Species Diversity of Fiddler Crabs (*Uca* spp.) in the Mangrove Ecosystem of Duta Coastal, Probolinggo Regency, East Java

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Abstract

Fiddler crab (Uca spp.) belongs to the Order Decapoda and Family Ocypodidae, which live by making burrows in the substrate between mangrove plants. The presence of fiddler crabs plays an important role in mangrove ecosystems, which can increase sediment mineralisation due to burrows that can increase oxygen distribution into the sediment. This research was conducted in the mangrove ecosystem of Duta coastal, Probolinggo Regency. The method used when sampling biota in this study is the transect-plot method, which is used to place 1x1 m² plots systematically along the transect. Sampling of fiddler crabs was carried out at the lowest low tide. Samples taken were fiddler crabs in the plot. Data on the species found, the number of individuals of each species, and the total number of individuals obtained from species composition were used to calculate species diversity. Fiddler crabs (Uca spp.) found in the mangrove ecosystem Duta coastal were 10 species, namely U. perplexa, U. rosea, U. vocans, U. annulipes, U. triangularis, U. coarctata, U. tetragonon, U. vomeris, U. forcipata, and U. dussumieri. The diversity value of fiddler crab species in the Ambassador Coastal Mangrove ecosystem is moderate (H' = 2.209). All species of fiddler crabs were found in the muddy sand substrate type, because the burrow structure is strong, so that when the tide, the burrow condition is maintained.

Keywords: *Fiddler Crabs; Diversity; Mangrove Forest; Duta Coastal*

INTRODUCTION

Fiddler crabs (Genus *Uca*) are crabs that have unique characteristics in the form of asymmetrical claws in male individuals, while in female individuals both claws are small (Swanson, *et al.,* 2013). The size of the Fiddler crab is small with varied body colours (Rahayu *et al.*, 2018). Fiddler crabs (*Uca* spp.) belong to the Order Decapoda and Family Ocypodidae which live making burrows in the substrate between mangrove plants (Rianjuanda *et al.*, 2020). This behaviour serves as a place to live and hide when threatened (Loviasari *et al*., 2018). Wa'dah & Hamidah (2016) reinforced the statement that the fiddler crab has burrowing behaviour which is a form of behavioural adaptation in the mangrove ecosystem.

Mangrove ecosystems play an important role for the life of fiddler crabs, namely as a spawning ground, feeding ground and nursery ground (Zeil & Hemmi, 2006; Nur & Kuntjoro, 2020). Conversely, the presence of fiddler crabs also plays an important role in the mangrove ecosystem, which can increase sediment mineralisation due to the presence of burrows that can increase oxygen distribution into the sediment (Andini *et al*. 2019). In addition, fiddler crabs also act as deposit feeders (Virgilio & Ribeiro, 2013), prey for predatory birds and fish, and as meiofauna of mangrove ecosystems that feed on bacteria and diatoms (Mahatma *et al.*, 2013). One of the mangrove ecosystems in Probolinggo Regency is the mangrove ecosystem Duta coastal which is a habitat for fiddler crabs.

Duta coastal is an ecotourism site that has two zones in it. The two zones include a public zone and a conservation zone. The conservation zone consists of sea pine stands and mangrove ecosystems (Bahiyah *et al.*, 2018). Based on information from the community around Duta Coastal, fiddler crabs have economic value, namely as fishing bait. Fiddler crabs can also be used as an ornamental crab that can be traded (Saidah *et al*., 2021). The genus Uca in Indonesia is found in mangrove ecosystems and has 17 species that have been identified in Indonesia, out of 97 total species worldwide (Murniati & Pratiwi, 2015).

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Research of Fiddler crabs that has been reported in Probolinggo Regency is in the mangrove ecosystem of Curahsawo, Gending District, by Riswandi *et al.* (2019) who found six species of fiddler crabs. The types of fiddler crabs found are *U. demani, U. dussumieri, U. vocans, U. rosea, U. lactea* and *U. perplexa* which are included in the 17 species of fiddler crabs that have been identified in Indonesia. Information on the species diversity of fiddler crabs in the mangrove ecosystem of Duta Coastal specifically has not been reported, but the presence of fiddler crabs has been listed in the 2018 Randutatah Biodiversity Report, as a fauna found in the conservation area of the Duta Coastal mangrove ecosystem as a member of the Subphylum Crustacea. The report by the Randutatah Biodiversity team in 2018, found three types of fiddler crabs in the mangrove ecosystem of Duta Coastal, but without specific identification to the species level. Based on this background, it is necessary to conduct research on the diversity of violin crab species in the mangrove ecosystem of Duta Coastal, Probolinggo Regency. The purpose of this study was to determine the species diversity of fiddler crabs (*Uca* spp.) in the mangrove ecosystem of Duta Coastal, Probolinggo Regency. The results of this study can be used as a database on the diversity of fiddler crab species and maintain mangrove ecosystems so that fiddler crab habitat is maintained.

MATERIAL AND METHODS

The research was conducted from October 2022 to January 2023. Data collection was carried out in the mangroves ecosystem of Duta Coastal, Probolinggo Regency, East Java (Figure 1) with coastline coordinates between 7042'12.98"S and 113028'31.86"E to 7042'17.77"S and 113028'19.67"E. Mangrove ecosystem at Duta coastal has a area based on GPS coordinates is about 68,704 m^2. Identification and data analysis activities were carried out at the Ecology Laboratory, Jember University.

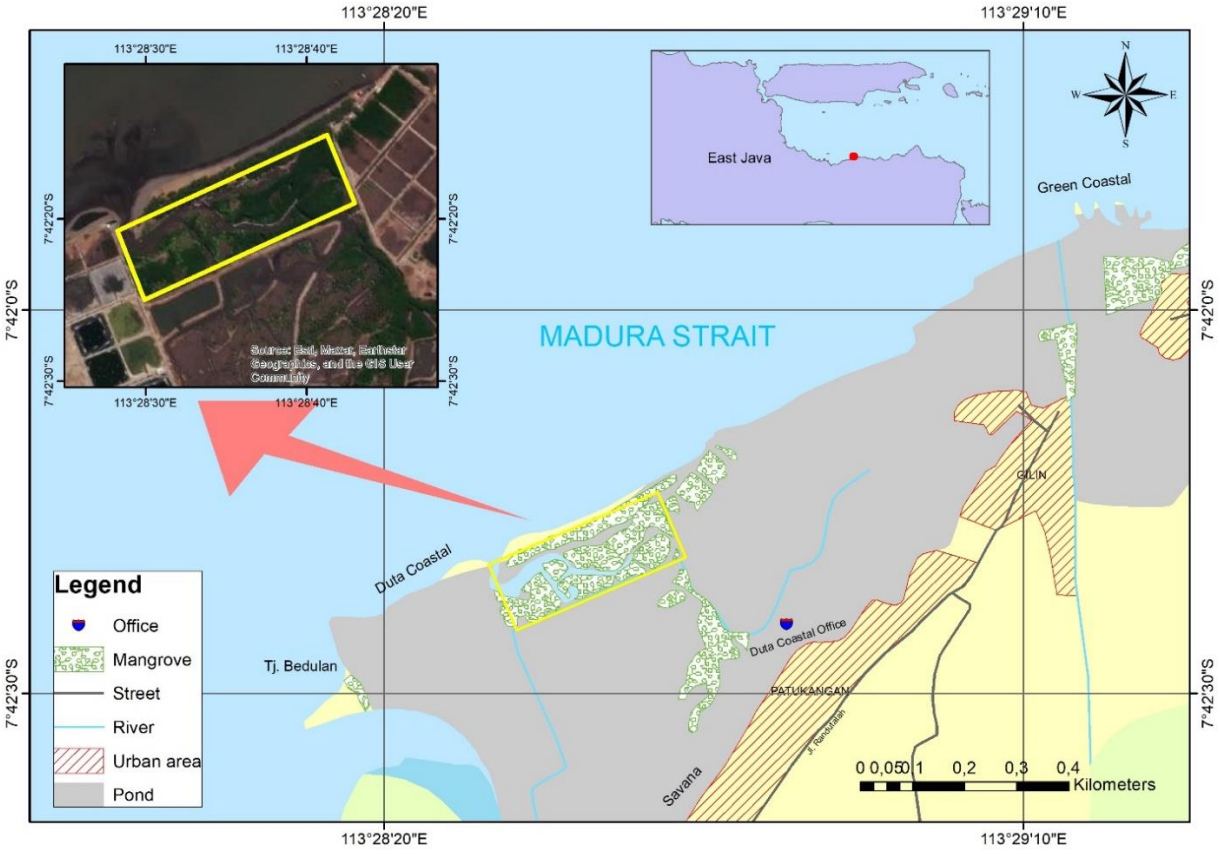

Figure 1. The Map of Sampling Location at Mangrove Ecosystem, Duta Coastal, Probolinggo

The method used when sampling biota in this study is the transect-plot method by placing 1x1 m^2 plots systematically along the transect (Figure 2). Plotting was determined based on the length of the mangrove ecosystem area of Duta Coastal. The length of the mangrove ecosystem determined as the research site is 400 m with a width of 100 m or with a total area of 40,000 m2 mangrove ecosystem. Transects placed at the research site were 25 m apart, and the number of transects placed at the research site was 5. 1x1 m2 plots were placed on each transect with a distance of 20 m between plots. The distance between transects and plots was determined based on the length, width and density of the mangrove ecosystem, resulting in a total of 100 plots.

Sampling of fiddler crabs was conducted at the lowest low tide. Samples taken were fiddler crabs in the 1x1 m^2 plot. The presence of fiddler crabs in the plot was confirmed by the presence of burrows. The burrows were then dug using a shovel to a depth of 15-20 cm. Fiddler crabs can dig burrows up to a depth of 50 cm, with the characteristics of burrows sloping like the letter 'J' (Murniati & Pratiwi, 2015). The fiddler crab samples obtained were cleaned of dirt using a fine brush and seawater. The purpose of using a fine brush is so that the body parts are not damaged. Samples were then anaesthetised using 70% alcohol. One bottle of anaesthetic contains one individual which aims to prevent fights that can lead to the release of limbs. Abiotic data measurements were made three times at nine predetermined points (upper, middle, and lower on transects 1, 3, and 5). The habitat environmental parameters taken are related to environmental factors that affect the life of fiddler crabs, including pH, temperature, salinity and substrate type.

Samples that have been documented are then stored in a bottle filled with 75% alcohol for preservation so that species name verification can be carried out in the laboratory. Preservation of fiddler crab (Subphylum Crustacea) specimens based on Murniati and Pratiwi (2015) is in alcohol with a minimum concentration of 75%, with the aim of preventing the release of the carapace and joints in the body parts. The samples collected were representative of each species found. Data recording of fiddler crabs at the research site includes a description of morphological characteristics such as carapace colour, carapace face (wide or narrow), carapace width size, orbit base (serrated or pitted), presence or absence of pustules on the large claw manus, manus colour, polex and large claw dactylus, so that the species name can be known. After knowing the name of the species, the number of individuals of each species and the total number of all individuals were calculated. The fiddler crab samples were described based on morphological characters and then identified to the species level, followed by verification. Verification was carried out up to the species level. Verification was carried out by referring to Crane's identification key book (1975), Rosenberg (2001), Naderloo *et al*., (2010), and Murniati & Pratiwi (2015).

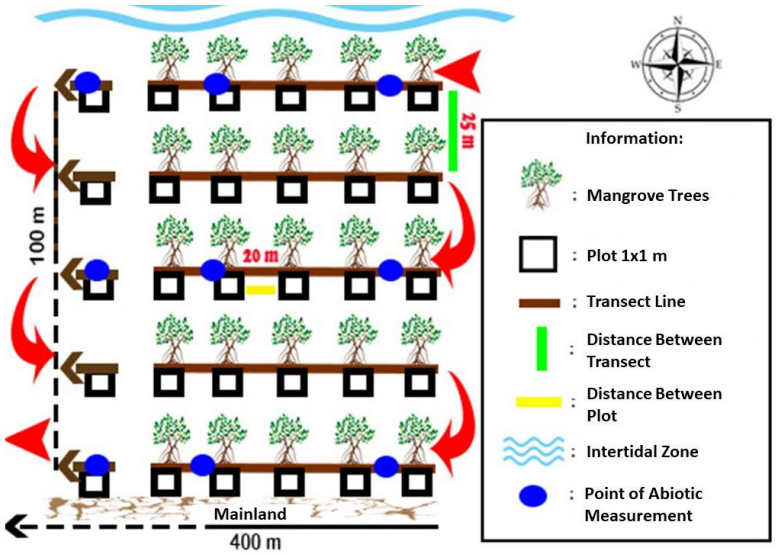

Figure 2. Technique of Schematic data collection in the Mangrove Ecosystem of Duta Coastal

Data on fiddler crabs species that have been identified and verified are then tabulated based on their taxon including name of species, number of individuals, way of life, and number of individual types. Abiotic parameter data is used to analyze the physical condition of the environment in the Mangrove ecosystems of the Duta coastal. The data that has been obtained is then entered into a table and the smallest to largest range value is determined.

Analysis of species diversity (H') uses the Shannon-Wiener Diversity Index with the following formula:

$$H' = - \Sigma \, pi \ln pi \text{ with } pi = ni/N \text{ (Magurran, 2011)}$$

H' value is the Shannon Wiener diversity index with the value of pi being the abundance of species and ni being the number of individuals per species. while the N value is the total number of all types. This formula is used to calculate all types of fiddler crabs found in the Duta Coastal.

Data collection of each abiotic parameter, namely water pH, temperature, salinity, and substrate type, was used to determine the physical conditions in the mangrove ecosystem of Duta Coastal, Probolinggo Regency. pH and water temperature were measured using a Hanna HI98107 pH meter at the lowest low tide and taken at a point that was flooded. Salinity was measured using an ATC refractometer at the lowest low tide and taken at the point that was flooded. The substrate occupied by fiddler crabs in each plot was observed directly, by taking the substrate and observing it visually and doing hand texture on the substrate. Abiotic data measurements were made three times at nine predetermined points (upper, middle, and lower on transects 1, 3, and 5). Data on environmental abiotic factors were analysed descriptively quantitatively. The value of abiotic data is determined first the value of the smallest to largest range and the results of the analysis are used to support the composition and diversity of fiddler crab species in the mangrove ecosystem of Duta Coastal, Probolinggo Regency.

RESULT AND DISCUSSION

The results showed that the species composition of fiddler crabs in the mangrove ecosystem of Duta coastal, Probolinggo Regency, consisted of 10 species, namely *U. perplexa, U. rosea, U. vocans, U. annulipes, U. triangularis, U. coarctata, U. tetragonon, U. vomeris, U. forcipata,* and *U. dussumieri* with a total of 1555 individuals (Table 1; Figure 3). These species occupied different substrate types: sand, silty sand, clayey mud, and sandy mud. There are more types of fiddler crabs in this research location compared to research conducted by Riswandi *et al.* (2019) in the Curahsawo mangrove ecosystem, Gending District, Probolinggo Regency which only found 6 species. Fiddler crabs found in this study are 10 species of 13 species whose existence has been reported in Java Island. The three types of fiddler crabs that were not found in this study were U. *demani, U. lactea* and *U. crassipes*.

The presence of fiddler crabs in the study site is largely determined by the type of substrate. Each type of fiddler crab found can occupy different types of substrate, based on its adaptability to substrates dominated by sand and mud. This adaptability is a form of morphological adaptation, because it is related to the type of setae on the second maxilliped that functions as a rake for organic material on the substrate (Pardo, *et al.*, 2020). Fiddler crabs that live in sand or sand-dominant substrates have more spoon-tipped setae than plumose setae, and vice versa (Murniati & Pratiwi, 2015). An example of a fiddler crab that has wide adaptability (in this study) is *U. Perplexa.*

According to Peer *et al.,* (2015) and Masiyah *et al.* (2021), the distribution of fiddler crabs is largely determined by the type of substrate, because it is related to the burrow used as a place to live. The results showed that all types of fiddler crabs can be found in muddy sand substrate types, because the burrow structure is strong, so that when the tide is high, the burrow condition is maintained. This is supported by the statement of Actuti *et al.* (2019), that muddy sand substrates are

Table 1. Species Composition of Fiddler Crabs in the Mangrove Ecosystems of Duta Coastal

Type of Fiddler Crabs	Individual Number	Substrate Types
Uca perplexa (H. Milne Edwards, 1837)	329	silty sand, Mud, Sandy mud, Sand
Uca rosea (Tweedie, 1937)	215	silty sand, Mud, Sandy mud
Uca vocans (Linnaeus, 1758)	185	silty sand, Mud, Sandy mud
Uca annulipes (H. Milne Edwards, 1837)	148	silty sand, Mud, Sandy mud, Sand
Uca triangularis (H. Milne Edwards, 1873)	145	silty sand, Mud, Sand
Uca coarctata (H. Milne Edwards, 1852)	141	silty sand, Mud
Uca tetragonon (Herbst, 1790)	121	silty sand, Mud, Sand
Uca vomeris (McNeill, 1920)	112	silty sand, Mud, Sandy mud, Sand
Uca forcipata (Adams & White, 1849)	92	silty sand, Mud, Sandy mud
Uca dussumieri (H. Milne Edwards, 1852)	67	silty sand
Total Individual	1555	

Table 2. The Value of Environmental Abiotic in the Mangrove Ecosystems of Duta Coastal

Abiotic Environmental	Value Range
Temperature (˚C)	28,7 – 30,6
pH	6,55 – 7,2
Salinity (‰)	24 – 25,7

more supportive of fiddler crab life due to their strong structure. In addition, the distribution of fiddler crabs is also influenced by the availability of food contained in muddy sand substrates, because fiddler crabs are deposit feeders (Murniati, 2010).

The existence of many types of fiddler crabs found in the mangrove ecosystem of Duta coastal is also supported by abiotic factors such as pH, temperature, and salinity. The degree of acidity (pH) in the waters of the Duta coastal mangrove ecosystem based on the measurement results is 6.5 - 7 (Table 2). The value of the pH range is classified as neutral, due to the flow of fresh water from the tributaries that flow into the estuary and through the mangrove ecosystem. The neutral and ideal pH conditions also affect the life of bacteria that decompose litter debris, so that bacterial activity in decomposing litter debris increases (Sunarti & Ridwan, 2017), and makes it easier for fiddler crabs to find food in the form of deposits on the substrate. The pH condition of the water supports the life of fiddler crabs, because fiddler crabs live in the pH range of 5 - 9. pH values that are too acidic or alkaline can result in the death of fiddler crabs (Septiani *et al*., 2019). This death can be caused by decreased oxygen concentration in the water so that respiratory activity becomes high and affects the decrease in foraging activity (Agus, 2008).

Temperature is one of the abiotic factors that is important for the life and growth of fiddler crabs (Natania *et al*., 2017; Vianna *et al.*, 2020). This study was conducted in the morning until noon, so the temperature was around 28.7 - 30.6 ◦C, which is the ideal temperature for the life of fiddler crabs. Light intensity at The light intensity from morning to noon is relatively high, so it can affect the water temperature. The temperature can affect the increased activity of fiddler crabs in searching for food, because fiddler crabs are diurnal organisms (active during the day). Based on Murniati & Pratiwi (2015), fiddler crabs can live in a temperature range of 27 – 32 ◦C. According to Uno *et al*. (2019), temperatures that are too low or high can affect the slowing of metabolic processes, thus slowing the development of fiddler crabs, and can result in death. Salinity is a parameter that can affect the life of fiddler crabs. Salinity greatly affects the growth of fiddler crabs. Salinity that is too high or low

causes a slowdown in the growth of fiddler crabs. Salinity in the waters of the Duta Coastal mangrove ecosystem based on the measurement results is 24 - 25.7 ‰. The salinity value is considered ideal and supports the life of fiddler crabs because according to Murniati & Pratiwi (2015), fiddler crabs in mangrove ecosystems live in the salinity range of 20 - 30 ‰. The ideal salinity affects the acceleration of growth for fiddler crabs, so that it can accelerate the rate of reproduction. According to Natania *et al.* (2017) salinity below and above the optimum limit can cause death in fiddler crabs, because it affects the amount of food consumed.

The results showed that the type of fiddler crab that was found more in the mangrove ecosystem of Duta coastal, Probolinggo Regency was *U. perplexa* with a total of 329 individuals. *Uca perplexa* is found more because it can adapt well to all four types of substrates, namely muddy sand, clay mud, sandy mud, and sand substrates. *Uca perplexa* is also found because it can make burrows in various places, such as in open mangrove ecosystems without mangrove plant cover, as well as making burrows near mangrove roots with dense mangrove plant cover. Internal factors that can influence high abundance are rapid development, thus affecting the acceleration of the reproduction rate (12 months of age can reproduce), and in a favourable environment can live up to 4 years (Murniati, 2008). *Uca perplexa* habitat in the mangrove ecosystem of Duta coastal has similarities with the habitat in the mangrove ecosystem of Kabonga Kecil, Donggala, Central Sulawesi by Aprilyanto *et al*. (2017). Uca perplexa in the Kabonga Kecil mangrove ecosystem can also occupy various types of substrates and make many burrows in the open, but are also found in mangrove roots.

The next most common fiddler crab species was *U. rosea* with 215 individuals. *Uca rosea* is able to adapt to muddy sand, clay mud, and sandy mud substrate types, and is found in dense mangrove roots. Fiddler crabs that live in dense mangrove roots such as *U. rosea* have low predation rates, because their habitat is protected by mangrove roots, so their numbers are found after U. perplexa. *Uca rosea* in the mangrove ecosystem of Curahsawo, Probolinggo Regency by Riswandi *et al.* (2019) also found more after *U. perplexa*. This is because U. rosea likes habitats with substrates containing mud and dense vegetation cover. The least common fiddler crab species found in this ecosystem is *U. dussumieri*. *Uca dussumieri* is the least found because it can only be found on muddy sand substrates. Muddy sand substrate at the research site was only found in certain locations, namely at the edge of the mangrove bordering the mainland, resulting in a small number of *U. dussumieri* individuals. The habitat of *U. dussumieri* at the research site is around mangrove roots and also in places that are not covered by vegetation. Internal factors that cause low abundance are slow reproduction (reproductive age can reach 14 months) (Murniati, 2008; Kareho *et al*., 2019). According to research conducted by Suprayogi *et al.* (2014), *Uca dussumieri* was found the least because it can only adapt to substrates that are more dominant in sand than mud.

Based on the results of the calculation, it is known that the index value of the species diversity of fiddler crabs in the mangrove ecosystem of Duta coastal, Probolinggo Regency is classified as moderate. This is indicated by the value of $H' = 2.209$. The moderate value of species diversity is due to the number of individuals in each species that is almost evenly distributed, as well as the total number of all individuals that are abundant (1555 individuals), but there are several species that have more individuals than other species. The dominant species found were *U. perplexa* and *U. rosea*. According to Krebs (2014), species diversity is determined by the number of species and the number of individuals of each species in a community. If the number of species is getting smaller, and there are some individuals that are more dominant, then the diversity of the species will decrease.

The moderate species diversity value can also be caused by the mangrove ecosystem of Duta Coastal which is a mangrove conservation area that is still in the process of rehabilitation, so the density of mangrove plants is still sparse. Therefore, the abundance of fiddler crab species found in this location is uneven. This statement is supported by Hanafi *et al.* (2020) and Haruna *et al.* (2022), that the value of the diversity of species of fiddler crabs can be caused by the research location which is a mangrove conservation area in the growth stage or rehabilitation process.

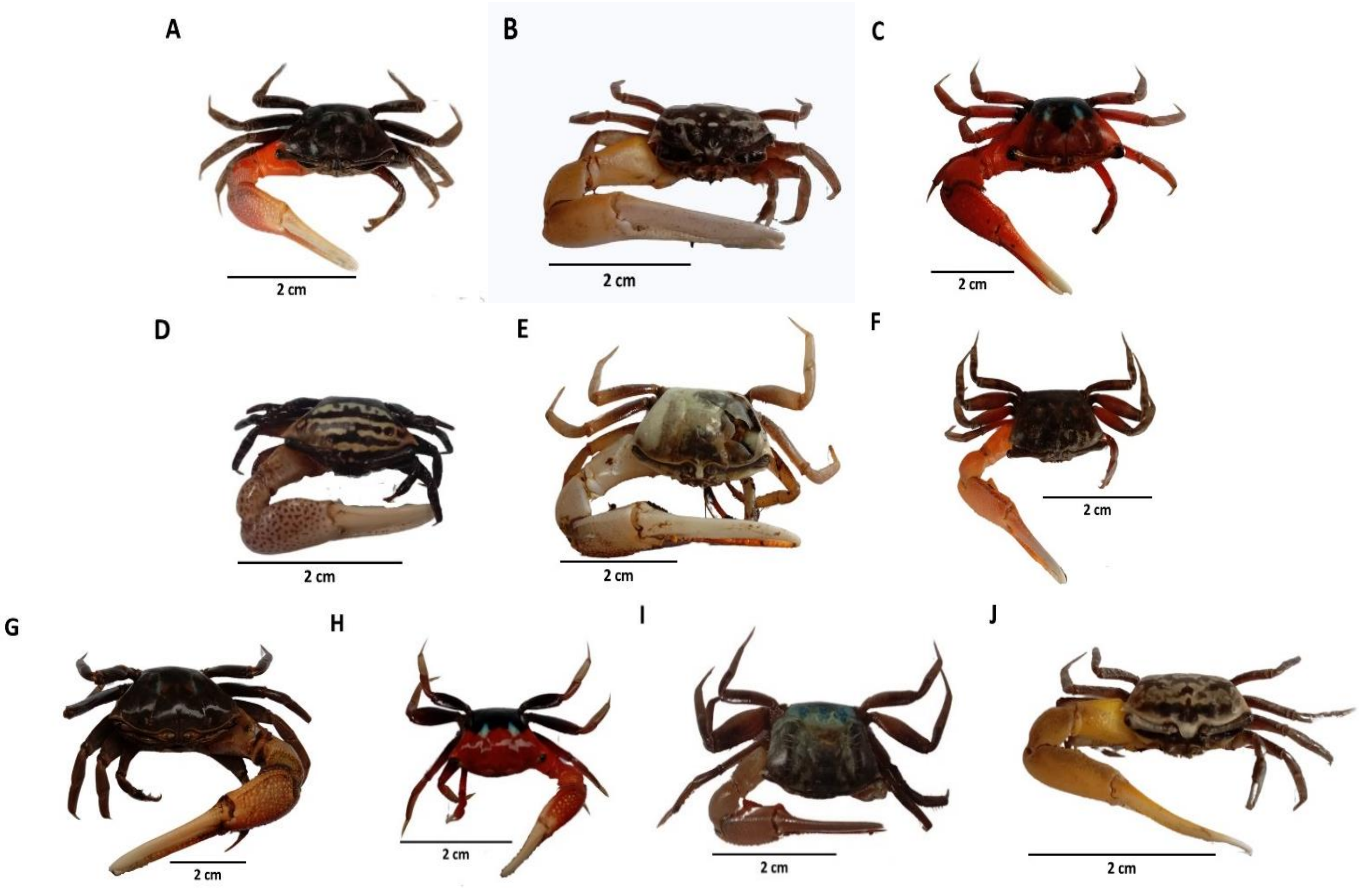

Figure 3. Genus *Uca* spp. in the Mangrove Ecosystems of Duta Coastal, Probolinggo Regency. A) *Uca coarctata*. B) *Uca perplexa*. C) *Uca rosea*. D) *Uca triangularis.* E) *Uca vocans*. F) *Uca vomeris*. G) *Uca dussumieri*. H) *Uca forcipata*. I) *Uca tetragonon*. J) *Uca annulipes*

According to Cadotte *et al.* (2011), moderate species diversity values indicate a fairly balanced/stable ecosystem condition and moderate ecological pressure. A fairly balanced ecosystem can occur due to a fairly stable food chain, but there are interactions between individuals and types of fiddler crabs that cause competition (interspecies competition) in fighting for food (Pramudji, 2010). Such competition can occur because fiddler crabs in a place (plot) consist of 2-5 species (Murniati & Pratiwi, 2015). Moderate ecological pressure can be caused by the presence of tourists (visitors) in the mangrove ecosystem because in addition to being a conservation area, the mangrove ecosystem of Duta Coastal is also used as ecotourism. Another cause is the hunting of fiddler crabs by local residents as fishing bait. The habitat of fiddler crabs that has turned into ecotourism and hunting as fishing bait has resulted in increased human activity in the ecosystem. Human activities can disturb the habitat of fiddler crabs, because fiddler crabs like quiet habitats (Actuti *et al.*, 2019).

CONCLUSION

Fiddler crabs found in the mangrove ecosystem of Duta coastal are 10 species, namely *U. perplexa, U. rosea, U. vocans, U. annulipes, U. triangularis, U. coarctata, U. tetragonon, U. vomeris, U. forcipata,* and *U. dussumieri*. The index value of the species diversity of fiddler crabs in the mangrove ecosystem of Duta coastal is moderate (H' = 2.209).

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REFERENCES

Actuti, N., Apriansyah., & Nurdiansyah, S.I. (2019). Keanekaragaman kepiting biola (*Uca* spp.) di ekosistem mangrove Desa Pasir, Kabupaten Mempawah Kalimantan Barat. *Jurnal Laut Khatulistiwa, 2*(1), 25-31. doi: 10.26418/lkuntan.v2i1.30162.

Agus, M. (2008). Analisis *carryng capacity* tambak pada sentra budidaya kepiting bakau (*Scylla* sp.) di Kabupaten Pemalang-Jawa Tengah. *Thesis*. Semarang: Universitas Diponegoro.

Andini, M. D., Andriman., & Sumiarsih, E. (2019). Struktur komunitas kepiting biola (*Uca* sp.) di ekosistem mangrove Desa Sungai Rawa Kecamatan Sungai Apit Kabupaten Siak. *Jurnal Fakultas Perikanan dan Kelautan Universitas Riau, 2*(2),1-10. doi: 10.31258/jpk.24.1.52-60

Aprilyanto, D., Fahri., & Annawaty. (2017). Kelimpahan relatif dan preferensi habitat pada kepiting mangrove (Uca spp.) di Kabonga Kecil, Donggala, Sulawesi Tengah. *Natural Science: Journal of Science and Technology, 6*(3), 284-290. doi: 25411969.2017.v6.i3.9203

Bahiyah, C., Hidayat, W., & Sudarti. (2018). Strategi pengembangan potensi pariwisata di Pantai Duta Kabupaten Probolinggo. *Jurnal Ilmu Ekonomi 2*(1), 95-103. doi: 10.22219/jie.v2i1.6970

Cadotte, M.W., Carscadden, K., & Mirotchnik, N. (2011). Beyond species: functional diversity and the maintenance of ecological processes and services. *Journal of Applied Ecology, 48*(2), 1079-1087. doi: 10.1111/j.1365-2664.2011.02048.x

Crane, J. (1975). Ocypodidae: Genus Uca. New Jersey: Princeton University Press.

Fitriana, Y.R. (2006). Keanekaragaman dan kemelimpahan makrozoobentos di hutan mangrove hasil rehabilitasi Taman Hutan Raya Ngurah Rai Bali. *Biodiversitas, 7*(1), 67-72. doi: 10.13057/biodiv/d070117

Hanafi., Anwari, M.S., & 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

Haruna, M.F., Karim, W.A., Rajulani, R., & Lige, F.N. (2022). Struktur komunitas kepiting bakau di kawasan konservasi mangrove Desa Polo Kecamatan Bunta Kabupaten Banggai. *BIO-Lectura: Jurnal Pendidikan Biologi,* 9(2), 150-159. doi: 10.31849/bl.v9i2.10659

Kareho, M.A.B., Masithah, B.D., & Tjahjaningsih, W. (2019). Bacterial composition in the gastrointestinal tract of *Uca* spp. Crabs fed on *Avicennia marina* leaf litter. *Earth and Environmental Science, 236*(3), 1-5. doi: 10.1088/1755-1315/236/1/012080

Krebs, C.J. (2014). Ecological Methodology, 3rd Edition. New York: Harper & Row Publisher.

Loviasari, N.W., As-Syakur, A.R., & Faiqoh, E. (2018). Struktur komunitas *Uca* sp. di kawasan Teluk Benoa pada karakteristik substrat yang berbeda. *Journal of Marine and Aquatic Sciences, 4*(1): 141-150. doi: 10.24843/jmas.2018.v4.i01.141-150

Magurran, A.E., & McGill, B.J. (2011). Biological Diversity: Frontiers in Measurement and Assesment. Oxford: Oxford University Press.

Mahatma, R. Kharijon., Iriani, D., Nasution, S., Nery, E., & Nurmalisyah. (2013). Analisis Meiofauna di kawasan mangrove Kota Dumai Propinsi Riau. *Prosiding Seminar FMIPA Universitas Lampung,* pp 225-230

Masiyah, S., Nisaa, K., Melmambessy, E.H.P, & Lutfi, M.A. (2021). Keanekaragaman kepiting biola (*Uca* spp.) dan respon tekstur tanah di Pantai Payung Kabupaten Merauke. *AGRIKAN - Jurnal Agribisnis Perikanan, 14*(2), 734-756. doi: 10.29239/j.agrikan.14.1.99-107

Mokhtari, M., Ghaffar, M.A., Usup, G., & Cob, Z.C. (2015). Determination of Key Environmental Factors Responsible for Distribution Patterns of Fiddler Crabs in a Tropical Mangrove Ecosystem. *Plos One, 13*(1), 77-89. doi: 10.1371/journal.pone.0117467

Murniati, D.C. (2008). *Uca lactea* (De Haan, 1835) (Decapoda; Crustacea): kepiting biola dari mangrove. *Fauna Indonesia, 8*(1), 14-17. doi: 10.29303/FI.v21i3.2990

Murniati, D.C. (2010). Keanekaragaman Uca spp. dari Segara-Anakan, Cilacap, Jawa Tengah sebagai pemakan deposit. *Fauna Indonesia, 9*(1), 19-23. doi: 10.270606/FI.v21i3.3345

Murniati, D.C., & Pratiwi, R. (2015). Kepiting Uca di Hutan Mangrove Indonesia. Jakarta: LIPI Press.

Naderloo, R., Turkay, M., & Chen, H.L. (2010). Taxonomic revision of the wide-front fiddler crabs of the Uca lactea group (Crustacea: Decapoda: Brachyura: Ocypodidae) in the Indo-West Pacific. *Zootaxa, 2*(1), 1-38. doi: 10.11646/zootaxa.2500.1.1

Natania, T., Herliany, N.E., & Kusuma, A.B. (2017). Struktur komunitas kepiting biola (*Uca* spp.) di ekosistem mangrove Desa Kahyapu Pulau Enggano. *Jurnal Enggano, 2*(1), 11-24. doi: 10.31186/jenggano.2.1.11-24

Nur, B.A., & Kuntjoro, S. (2020). Keaneakaragaman dan kelimpahan kepiting biola (Crustacea: Ocypodidae) di pantai selatan Kabupaten Bangkalan, Madura. *Lentera Bio, 9*(3), 176-184. doi: 10.26740/lenterabio.v9n3.p176-184

Pardo, J.C.F., Silva, G.F., Christy, J.H., & Costa, T.M. (2020). Fiddler crabs and their above-ground sedimentary structures: a review. *Journal of Ethology, 38*(1), 137-154. doi: 10.1007/s10164-020-00647-1

Peer, N., Miranda, N.A.F., & Perissinotto, R. (2015). A review of fiddler crabs (Genus *Uca Leach*, 1814) in South Africa. *African Zoology, 50*(3), 187-204. doi: 10520/EJC178632

Pramudji. (2010). Upaya pengelolaan hutan mangrove dlihat dari aspek perlindungan lingkungan. *Oseana, 25*(3), 1-8. doi: 10.22219/oseana.v14i0.4292

Rahayu, S.M., Wiryanto., & Sunarto. (2018). Keanekaragaman kepiting biola di kawasan mangrove Kabupaten Purworejo, Jawa Tengah. *Bioeksperimen, 4*(1), 53-63. doi: 10.20527/es.v13i1.3517

Rianjuanda, D., Zulfahmi, I., Melanie, K., Nisa, C. Paujiah, E., Irfannur, I., Muliari, M., & Marlinda, R. (2020). Variasi morfometrik tiga jenis kepiting biola jantan (Decapoda: Ocypodidae) yang ditangkap di kawasan mangrove Jaboi, Pulau Weh, Indonesia. *Jurnal Ilmu-ilmu Perairan, Pesisir dan Perikanan, 9*(3), 464-470. doi: 10.13170/depik.9.3.16887

Riswandi, A., Yuli, A., & Mulyanto. (2019). Studi komunitas kepiting biola (*Uca* sp.) pada ekosistem mangrove kawasan mangrove Curahsawo Probolinggo, Jawa Timur. *Jurnal Ilmu Perikanan 10*(1), 31-37. doi: 10.20358/JIP.v13i1.2876

Rosenberg, M.S. (2001). The Systematics and Taxonomy of Fiddler Crabs: A Phylogeny of the Genus Uca. *Journal of Crustacean Biology 21*(3), 839-869. doi: 10.1163/20021975-99990176

Saidah, B., & Rubianti, I. (2021). Keanekaragaman jenis kepiting biola (*Uca* spp.) di kawasan mangrove Kecamatan Monta Kabupaten Bima. *Oryza Jurnal Pendidikan Biologi 10*(2), 43-53. doi: 10.33627/oz.v10i2.629

Septiani, M., Sunarto, Y., Mulyani, I., Riyantini., & Prihadi, D.J. (2019). Pengaruh kondisi mangrove terhadap kelimpahan kepiting biola (*Uca* spp.) di Karangsong Kabupaten Indramayu. *Jurnal Perikanan dan Kelautan, 10*(1), 84-91. doi: 10.31258/jpk.24.1.61-68

Sunarti & Ridwan, A.Y. (2017). Keanekaragaman bakteri serasah daun mangrove *Rhizophora apiculata* yang terdekomposisi di Kawasan Konservasi Mangrove dan Bekantan (KKMB) Kota Tarakan. *Jurnal Perikanan dan Kelautan Tarakan, 2*(1), 34-41. doi: 10.31539/JPKTs.v4i1.2205

Suprayogi, D., Siburian, J., & Hamidah, A. (2014). Keanekaragaman kepiting biola (Uca spp.) di Desa Tungkal I Tanjung Jabung Barat. *Biospecies, 7*(1), 22-28. doi: 10.22437/biospecies.v7i1.1493

Swanson, B.O., George, M.N., Anderson, S.P, & Christy, J.H. 2013. Evolutionary variation in the mechanics of fiddler crab claws. *BMC Evolutionary Biology, 137*(13), 1-11. doi: 1 10.1186/1471-2148-13-137

Uno, I., Katili, A.S., & Zakaria, Z. (2019). Variasi morfometrik kepiting biola (*Uca* sp.) di kawasan hutan mangrove Cagar Alam Tanjung Panjang Kecamatan Randangan, Gorontalo. *JAMBURA: Edu Biosfer Journal, 1*(2), 53-63. doi: 10.34312/jebj.v1i2.2429

Vianna, B.D., Miyai, C.A., Augusto, A., & Costa, T.M. (2020). Effects of temperature increase on the physiology and behavior of fiddler crabs. *Physiology & Behaviour, 215*(2), 313-328. doi: 10.1016/j.physbeh.2019.112765

Virgilio, A.D., & Ribeiro, P.D. (2013). Spatial and temporal patterns in the feeding behavior of a fiddler crab. *Marine Biology, 160*(2), 1001-1013. doi: 10.1007/s00227-012-2153-9

Wa'dah, & Hamidah, S. (2016). Analisa lubang kepiting binatu (*Uca demani*) pada Ekosistem Hutan Mangrove Tahura "Ngurah Rai" Desa Suwung Kauh, Kecamatan Denpasar Selatan Provinsi Bali. *Journal Ilmiah Rinjani, 3*, 163-172. doi: 10.53952/jir.v3i1.239

Zeil, J., & Hemmi, J.M. 2006. The visual ecology of fiddler crabs. *Journal of Comparative Physiology A, 192*(1), 1-25. doi: 10.1007/s00359-005-0048-7