil, help the carbon cycle, and act as natural food providers for various types of biota in the waters. Therefore, this study aims to determine the condition of the mangrove ecosystem, which can be determined by research in the form of population density and distribution patterns of *A. annulipes* in the Bogowonto Estuary Mangrove area, Kulon Progo, Yogyakarta, Indonesia.

MATERIALS AND METHODS

Study area

This research was conducted in November 2022 in the Mangrove of Bogowonto Estuary area (Jembatan Api - Api and Pasir Kadilangu), located in Jangkaran Village, Temon Sub-district, Kulon Progo District, Yogyakarta Province, Indonesia (Figure 1), with geographical coordinates 7.89476, 110.02536. The reason for choosing this location was based on the initial survey showing that in this location, there were *A. annulipes* species crabs with populations that were quite dominating compared to other crabs. In addition, no research examines the research topic that we did.

Procedures

Sampling techniques

Observations for sampling *A. annulipes* crab species were made by making 32 plots measuring 10 m x 10 m at the sampling location. Plot selection is based on the substrate and tidal conditions that differ in each location. After that, the total number of *A. annulipes* crab species in each plot caught was counted and recorded. In addition, to support the completeness of the field data, supporting data was also taken on abiotic environmental factors such as water, water and soil temperature, water and soil pH, humidity, and water salinity. This sampling was carried out by 7 people at 8.00 a.m. to 2.00 p.m. In addition, this sampling was also carried out at low tide conditions so that the habitat of the *A. annulipes* crab could be seen on the surface. The collection of crabs is conducted by hand-picking techniques and a shovel to dig into the ground the crabs are hiding. Some of the caught crabs are then put into bottles and treated with alcohol (70%) to be preserved before being identified.

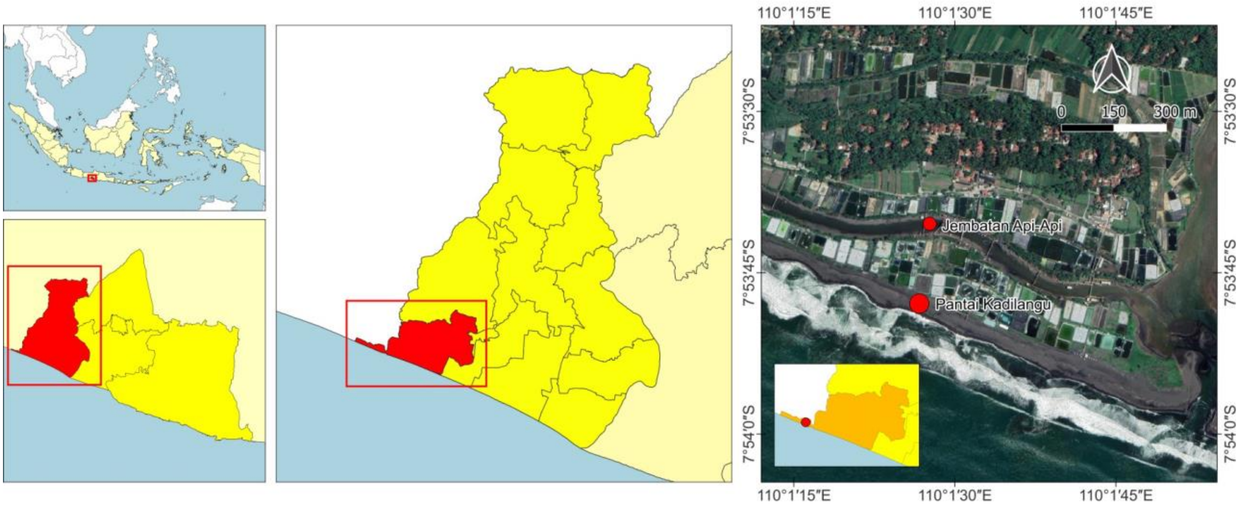


Figure 1. Research location of *Austruca annulipes* crab ecosystem in Mangrove Bogowonto Estuary, Kulon Progo District, Yogyakarta, Indonesia

Identification and behavioral activity

The *A. annulipes* crab type was identified based on its morphological characteristics, such as the color and size of the carapace surface; shape and color of pincers; body color; orbital area (the area around the eye); and body size. According to Michael et al. (2020), in the early stages of the crab species identification process, an introduction was made to the body parts of the crab used in the diagnosis process. Therefore, observations can be compared and described with the identification carried out by Michael et al. (2020) and strengthened by the identification book of violin crabs by Murniati and Pratiwi (2015).

The behavioral activity of the *A. annulipes* was directly observed and documented at each sampling location. The crab activities are obtained, such as entering the walking hole on the substrate, looking for food, eating bacteria deposited in the mud, competing with other species, and attention seeking (Table 1). Crab activity was observed for approximately 2 hours, with an average behavior observation of roughly 4-5 minutes for each plot.

Data analysis

Population density is defined as the number of individuals in a certain area in a community. The density of crab species is calculated relatively using the method below (Krebs 1998), namely :

$$N = \frac{\Sigma ni}{A}$$

Where:

N : Density of crabs (ind/m^2)

$\sum$ni : Total number of individuals for species i (individuals)

A : The total area of the sampled area

$$id = n\frac{\Sigma X^2 - N}{N(N-1)}$$

Where:

id : Morisita spread index

n : Number of sampling plots

N : Total number of individuals in n plots

$\sum x^2$: Square of the number of individuals per n plots

After being analyzed, the Morisita index (Id) obtained values are interpreted as follows: (i) Id = 1, as a random distribution pattern, (ii) Id < 1, as a uniform distribution pattern, (iii) Id > 1, as a clumped distribution pattern.

RESULTS AND DISCUSSION

***Austruca annulipes* density**

The Mangrove Bogowonto Estuary (Jembatan Api - Api and Pasir Kadilangu) is a mangrove ecosystem with great potential to become a habitat for living organisms, like *A. annulipes*. Extensive mangrove ecosystem areas will also have high biodiversity. That is because the location of the mangrove ecosystem at this research location is between land and sea and is in tropical areas rather than sub-tropical. The divergence of biodiversity found in this location is also influenced by several factors, such as aquatic ecosystems that are regularly inundated by seawater due to tides, basic substrates in the form of soil compositions such as stagnant mud, and salinity values that are suitable for the needs of aquatic organisms. However, in this study, one of the biodiversity studied was a species originating from the crustacean community, namely the crab population. In the mangrove ecosystem, crabs are a group of animals that play a significant role in ecology, especially in the structure and function of mangroves (Fauzan et al. 2020). Crabs play an important role as the main linkage in the food chain. Crabs act as detritus eaters (related to the mineralization of organic matter) and control the number of residues in the mangrove ecosystem. Several groups of crabs that occupy mangrove habitats in tidal areas can generally be found in abundant quantities. The density of crabs has closely related to the substrate's organic matter content and the density of mangrove plants. The higher the value of organic matter content and the density of mangrove plants will result in a higher total density of crabs in the region (Septiani et al. 2019). One type of crab identified that live densely in the Mangrove Bogowonto Estuary is *A. annulipes*.

The *A. annulipes*, also called fiddler or violin crabs, are a species that play a role in maintaining order between the food chain and the nitrogen cycle in mangrove ecosystems (Actuti et al. 2019). The *A. annulipes* live in nests in the form of holes in the ground, which are useful during high tide to serve as a place to hide. These holes can provide safe protection from temperature differences, predators, extreme salinity, and incursion from fellow crabs. The substrate content in this study site has a type of muddy sand and sand with an average soil moisture value of 10, a neutral soil pH, and a temperature of 32°C. According to Natania et al. (2017), this type of sandy soil makes it easy for *A. annulipes* to make holes because sandy soil has a high organic matter content. Based on this phenomenon, the substrate is an important environmental factor for the life of *A. annulipes*. Therefore, substrate suitability in the Mangrove Bogowonto Estuary affects the amount of density of the *A. annulipes* habitat. The population density of *A. annulipes* in the Mangrove Bogowonto Estuary (Jembatan Api - Api and Pasir Kadilangu), with a total of 32 plots of 10x10m^2 is 0.99 ind/m^2.

Out of a total of 97 *Austruca* crabs species in the world, there are around 19 species found in Indonesia (Krisnawati et al. 2018). The *A. annulipes* is a species of the genus *Austruca* (Naderloo et al. 2016). The diversity and density of *A. annulipes* are strongly influenced by environmental factors, such as salinity levels, tides, and the substrate where it lives. Therefore, *A. annulipes* will live well in suitable areas and could still live within their tolerance limits. However, changes in the salinity of the waters will affect the density of the crab population so that the population growth rate becomes higher in the higher salinity (Mumbah et al. 2018).

The density of *A. annulipes* is related to the organic matter content in a substrate, where the higher the organic matter content in the substrate, the higher the density (Krisnawati et al. 2018). Substrate plays an important role in the life of *Austruca* spp. (another type of fiddler crab), because the substrate is important for suitable spawning, foraging, and rearing children. Several studies reported that *Austruca* spp. found in mangrove areas in West Sumatra (Lauren and Sumarmin 2020), South Kalimantan (Fauzan et al. 2020), Central Java (Irwansyah et al. 2021), North Sulawesi (Rianta et al. 2018), Manado (Michael et al. 2020), and South Papua (Masiyah et al. 2021). In the mangrove ecotourism area of Pagatan Besar, Tanah Laut District, *A. annulipes* in the three observation plots with species density values in each plot sequentially, namely 0.42 ind/m^2, 1.08 ind/m^2, and 8.50 ind/m^2 (Fauzan et al. 2020). The increase in the density of *A. annulipes* was influenced by the type of substrate and direct exposure to sunlight. In Kema, North Sulawesi, the density of *A. annulipes* was 24.89 ind/m^2 throughout the forest (Rianta et al. 2018).

According to Michael et al. (2020), *A. annulipes* were found in two observation plots in Bahowo Waters, Manado, with density values of 1.6 ind/m^2 and 0.2 ind/m^2, where the Bahowo waters is a mangrove conservation area. On the mangrove area in Pacitan, East Java, to be precise in Teleng Ria, Grindulu, and Siwil Beaches, the average density of *A. annulipes* is 0.2 ind/m^2 (Irwansyah et al. 2021). Compared to the two previous studies, the density of *A. annulipes* in the Mangrove Bogowonto Estuary (Jembatan Api - Api and Pasir Kadilangu), Kulon Progo, Yogyakarta is quite high with a density value of 0.9975 ind/m^2. That is due to the environmental conditions in the Mangrove Bogowonto Estuary, which are suitable for the breeding habitat of *A. annulipes*.

Distribution pattern

Population distribution is the movement of individuals into and out of a population. The occurrence of distribution in a population, including *A. annulipes*, is due to the need to find food, avoid predators, climatic influences carried by water or wind, the desire to reproduce, and other physical factors. Populations of natural organisms generally have a clumped distribution pattern and are rarely found in a uniform pattern (Putra et al. 2018). Therefore, natural populations distribution is divided into uniform, random, and clumped distributions (Raunsay et al. 2020). Based on data from the calculation of the species *A. annulipes* in the Mangrove Bogowonto Estuary, the calculation results were obtained using the Morishita index formula of 1.38. Therefore, it can be concluded that the distribution pattern of *A. annulipes* in the Mangrove Bogowonto Estuary is clumped.

The distribution pattern of these crabs can be diverse in each place. For example, the distribution of crabs in a study conducted by Riswandi and Febriyani (2022) in the Curahsawo mangrove area, Probolinggo, Central Java, found 6 types of fiddler crabs, namely *Austruca rosea*, *Austruca lactea*, *Austruca vocans*, *Austruca perplexa*, *Austruca dussumieri*, and *Austruca demani*. The distribution patterns of the six types of fiddler crabs are divided into uniform and clumped distribution patterns, besides those three patterns described above. Types of fiddler crabs with a uniform distribution, namely *Austruca lactea*, *Austruca vocans*, *Austruca dussumieri*, and *Austruca demani*. In comparison, the types of fiddler crabs with a clumped distribution pattern are *Austruca rosea* and *Austruca perplexa*.

Abiotic factors and their relation to *Austruca annulipes* density

Environmental conditions are suitable for crabs, given the carrying capacity for *A. annulipes* to survive. However, *A. annulipes* have a vulnerable adaptability when drastic changes and conditions occur in the environment. The life of *A. annulipes* during the larval phase depends on salinity, temperature, and patterns of ocean currents. Meanwhile, when they are adults, they tend to live in holes around mangroves with sandy or muddy soil conditions and have a high dependence on substrate conditions. The mangrove zone showed high levels of nutrients (N, P, TOC), silt, clay, soil moisture, high pore-water salinity, and low levels of porosity, sand, pH, temperature, and light mudflats compared to open mudflats (Min and Kathiresan 2021).

Environmental parameter values measured included soil moisture, air temperature, water temperature, soil temperature, water pH, soil pH, and soil salinity. Soil moisture obtained at 3 different sampling points in the Mangrove Bogowonto Estuary area (Jembatan Api-Api and Pasir Kadilangu) is 10 RH. According to Hanafi et al. (2020), soil moisture is affected by the water level in the soil. High groundwater causes the percentage of soil moisture to be high, this also affects the life of fiddler crabs. Fiddler crabs use a breathing apparatus in the form of gills, when at low tide the gills of fiddler crabs are modified to become like lungs. Modified breathing lasts only a short time, so it requires groundwater to breathe.

The *A. annulipes*, those living in mangrove ecosystems, have a tolerance to the temperature range between 23-33°C, and the optimum temperature for survival is not less than 20°C (Saparinto 2010). Based on temperature measurements in the field at three sampling points and three categories (water temperature, air temperature, and soil temperature), a water temperature value of 28.2-38.0°C was obtained; air temperature at the location is 27.4-37.5°C; and soil temperature at the location of 27-35°C. That shows that *A. annulipes* in the Mangrove Bogowonto Estuary live within their tolerance threshold.

The water pH, soil pH, and salinity have no differences significantly at each data location. The pH of the water at the data collection point is in the range of 7.5-8.2, and the soil pH based on three points has a value of 7. According to Saputri and Muammar (2018), under normal conditions, *A. annulipes* have a pH tolerance value of 6.5-9, which means crab *A. annulipes* or mud crabs can live in acidic to alkaline waters.

According to the identification results at three points in the field, a salinity value of 5-10 ppt was obtained. The range of salinity that can support crab life is oligohaline values (0.5-5 ppt) to mesohaline (5-18 ppt) and can still provide a suitable life for crustaceans (Rahayu et al. 2018). The highest salinity is at point 3 because this point is measured across the bridge, which is the closest point to the coast, so seawater has a more significant effect than fresh water. Salt levels in river waters in mangrove areas have fluctuating values and are influenced by freshwater runoff from the mainland and seawater inflow from river mouths (Kulkarni et al. 2010).

Furthermore, abiotic factors on environmental parameters influence the life of *A. annulipes*, which consist of the substrate, temperature, pH, humidity, and water salinity. For example, the fiddle crab, *A. annulipes*, is a crab type that can live in holes and only be found in mangrove forests, so the substrate and the availability of nutrients are the environmental factors that affect the life of *A. annulipes*. In addition, the density and size of mangrove trees will affect the area of canopy cover and the organic matter produced (Irwansyah et al. 2021).

Mangrove vegetation in the Mangrove Bogowonto Estuary area in the tree, sapling, and seedling phases all supported the life of the *A. annulipes* crab. That is because *A. annulipes* can grow, develop and forage among its roots. Therefore, the abiotic environmental conditions at the location of the plots and the sampling points can be categorized as good for mangrove ecosystems and the *A. annulipes*. Temperature values range from 28.5-38°C of water; 27.4-37°C of air; and 27-35°C of soil. In addition, pH values range from 7.0-8.2; humidity value 10 RH; salinity values of 5-10 ppt and sandy mud substrates are related to the density of *A. annulipes* in the Mangrove Bogowonto Estuary, Kulon Progo, Yogyakarta.

Austruca annulipes **morphology**

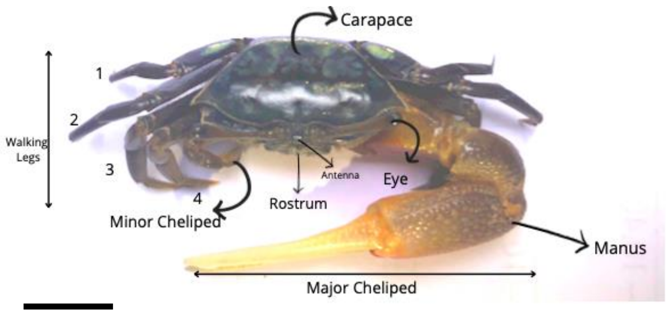
The *A. annulipes* population is the most observable part of this crab, so it has a significant impact on other observable parts except for populations, which are also important to examine, for example, 'reproduction', 'sex ratio', and 'fecundity.' Mangrove ecosystems are claimed to be habitats with critical status for animals, for example, the function of breeding places for fishery resources, where *A. annulipes* were becoming a threat (Chen et al. 2022). Specific features that can differentiate *A. annulipes* are the presence of sexual dimorphism and unbalanced or asymmetrical conditions on the claws (Figures 2 and 3), which are only shared by a few types of crabs. The asymmetrical condition of the male *A. annulipes* crab claws can be observed from the juvenile phase. In adult female crabs, the pair of claws is symmetrical and small compared to the claws of male crabs with large right pincers. Recent research has found that large and small claws' shape functions differ according to their objectives. The large claws of the *A. annulipes* crab do not change position even though they have undergone autotomy (Murniati and Pratiwi 2015).

The carapace shape of the *A. annulipes* crab is generally rectangular, which extends transversely with a size of 20-60 mm (Rahayu et al. 2018). The carapace color of this crab cannot be used as an identifying characteristic because the habitat can affect the color characteristic of the carapace, especially for *A. annulipes*. The *A. annulipes* that live in open space areas will directly be exposed to the sun and will have a lighter color, and vice versa. In addition, crab claws are formed by pollex and dactyl. Dactyls in *A. annulipes* located at the tips of the fingers, and the claws are shaped like spoons and function as a tool to take sand and mud substrates into the mouth. The large claws of male crabs do not have grooves on the outer surface of the dactilus and the outer surface of the pollex. Besides that, the manus is also not equipped with nodules. When examined by the morphology of male crabs, the larger claws of adult male crabs compared to female crabs are the main character trait of *A. annulipes* crabs.

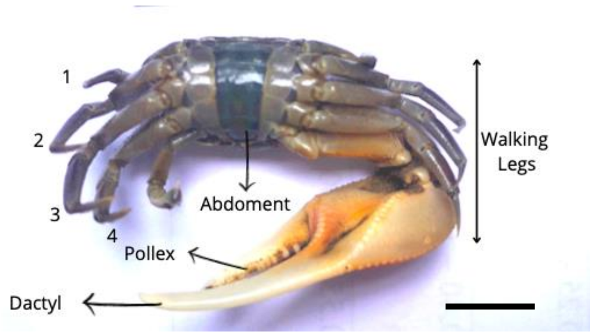
Moreover, identification can be carried out on other body characters to distinguish the type. However, the difference in color types in male and female *A. annulipes* is a weak differentiator. Morphological characteristics that can be used to determine the species of *A. annulipes* can be observed on the carapace, the obit area around the eyes, the gonopod as the male genitalia, the gonopod as the female genitalia, the large claws on the male crab, the small claws, and the steae on the second maxilliped (Murniati and Pratiwi 2015).

Table 1. Ethogram behavior of *Austruca annulipes* crabs

Classification behavior	Behavior	Description
Territorial behavior	Take cover	Have an instinct or reflex to the presence of vibrations around its habitat so that when feeling the vibrations this crab will hide in its hole.
	Ingestif	Moving the claws repeatedly from the substrate to the mouth and back again to the substrate, this is similar to the movement of a violinist when moving the bow to the violin.
	Fighting or compete	Moving his large claws into the air to defend himself in the event of a fight between other species.
	Exploration	Walking touches the substrate using chelipeds and locomotion appendages (pereopods) while it moves.
Affiliative behavior	Attention-seeking	Male individuals will move their large claws up and down. This behavior indicates dominance to attract the attention of female individuals.



A



B

Figure 2. A. Upper and B. lower *Austruca annulipes* morphology. Bar = 1 cm

Figure 3. Difference between male and female *Austruca annulipes* crabs

The behavior of *Austruca annulipes* and its habitat

The behavior of *A. annulipes* in the observed habitat, namely in the Mangrove Bogowonto Estuary (Jembatan Api-Api and Pasir Kadilangu), Kulon Progo, Yogyakarta, observed as was walking on the substrate, going in and out of their hiding holes, eating, and interacting with other crabs. Crabs carry out the above activities at low tide because, at high tide, the crabs will crawl into the hole and then cover it with mud. While the *A. annulipes* crab is seen on the substrate, it quickly ducks into its hiding hole when it senses movement. That is because the *A. annulipes* prefer a quiet place, so when it feels vibrations, the *A. annulipes* will hide in its hole. Besides that, this action was also carried out as a form of self-protection for the *A. annulipes* crab from predators. When it feels safe, this crab will return and continue its activities, such as looking for food. In addition, *A. annulipes* also guard its territory against other crabs. If any animal invades their territory, *A. annulipes* will try to defend that area. Larger claws on crabs are used to defend themselves during a fight, as *A. annulipes* will try to defend the territory. In the observations that have been made, observed behavior such as ingestive movements can be carried out 20-40 times per minute, then fighting or competing behavior can be carried out as many as 20-35 moves per minute, draw attention behavior can be carried out as 15-30 times per minute. The take cover behavior is only carried out when *A. annulipes* feels a sudden vibration/movement from a predator or a foreign object. The exploration behavior was observed when *A. annulipes* was looking for food (more details can be seen in Table 1).

Figure 4. Habitats of *Austruca annulipes*

The holes made by crabs serve as a survival place and shelter from predators, a breeding ground, help crabs find food, and play a role in communication between vegetation (Figure 4) (Shofi 2021). When eating, the male *A. annulipes* crab often moves its large claws into the air while the other claws take food from the substrate. This movement is repeated and makes the claws of the *A. annulipes* crab look like a violin, so this crab is known as the violin crab. First, crab claws pick up the substrate and place it in the gap between a pair of maxillipeds. After that, there is a separation of organic matter from non-organic matter. This organic material will then slip into the crab's mouth, while non-organic material will be dropped or moved in the form of small grains. According to Lim et al. (2022), *A. annulipes* crabs prioritize activities to satisfy their hunger over other activities. This is related to the research of Xiang et al. (2020) which states that crabs spend 42.3% of their time eating, 27.0% eating while walking and 10.6% stationery respectively.

The density of *A. annulipes* in the ecosystem of Mangrove Bogowonto Estuary (Jembatan Api-Api and Pasir Kadilangu) based on the sampling results at 32 observation plots with a total density value of 0.9975 individuals/m². As for its distribution, *A.annulipes* can be found in areas with characteristics that can support life and are still within tolerance limits. Many factors, including abiotic factors such as soil moisture, temperature, air, salinity, and pH, influence this distribution pattern. Based on the calculation of the Morisita Index for the species *A.annulipe*s in the Mangrove Bogowonto Estuary, a value of 1.38 was obtained. This value means that the distribution pattern of *A. annulipes* is spread out in clumped distribution pattern. Besides that, existing vegetation in the study area affects the density of *A. annulipes* which can be used to shelter, grow, develop, and find food under the roots.

ACKNOWLEDGEMENTS

In compiling this journal, the authors would like to thank various parties who have provided motivation, guidance, and support. Thank you sincerely to the manager of the Mangrove Bogowonto Estuary forest (Bridge Api-Api and Kadilangu), Kulon Progo, Yogyakarta, Indonesia for allowing it to be the subject of research.

REFERENCES

Actuti N, Apriansyah, Nurdiansyah SI. 2019. Keanekaragaman kepiting biola (*Uca* spp.) di Ekosistem Mangrove Desa Pasir, Kabupaten Mempawah Kalimantan Barat. Jurnal Laut Khatulistiwa 2: 25-31. DOI: 10.26418/lkuntan.v2i1.30162. [Indonesian]

Aprilyanto D, Fahri, Annawati. 2017. Identification of mud crab species of the Ocypodidae Family in Kabonga Kecil, Donggala, Central Sulawesi. Indones Zoo 26: 91-106.

Chen G, Mo Y, Gu X, Wang W, Cui B. 2022. Mapping the spatio-temporal dynamics of global mangrove crabs to reveal its status and challenges: A bibliometric evaluation of research output during 1980-2016. Watershed Ecol Environ 4: 100-111. DOI: 10.1016/j.wsee.2022.09.002.

Dahlia, Mukti BH. 2021. Keanekaragaman jenis kupu-kupu di perkebunan jeruk (*Citrus sinensis*) Desa Pisangan, Kecamatan Kandangan Barat, Kabupaten Hulu Sungai Selatan. Jurnal Pendidikan Hayati 7 (4): 217-225. [Indonesian]

Driptufany DW, Fajrin, Yulius H, Hidayat M, Kamal E, Razak A, Putra A. 2021. Karakteristik spesies fauna ekosistem mangrove dengan metode survey di Kawasan Teluk Bungsu-Padang. Jurnal Kependudukan dan Pembangunan Lingkungan 2 (1): 60-67. [Indonesian]

Fauzan N, Soendjoto MA, Zaini M. 2020. Kepadatan dan keragaman kepiting di Kawasan Ekowisata Mangrove Pagatan Besar, Kabupaten Tanah Laut, Indonesia. EnviroSci 16: 287-295. DOI: 10.20527/es.v16i2.9660. [Indonesian]

Hanafi H, Anwari MS, Yani A. 2020. Keanekaragaman kepiting biola pada Kawasan Hutan Mangrove Desa Karimunting Kecamatan Sungai Raya Kepulauan Kabupaten Bengkayang. Jurnal Hutan Lestari 8 (2): 350-364. DOI: 10.26418/jhl.v8i2.40332. [Indonesian]

Harini R, Ariani RD, Fistiningrum W, Ariestantya D. 2019. Economic valuation of mangrove management in Kulon Progo Regency. IOP Conf Ser: Earth Environ Sci 256: 1-1. DOI: 10.1088/1755-1315/256/1/012036.

Hasan S, Serosero RH, Abubakar S. 2020. Distribusi vertikal dan komposisi Moluska pada Ekosistem Hutan Mangrove di Gugusan Pulau-Pulau Sidangoli Kabupaten Halmahera Barat Provinsi Maluku Utara. Agrikan 13 (1): 29-37. DOI: 10.29239/j.agrikan.13.1.29-37. [Indonesian]

Irma W, Atmaja AT, Marfa'i MA. 2020. Biodiversitas vegetasi mangrove di Kecamatan Concong Kabupaten Indragiri Hilir Provinsi Riau. Majalah Ilmiah Biologi Biosfera 37 (2): 85-90. [Indonesian]

Irwansyah RM, Azzahra SIN, Darmastuti SA, Ramadhandi AR, Firdaus O, Daeni F, Safitri N, Fajri, Nugroho GD, Naim DMD, Setyawan AD. 2021. Crab diversity and crab potential as support for ecotourism in Teleng Ria, Grindulu and Siwil Beach, Pacitan, East Java, Indonesia. Intl J Bonorowo Wetlands 11: 75-83. DOI: 10.13057/bonorowo/w110204.

Kalor JD, Dimara L, Ottouw G, Piaki K. 2018. Status kesehatan dan uji spesies indikator biologi Ekosistem Mangrove Teluk Yotefa Jayapura. Journal Biosfera 35 (1): 1-9. DOI: 10.20884/1.mib.2018.35.1.495. [Indonesian]

Krebs CJ. 1998. Ecological Methodology (Second Edition). Addison-Welsey Educational Publishers, New York.

Krisnawati Y, Arthana IW, Dewi APWK. 2018. Variasi morfologi dan kelimpahan kepiting *Uca* spp. di Kawasan Mangrove, Tuban-Bali. J Mar Aquat Sci 4: 236-243. DOI: 10.24843/jmas.2018.v4.i02.236-243. [Indonesian]

Kulkarni VA, Jagta TG, Mhalsekar NM, Naik AN. 2010. Biological and environmental characteristics of mangrove habitats from Manori Creek, West Coast, India. Environ Monit Assess 168: 587-597. DOI: 10.1007/s10661-009-1136-x.

Lauren, Sumarmin R. 2020. Inventarisasi Decapoda di Hutan Mangrove Laguna Mangguang, Kota Pariaman, Sumatera Barat. Serambi Biologi 5: 79-85. [Indonesian]

Lim SSL, Mazlan D, Toh CKW. 2022. Larder hoarding versus immediate in situ food consumption in two fiddler crab species: Is it an evolutionarily stable strategy? Zool Stud 61: 1-19. DOI: 10.6620/ZS.2022.61-72.

Masiyah S, Nisaa K, Melmambessy EHP, Lutfi MA. 2021. Keanekaragaman kepiting biola (*Uca* spp.) dan respon tekstur tanah di Pantai Payunb Kabupaten Merauke. AGRIKAN - Jurnal Agribisnis Perikanan 14 : 734-756. [Indonesian]

Michael SC, Kaligis EY, Rimper JRTSL. 2020. Deskripsi, keanekaragaman jenis, dan kelimpahan kepiting (Brachyura Decapoda) di Perairan Bahowo Kelurahan Tongkeina Kecamatan Bunaken Kota Manado. Jurnal Pesisir dan Laut Tropis 8: 91-97. DOI: 10.35800/jplt.8.1.2020.27495. [Indonesian]

Min WM, Kathiresan K. 2021. Burrow morphologies crab characteristics and soil properties in different seasons across intertidal areas of a restored mangrove forest. J Sea Res 177: 102-111. DOI: 10.1016/j.seares.2021.102111.

Mujiono, Astuti W, Soehartono. 2021. Identifikasi flora dan fauna dalam pengelolaan keanekaragaman hayati di Kawasan Konservasi PT Indonesia Power Semarang. Neo Teknika 7: 42-46. [Indonesian]

Mumbah SK, Manyala JO, Njiru J. 2018. Influence of salt works' hyper-saline waste-brine on distribution of mangrove crabs (Decapoda) within the Gongoni-Kurawa Intertidal Area, Kenya. Kenya Aquat J 4: 38-47. DOI: 10.2022/ajest.v4i3.102.

Murniati DC, Pratiwi R. 2015. Kepiting *Uca* di Hutan Mangrove Indonesia: Tinjauan Aspek Biologi dan Ekologi Untuk Eksplorasi. Lipi Press, Jakarta. [Indonesian]

Musrifah S, Munir M. 2020. Membangun perisai pesisir dengan penanaman mangrove di Kawasan Pantai Desa Margosuko Kecamatan Bancar Kabupaten Tuban. J Abdi Mas TPB. 2: 54-59. DOI: 10.29303/amtpb.v2i1.43. [Indonesian]

Naderloo R, Schubart CB, Shihc HT. 2016. Genetic and morphological separation of *Uca occidentalis*, a new East African fiddler crab species, from *Uca annulipes* (H. Milne Edward, 1837) (Crustacea: Decapoda: Brachyura: Ocypodidae). Zoologischer Anzeiger 262: 10-19. DOI : 10.1016/j.jcz.2016.03.010.

Natania T, Herliany NE, Kusuma AB. 2017. Struktur komunitas kepiting biola (*Uca* spp.) di Ekosistem Mangrove Desa Kahyapu Pulau Enggano. Enggano Journal 2: 11-24. DOI: 10.31186/jenggano.2.1.11-24. [Indonesian]

Putra S, Ali MS, Huda I. 2018. Pola persebaran Gastropoda di Ekosistem Mangrove Sungai Reuleung Leupung Kabupaten Aceh. Jurnal Biotik 6: 59-62. DOI : 10.22373/biotik.v6i1.4044. [Indonesian]

Putriningtias A, Faisal TM, Komariyah S, Bahri S, Akbar H. 2019. Diversity of crab types in the Kuala Langsa Mangrove Forest Ecosystem, Langsa City, Aceh. J Trop Biol 19: 101-107. DOI: 10.29303/jbt.v19i1.1074.

Rahayu SM, Wiryanto, Sunarto. 2018. Biola crab diversity in mangrove areas, Purworejo Regency, Central Java. J Bioexp 4: 53-63. DOI: 10.23917/bioeksperimen.v4i1.5933.

Rahim S, Baderan DWK. 2017. Hutan Mangrove dan Pemanfaatannya. Depublish, Yogyakarta. [Indonesian]

Ramadhan DA, Hasibuan FU, Damayanti D, Amalia T. 2022. Persepsi masyarakat terhadap Ekowisata Hutan Mangrove Kuala Langsa. Jurnal Pengabdian Masyarakat Biologi dan Sains 1 (2) : 7-14. [Indonesian]

Raunsay EK, Akobiarek M, Ruamba MY. 2020. Distribusi vertikal *Asplenium nidus* L. di Kawasan Hutan Imbowiari, Kepulauan Yapen Papua. Jurnal Sylva Lestari 8: 390-399. DOI: 10.23960/jsl38390-399. [Indonesian]

Rianta P, Ernawati W, Chen G, Chen S. 2018. Diversity and abundance of mangrove fiddler crabs, genus *Uca* (Decapoda, Ocypodidae) at a Mangrove in Kema, North Sulawesi, Indonesia. Acta Oceanologica Sinica 37: 92-96. DOI : 10.1007/s13131-018-1336-8.

Riswandi A, Febriyanti U. 2022. Pola persebaran kepiting biola (*Uca* sp.) di Kawasan Mangrove Curahsawo Probolinggo, Jawa Timur. Jurnal Ilmu Perikanan Air Tawar (CLARIAS) 3 (13): 11-17. DOI: 10.56869/clarias.v3i1.345. [Indonesian]

Roberge JM, Angelstam P. 2004. Usefulness of the umbrella species concept as a conservation tool. Conserv Biol 18 (1): 76-85. DOI : 10.1111/j.1523-1739.2004.00450.x.

Saparinto C. 2010. Consumption Fish Business in 100 m^2 Land. Independent Spreader, Jakarta.

Saputri M, Muammar. 2018. Habitat characteristics of mangrove crab (*Scylla sp*.) in the Silang Cadek Mangrove Ecosystem, Baitussalam District, Aceh Besar District, Aceh Province. J Botik 6: 75-80. DOI: 10.22373/biotik.v6i1.4436.

Sari RN, Safe R, Iswandaru D. 2019. Biodiversitas fauna sebagai salah satu indikator kesehatan hutan mangrove. Jurnal Parennial 15 : 62-66. DOI: 10.24259/perennial.v15i2.6061. [Indonesian]

Septiani M, Sunarto, Mulyani Y, Riyantini I, Prihadi DJ. 2019. Pengaruh kondisi mangrove terhadap kelimpahan kepiting biola (*Uca* spp.) di Karangsong Kabupaten Indramayu. Jurnal Perikanan dan Kelautan 10: 84-91. [Indonesian]

Shofi S. 2021. Community Structure of *Uca* spp. (Crustacea: Decapoda: Ocypodidae) in the Mangrove Forest Area of Banyuurip Village, Gresik Regency. [Thesis]. Maulana Malik Ibrahim State Islamic University, Malang. [English]

Suryana IGPE, Antara IGMY. 2021. Pengembangan teknologi informasi geografi sebagai media eksplorasi keanekaragaman hayati (biodiversitas) di Indonesia. J Appl Comput Inform Syst 3: 46-55. DOI: 10.33173/jsikti.117. [Indonesian]

Xiang H, Li K, Cao l, Zhang Z, Yang H. 2020. Impacts of pollution, sex, and tide on the time allocations to behaviors of *Uca arcuata* in Mangroves. Sci Total Environ 742: 1-13. DOI : 10.1016/j.scitotenv.2020.140609.

Yudha RP, Sugito YS, Sillanpaa M, Nurvianto S. 2021. Impact of logging on the biodiversity and composition of flora and fauna in the mangrove forests of Bintuni Bay, West Papua, Indonesia. For Ecol Manag 488: 1-12. DOI: 10.1016/j.foreco.2021.119038.

Zeng Y, Friess DA, Sarira TV, Siman K, Koh LP. 2021. Global potential and limits of mangrove blue carbon for climate change mitigation. Curr Biol 31: 1737-1743. DOI: 10.1016/j.cub.2021.01.070.