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Spatial and temporal size structure abundance of the blue swimming crab (*Portunus pelagicus*) in Tiworo Strait, Southeast Sulawesi, Indonesia

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ABSTRACT

This study aimed to analyze spatial and temporal size abundance and sex ratio patterns of blue swimming crab (BSC). It was conducted from June to December 2018. Samples were taken monthly using collapsible pots and gillnets from different habitat characteristics of intertidal (station A), river mouth (station B), seagrass (station C and D), and depth of > 30 m (station E). Each sample was sexed, measured its CW (cm), and weighed its body weight (g). Those were classified according to sex and CW into: < 6.0 cm (juvenile), ≥ 6.0 - 9.0 cm (mature), and ≥ 9.0 cm (adult) and counted to perform abundance and sex ratio of each station and month. Results showed that juveniles were more abundant in station A, while mature abundance has no distribution pattern. Adults tended to be abundant in station E. Those may affect sex ratio in all stations and months. Male juvenile sex ratio preponderated over female in station A, while in other stations have no pattern. On the contrary, mature females preponderated over males in station A, but have no pattern in other stations, while adults showed females preponderated over males in station E. It implies that females of the blue swimming crab (BSC = *Portunus pelagicus*) prefer deep water having high salinity to release eggs.

INTRODUCTION

The blue swimming crab (BSC = *Portunus pelagicus*) has been widely studied around the world due to its widely distributed which occurs in the entire of Indian and Indo-West Pacific Oceans including Japan, Philippines, Malaysia, Brunei Darrusalam, eastern Australia, Fiji Island, Red Sea and East Africa **(Williams, 1982, Edgar, 1990, Potter and de Lestang, 2000, Johnston *et al*., 2011)**, Indonesia **(La Sara *et al*., 2016a)** and extends eastwards in the Pacific to Hawaiian waters **(Apel and Spiridonov, 1998)**.

This species typically inhibits sandy oceanic habitats to a depth of 30 m **(Carpenter *et al*., 1997, La Sara *et al*. 2016a)**.

It is well known that Indonesian water is one of BSC habitats in the Indo Pacific regions as shown its wide distribution extending in the entire of its coastal waters from Western Sumatera, northern Java (Java Sea), around South and Southeast Sulawesi up to eastern part of Papua. In Indonesia this species occupies coastal and estuarine waters in the intertidal zones, river mouth and extends forward to water depth of 50 m **(La Sara *et al*. 2016a, 2017)**. It lives in a variety of inshore and continental shelf areas, including sandy mixed with muddy adjacent mangrove area or algal and seagrass habitats **(Kailola *et al*., 1993, La Sara *et al*. 2016a)**. BSCs move to deeper water as they mature and in response to water temperature and salinity **(Kailola *et al*., 1993)**. This species is consumed by many people due to its high protein and is to be one of the most important species for small-scale commercial fisheries around Indonesian waters, aside other crustacean of shrimps, mud crabs, and lobsters **(La Sara *et al*., 2016a)**.

This species has been exploited since last 3 decades using unselective collapsible crab pots and bottom gillnets. There is trawling operation for shrimps taking a considerable number of BSCs as by-catch **(La Sara *et al*., 2016b, 2016c)**. In this waters, fishermen catch all BSC CW sizes due to all crab meat processing mini plants accepting those sizes. Massive cutting mangrove trees around coastal area for jetty, road and housing are somethings hard to be rejected in the remote areas. Those are considerably the main problems faced in BSC management in order to sustain its population.

Some studies conducted around Indonesian coastal waters show high exploitation on this species as indicated by (1) its carapace width (CW) size is dominated by small size of < 7 cm, (2) CPUE is few and the sizes have been declining for several years **(Zairion *et al*., 2015)**, and (3) its fishing ground is limited and moving afield from shore line **(La Sara *et al* 2016a, 2016b)**. The study on experimental fishing conducted in Australia mainly to develop and test commercially viable gear for targeting crabs but met with little success **(Xiao and Kumar, 2004)**. **La Sara *et al*. (2016c)** have recommended to the fishermen to use rectangular collapsible pots using escape vent size of 4.5 cm x 5.0 cm which is put in both sides of crab pot.

Although many studies on this species have been conducted such as selective fishing gear design **(La Sara *et al*., 2016b)**, reproductive biology **(Zairion *et al*., 2015, La Sara *et al*., 2016a, Basri *et al*., 2017, Hisam *et al*., 2018)**, population parameters **(La Sara *et al*., 2017, Muchtar *et al*., 2017)**, harvest control rule **(La Sara *et al*., 2016b)**, mapping fishing ground, however, there is paucity studies explain spatial and temporal distribution of BSC size abundance in Indonesian waters. The objective of present study was to analyze the spatial and temporal of BSC sizes abundance distribution and sex ratio.

MATERIALS AND METHODS

Design of study location

Tiworo strait waters is a well known as BSC fishing ground in Southeast Sulawesi and in Indonesia in general. This fishing ground is surrounded by four main lands of South Konawe, Bombana, Muna, and West Muna. The location of study was purposively chosen at the BSC fishing ground in South Konawe **(Fig. 1)**. All life cycles of BSC happen in this waters starting from copulation, mating, release eggs, hatching to be larvae, growing to be megalopa, juvenile, mature and adult. Sampling locations of BSCs were chosen according to habitat characteristics of BSC fishing ground, namely coastal waters grown mangroves (intertidal zone) (station A), river mouth (station B), coastal area with fine sand substrate grown few seagrasses (station C), coastal area grown heavy seagrass (station D), and deep water of > 30 m (station E). The study was conducted from June to December 2018.

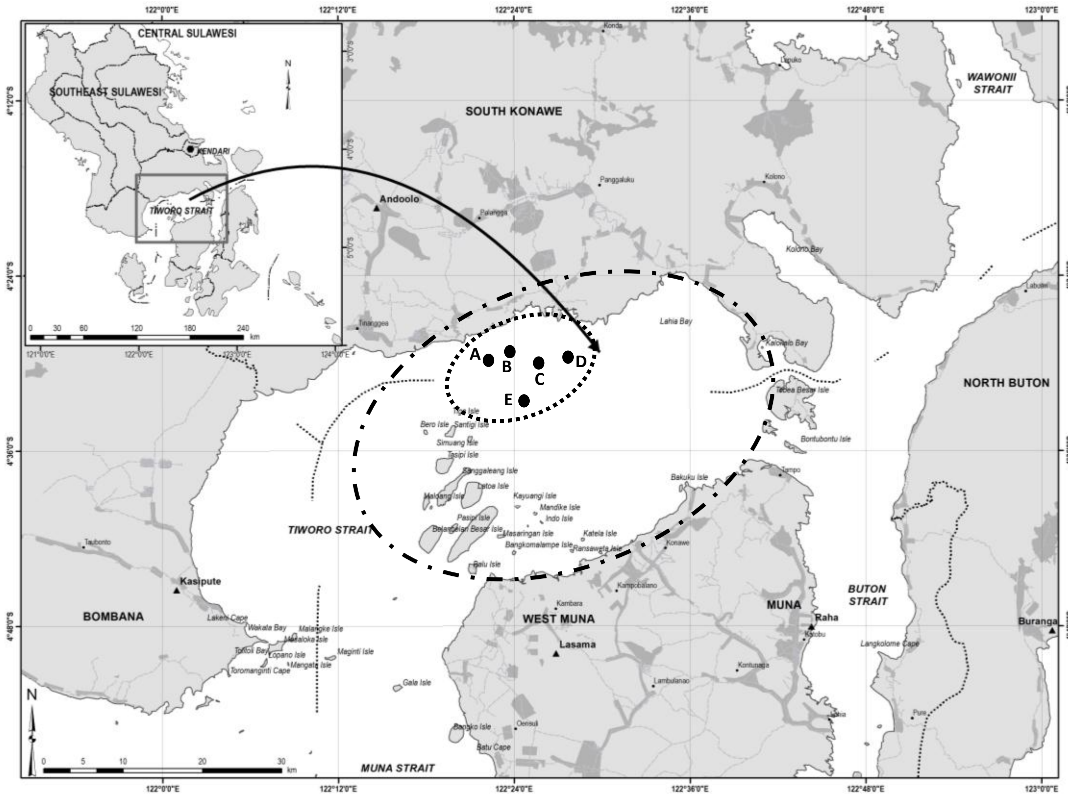

Fig. 1. Map of Tiworo Strait waters of Southeast Sulawesi (dash line is study locations and black circle is station of sampling of BSC. There are 5 stations (A, B, C, D and E) of sampling).

Sampling Methods

BSCs sampling at each station was taken monthly. Fishing gears used at station A – D were collapsible rectangular collapsible crab pot (length = 54 cm, width = 36 cm, and height = 19 cm) covered with nylon net of ± 0.5 cm mesh size **(Fig. 2)**, while at station E was bottom gillnet. As many 150 units of crab pots were deployed at each station. Each crab pot was tied at main nylon polypropylene rope (Ǿ=0.5 mm) using small nylon polypropylene (Ǿ=0.25 mm). The distance between crab pots at main nylon polypropylene was ± 10 m. Each crab pot was put fresh fish bait with size relatively the same at each crab pot. All crab pots tied in the main nylon polypropylene were deployed during flood tide then hauled at ebb tide. The BSC sampling at station E used a bottom gillnet of 1 km length, 1 m height, and 4 inch mesh size **(Fig. 3)**. Each BSC sample caught at each station was recorded, sexed according to abdomen morphometric characteristics, measured its CW (to the base of the spines) using a caliper (to an accuracy of 0.1 mm), weighed its body weight using electronic balance (to an accuracy of 1 g), and then each sex counted its number **(La Sara *et al*., 2016a, 2017)**.

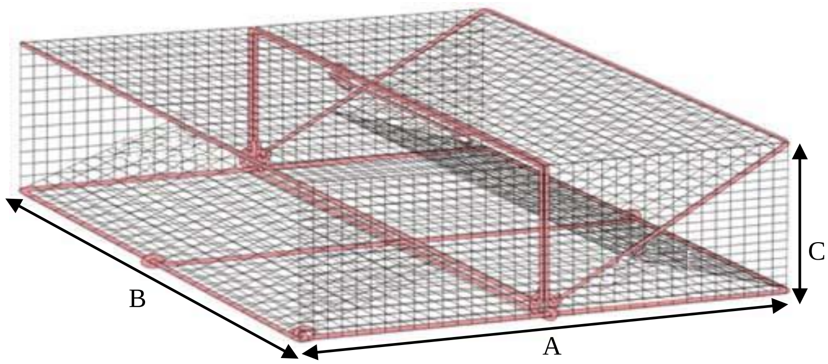

Fig. 2. Rectangular collapsible crab pot used for BSC sampling at stations A – D in Tiworo Strait of Southeast Sulawesi (length, A = 54 cm; width, B = 36 cm and height, C = 19 cm) **(La Sara *et al*., 2016a)**.

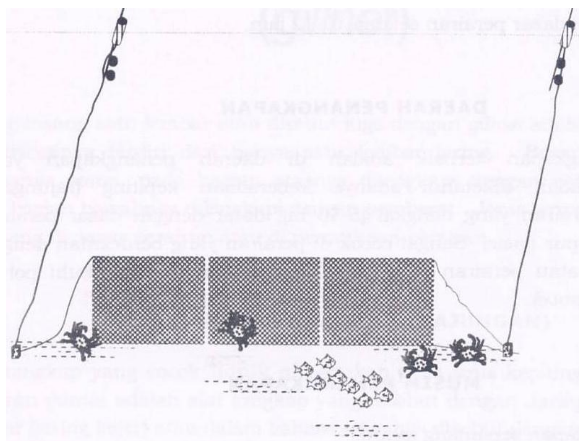

Fig. 3. Bottom gillnet used for BSC sampling at station E in Tiworo Strait of Southeast Sulawesi (length = ± 1 km and; height = 80 – 100 cm, mesh size = 4.0 inch) **(La Sara *et al*., 2019)**.

Data Analysis

Abundance of CW size structure of BSC

All BSC samples taken from each station (spatial) and month (temporal) were grouped (tabulated), then classified according to sex and CW of < 6.0 cm (juvenile), ≥ 6,0 – 9.0 cm (mature), and ≥ 9,0 cm (adult). The abundance (number) of each size group and sex were counted according to station and month.

Sex Ratio

Males and females BSCs taken from each station and month were counted, and then sex was analyzed as follows:

$$SR = \frac{\sum Male}{\sum Female}$$

Significance of the sex ratio was tested using Chi-square test (α = 0.05) **(Sudjana, 1989, La Sara *et al*., 2016b)**, as follows:

$$\chi^2 = \sum_{k=0}^{n} \frac{(O - E)^2}{E}$$

Note: χ^2 = Chi-square, O = frequency number of observed male and female BSCs, E = frequency number of expected male and female BSCs.

RESULTS

1. Spatial and Temporal Abundance of CW size structure

1.1. Abundance of Juveniles (CW < 6.0 cm)

Abundance of juvenile BSCs (CW < 6.0 cm) of both sexes was always high in station A compared to other 4 stations in almost months (June – December) **(Fig. 4)**. The juvenile BSCs at station B and D had high abundance in the same months (November), while at station C was found in July. Abundance of juvenile BSCs at station E was only found in November which was very few **(Fig. 5)**.

1.2. Abundance of Matures (CW ≥ 6.0 – 9.0 cm)

The present results showed that mature BSCs (CW ≥ 6.0 – 9.0 cm) were_more abundant at station A. This size was abundant only in November at station B, while at stations C and D was abundant in August – October and August – November, respectively and only in November at station E **(Fig. 6 and 7)**. However, both males and females of this size were relatively distinguished its abundance. The female BSCs generally were more abundant than that of males, particularly at station A (unless November), station B (November), station C (August), and station D (November).

1.3. Abundance of Adults (CW > 9.0 cm)

The adult BSCs (CW > 9.0 cm) of both males and females were was still found at station A. Their number was relatively similar at stations D and E, while at stations B and C was very few **(Fig. 8 and 9)**. The adult BSCs at intertidal zone (station A) was few compared to juveniles and matures due to those adult BSCs move to deep sea water particularly females. When those adult BSCs move to deep sea water (station E), they cross first seagrass habitats (stations C and D) and intertidal zone (station A).

2. Spatial and Temporal Sex Ratio

The results of sex ratio of juvenile BSCs showed that, males were generally preponderated over females, particularly at stations A and D. Sex ratio at stations B and C exhibited also males preponderated over females, but there was no juveniles were found in some months; while sex ratio at station E was only found in November with high ratio for males than females. However, overall sex ratio of M : F was 1.44 : 1 **(Table 1)**. For mature BSCs, it was different, whereas females were mostly preponderated over males (M < F) at stations A and B, but showed no regular pattern at stations C and D. The sex ratio at station E was only found in October and November, where males preponderated over females. The overall sex ratio of M : F was 1 : 1.27 **(Table 2)**. The sex ratio showed no regular pattern and was also found in adult BSCs, particularly at stations A, B, C, and E, but at station D tended to males preponderated over females. It showed that the overall sex ratio of M : F adult BSCs was 1 : 1.28 **(Table 3).**

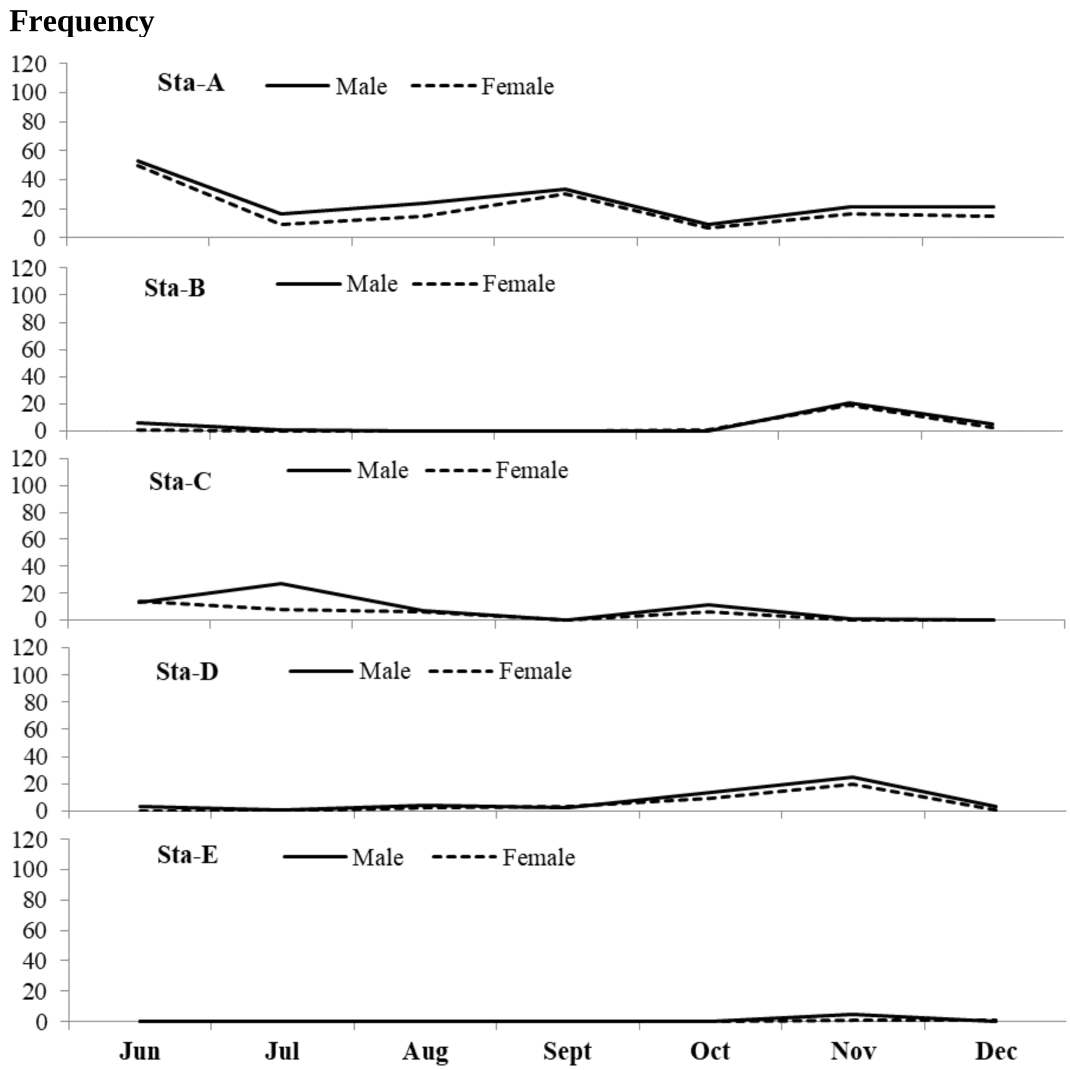

Fig. 4. Abundance of male and female BSCs of < 6.0 cm CW according to stations (spatial) at each month (temporal) in Tiworo Strait waters of Southeast Sulawesi, Indonesia.

Table 1. Sex ratio (males : females) of the BSCs of < 6.0 CW according to months (temporal) at each station (spatial) of Tiworo Strait of Southeast Sulawesi, Indonesia.

Station	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Overall sex ratio
Sta – A	1.06 : 1.00	1.78 : 1.00	1.60 : 1.00	1.10 : 1.00	1.29 : 1.00	1.31 : 1.00	1.40 : 1.00	1.25 : 1
Sta – B	6.00 : 1.00	1.00 : 0	-	-	0 : 1.00	1.11 : 1.00	1.67 : 1.00	1.38 : 1
Sta – C	1.00 : 1.08	3.50 : 1.00	1.17 : 1.00	-	1.83 : 1.00	1.00 : 0	-	1.74 : 1
Sta – D	3.00 : 0	1.00 : 0	2.00 : 1.00	1.00 : 1.50	1.56 : 1.00	1.25 : 1.00	3.00 : 1.00	1.49 : 1
Sta – E	-	-	-	-	-	5.00 : 1.00	0 : 1.00	2.50 : 1
Overall sex ratio	1.15 : 1	2.65 : 1	1.52 : 1	1.06 : 1	1.48 : 1	1.30 : 1	1.44 : 1	1.44 : 1

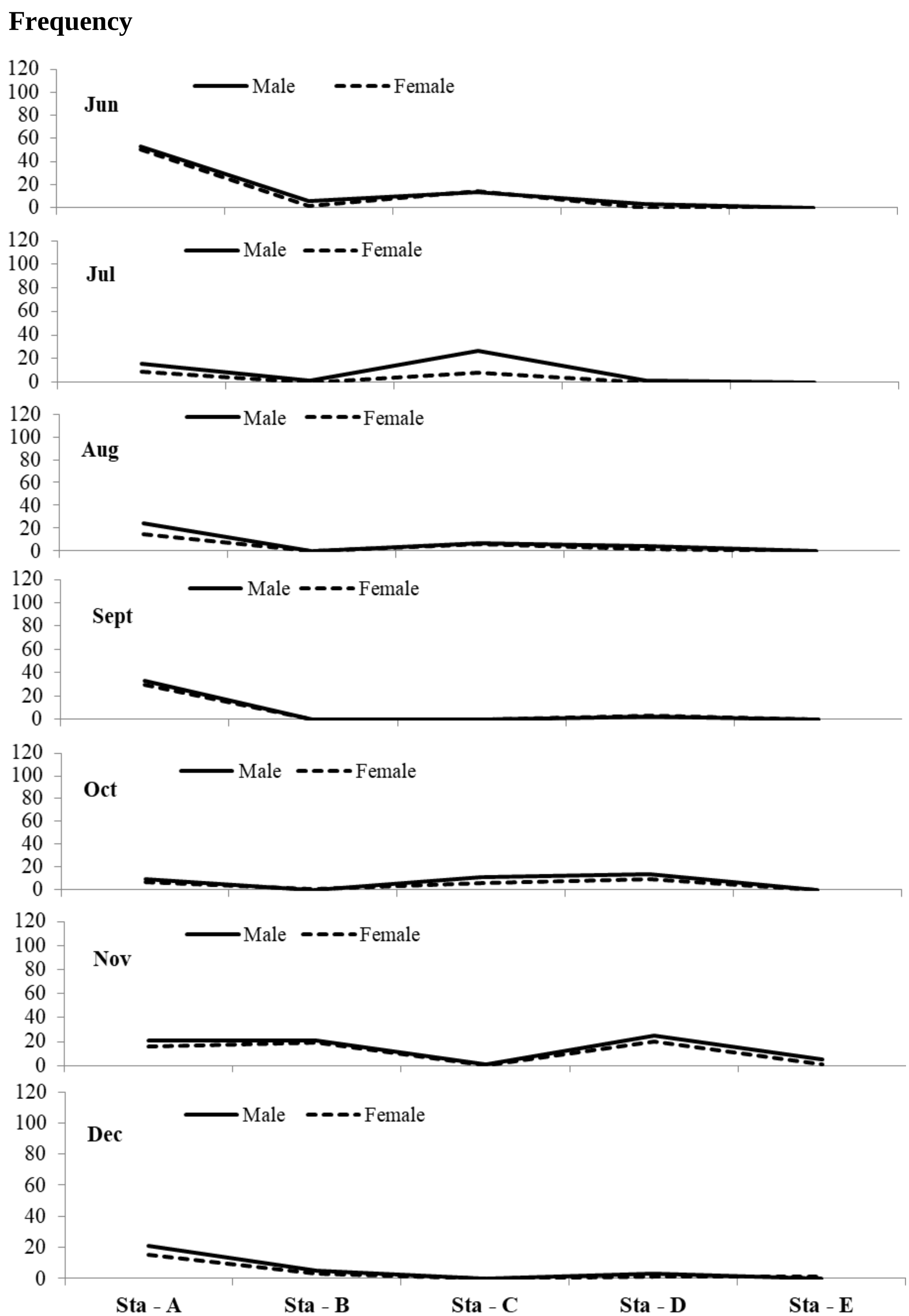

Fig. 5. Abundance of male and female BSCs of < 6.0 cm CW according to months (temporal) at each station (spatial) in Tiworo Strait waters of Southeast Sulawesi, Indonesia.

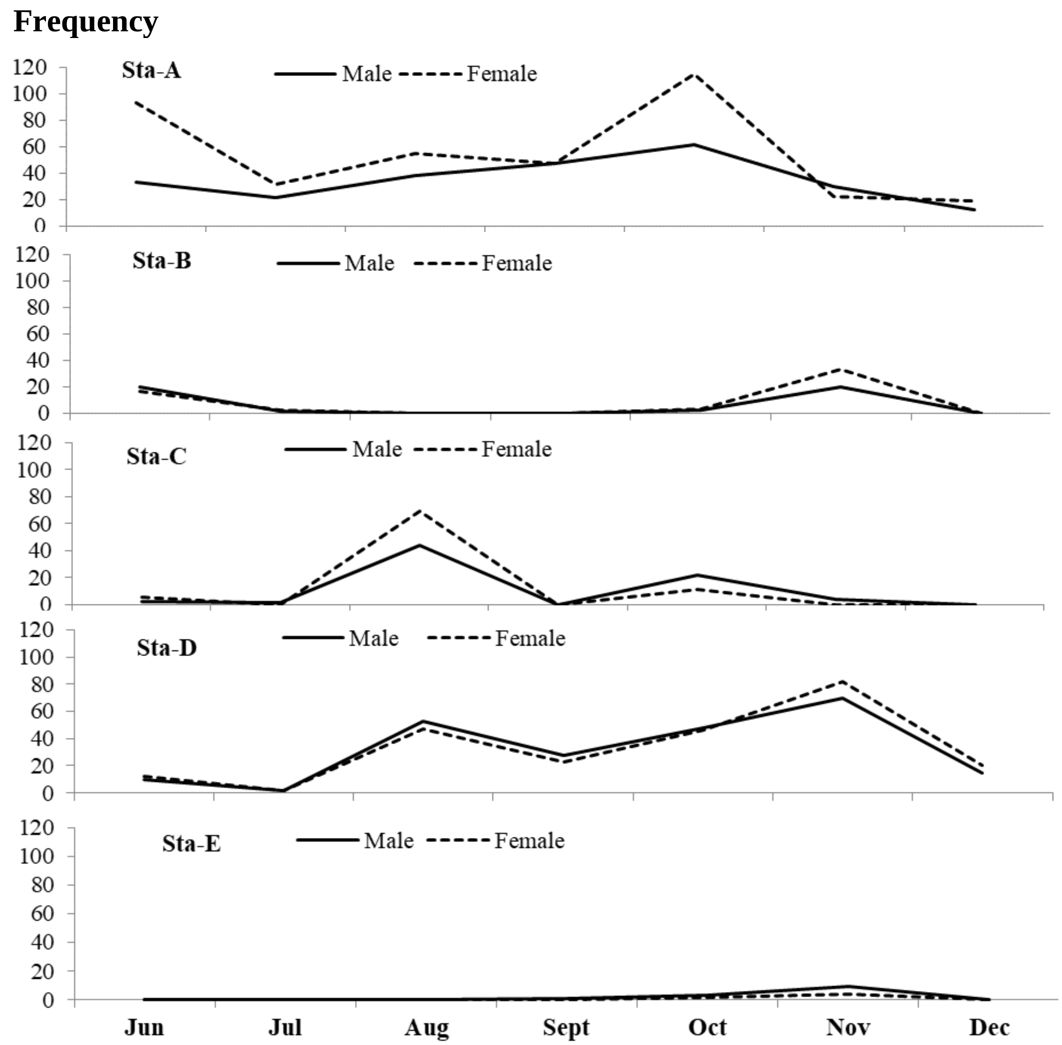

Fig. 6. Abundance of male and female BSCs of ≥ 6.0 – 9.0 cm CW according to stations (spatial) at each month (temporal) in Tiworo Strait waters of Southeast Sulawesi, Indonesia.

Table 2. Sex ratio (males : females) of the BSC of ≥ 6.0 - 9.0 CW according to months (temporal) at each station (spatial) of Tiworo Strait of Southeast Sulawesi, Indonesia.

Station	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Overall sex ratio
Sta – A	1.00 : 2.82	1.00 : 1.48	1.00 : 1.45	1.00 : 1.00	1.00 : 1.89	1.36 : 1.00	1.00 : 1.58	1 : 1.58
Sta – B	1.25 : 1.00	1.00 : 1.00	0 : 0	-	1.00 : 1.50	1.00 : 1.65	-	1 : 1.26
Sta – C	1.00 : 2.50	1.00 : 0	1.00 : 1.57	-	2.00 : 1.00	4.00 : 0	-	1 : 1.16
Sta – D	1.00 : 1.20	1.00 : 1.00	1.13 : 1.00	1.22 : 1.00	1.04 : 1.00	1.00 : 1.17	1.00 : 1.33	1 : 1.03
Sta – E	-	-	-	1.00 : 0	1.50 : 1.00	2.25 : 1.00	-	2.17 : 1
Overall sex ratio	1 : 1.94	1 : 1.40	1 : 1.27	1.09 : 1	1 : 1.30	1 : 1.06	1 : 1.44	1 : 1.27

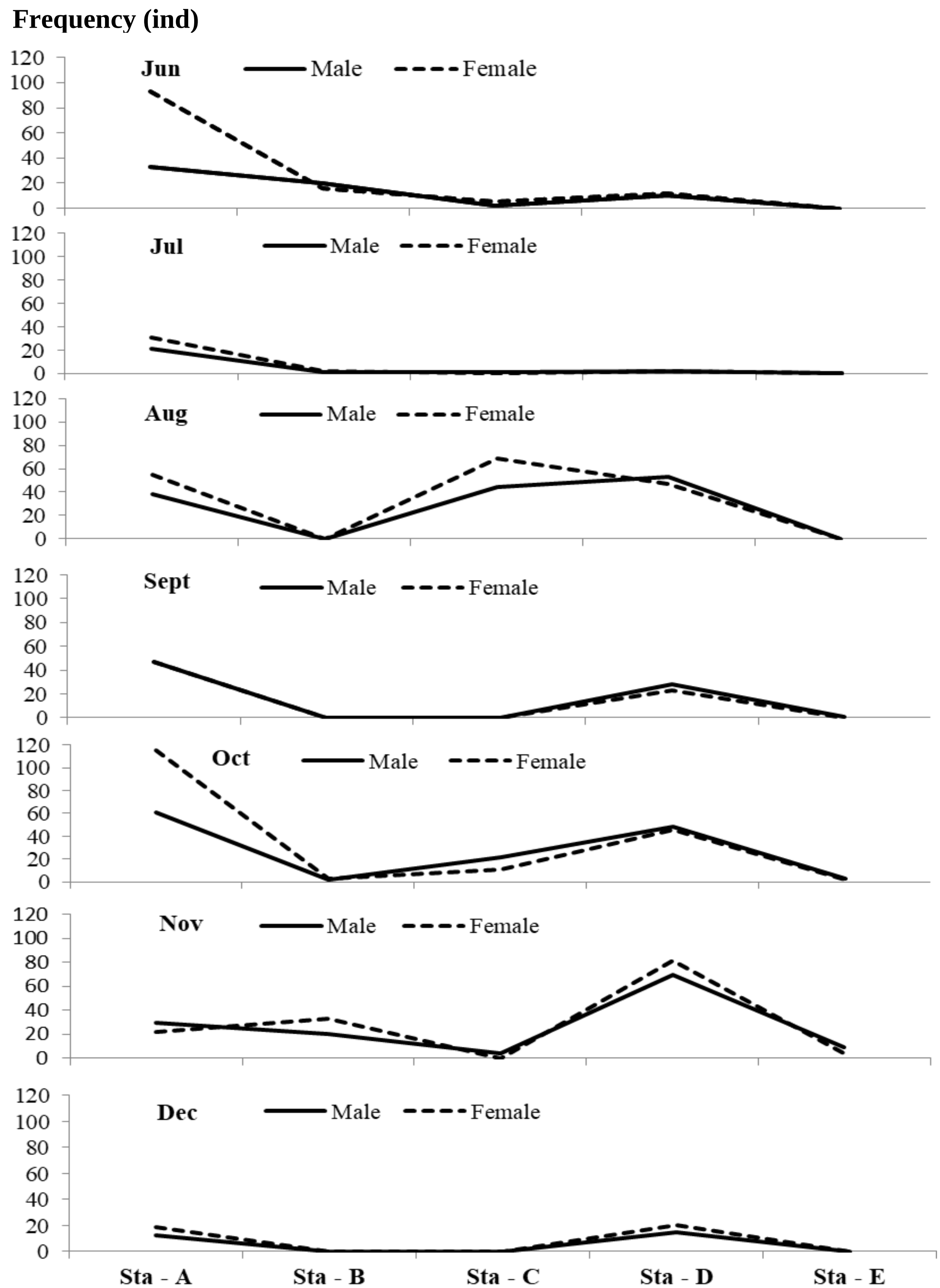

Fig. 7. Abundance of male and female BSCs of ≥ 6.0 – 9.0 cm CW according to months (temporal) at each station (spatial) in Tiworo Strait waters of Southeast Sulawesi, Indonesia.

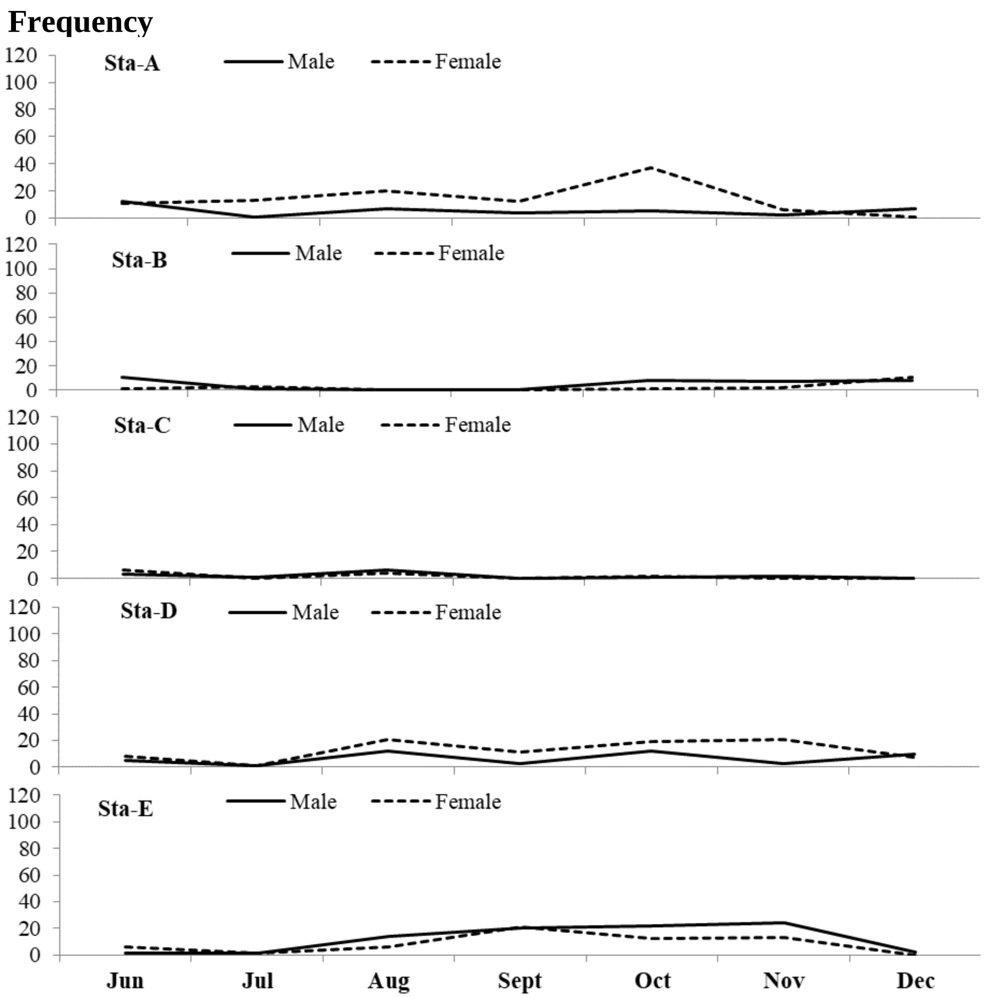

Fig. 8. Abundance of male and female BSCs of ≥ 9.0 cm CW according to stations (spatial) at each month (temporal) in Tiworo Strait waters of Southeast Sulawesi, Indonesia.

Table 3. Sex ratio (males : females) of BSC of > 9.0 CW according to months (temporal) at each station (spatial) of Tiworo Strait of Southeast Sulawesi, Indonesia.

Station	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Overall sex ratio
Sta – A	1.09 : 1.00	1.00 : 13.00	1.00 : 2.86	1.00 : 3.00	1.00 : 7.40	1.00 : 3.00	7.00 : 1.00	1 : 1.58
Sta – B	11.00 : 1.00	1.00 : 3.00	-	-	8.00 : 1.00	3.50 : 1.00	1.00 : 1,38	1 : 1.26
Sta – C	1.00 : 2.00	1.00 : 0	1.25 : 1.00	-	1.00 : 2.00	2.00 : 0	-	1 : 1.16
Sta – D	1.00 : 1.60	1.00 : 1.00	1.00 : 1.75	1.00 : 3.67	1.00 : 1.58	1.00 : 7.00	1.43 : 1.00	1 : 1.03
Sta – E	1.00 : 6.00	1.00 : 1.00	2.33 : 1.00	1.00 : 1.05	1.83 : 1.00	1.85 : 1.00	2.00: 0	2.17 : 1
Overall sex ratio	1 : 1	1 : 3.60	1 : 1.31	1 : 1.63	1 : 1.48	1 : 1.11	1.42 : 1	1 : 1.28

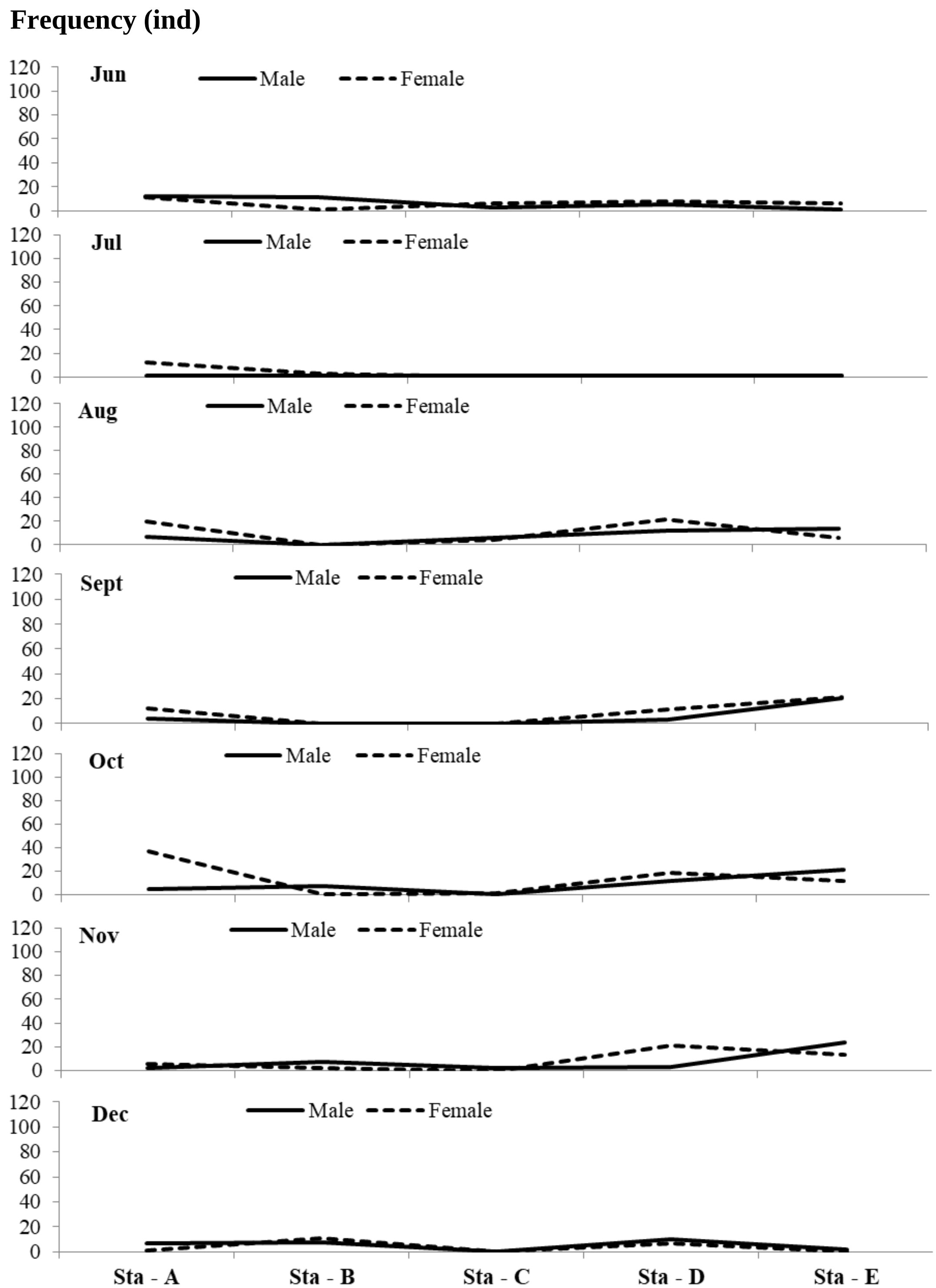

Fig. 9. Abundance of male and female BSCs of > 9.0 cm CW according to months (temporal) at each station (spatial) in Tiworo Strait waters of Southeast Sulawesi, Indonesia.

DISCUSSION

1. Spatial and Temporal Abundance of CW Size Structure

The species of BSC (*P. pelagicus*) lives in a wide range of nearshore marine and estuarine waters throughout the Indo-West Pacific **(Stephenson, 1962, Kailola *et al*., 1993)**, Red Sea, Suez Canal and the Middle-Eastern coast of the Mediterranean Sea **(Mehanna and Haggag, 2007, Mehanna and El-Aiatt, 2011)**. In Tiworo strait this species was found all year rounds at different habitat characteristics **(La Sara *et al.*, 2016a)**, such as at intertidal zone (station A), river mouth (station B), seagrass with fine and coarse sandy substrate (stations C and D), and deep-sea water of > 30 m (station E). Its abundance in those habitats is different depending on each habitat characteristics (spatial) and season of each month (temporal). Abundance of juvenile BSCs according to station characteristics (spatial) and month (temporal) **(Figs. 4 and 5)** and mature BSCs **(Figs. 6 and 7)** showed that both those sizes were dominant found at intertidal zone, closed to mangrove area and sandy substrate (station A). There were studies showed that this species lives in inshore and continental shelf areas, including sandy, muddy or algal and seagrass habitats, from the intertidal zone to at least 50 m depth **(Williams, 1982, Edgar, 1990, Kailola *et al*., 1993)**. They are also usually found in large numbers in shallow bays with sandy bottom **(William, 1974, Batoy *et al*., 1987)** and are important commercial species in Tiworo strait and many other coastal waters in Indonesia, Southeast Asia countries, and Persian Gulf countries **(Willams, 1974, Batoy *et al.*. 1987, Hosseini *et al*., 2014)**. However, **La Sara *et al*. (2016a)** found that juvenile BSCs are generally found at intertidal zone closed to mangrove forests with sandy mixed muddy substrates. Moreover, **La Sara *et al*. (2019)** suggested that such habitat characteristics (station A) are recommended to be a BSC nursery ground.

The BSC abundance found at river mouth (station B) was very few. The salinity at this station was low (12 – 18 ppt), high current water and substrate dominated by mud. The relatively similar abundance was found at habitats dominated by seagrass and coarse sandy substrates (station C and D). This data implies that such habitat characteristics are not preferred by BSC of all sizes. The juvenile BSCs which grow to be the mature BSC will occupy several habitat types and its abundance pattern is no regular pattern **(Figs. 6 and 7)**. However, the mature BSC is still more abundant found at station A compared to other stations B, C, D and E. Generally, the mature BSCs and adults will move forward to deep sea water. BSCs move to deeper water as they mature and in response to water temperature and salinity **(Kailola *et al*., 1993, de Lestang *et al*., 2010, Johnston *et al*., 2011)**. Those two water parameters can also affect size at sexual maturity in crabs **(Rasheed and Mustaquim, 2010)**. **Fisher (1999)** who investigated effect of temperature and salinity on size at sexual maturity of female blue crab *Callinectes sapidus* from nine Texas bay systems stated that size at maturity can vary along the Texas coast, as temperature and salinity vary from bay to bay. He also mentioned that seasonal and annual variations in temperature and salinity in the bay could also affect size at onset of maturity. When the female BSCs reach maturity, they immediately move to deep water. This condition happens all most in all portunid mature particularly female is more abundant in deep water, while juveniles are always very few.

Similar data is shown by **La Sara *et al*. (2016a)**. Data in **Figs. 8 and 9** shows that the adult BSCs are few at stations A, as well as at stations B, C, and D, while at station E they show increasing in number. Those data show different habitats of BSC following its life stage namely juveniles occupy shallow water at intertidal zone closed to mangrove forests with sandy substrate (station A), while the mature BSCs occupy variable habitats (all stations) without regular pattern. It is clearly that adult BSCs occupy deep water (station E) which probably they maintain their eggs development for females (ovigerous females) up to spawning occurs **(de Lestang *et al*., 2003)**. In the previous study in western Australia waters had been shown its historically large fluctuations in commercial BSC catches in Cockburn Sound **(Johnston *et al*., 2011)** which have previously been attributed to changes in commercial fishing practices, normal variations in recruitment and natural mortality **(Bellchambers *et al*., 2006)**. The resultant collapse of the BSC fishery in Cockburn Sound can be attributed to a combination of factors related to the biology and distribution of this species, fishery dependent influences and environmental conditions **(Johnston *et al*., 2011)**.

2. Spatial and Temporal Sex Ratio

Difference in sex abundance according to life stages of portunid and other crustaceans causes difference in sex ratio (biased sex ratio). Sex ratio of male juvenile BSCs is always preponderated over females at station A (overall sex ratio of M : F = 1.25 : 1) and part of station D (overall sex ratio of M : F = 1.49 : 1), while at the other stations show no regular pattern **(Table 1)**. It also happens in the mature BSC sex ratio **(Table 2)** and adult **(Table 3)**. There are many factors cause variations (biased) sex ratio in portunid. **Johnston *et al.* (2011)** elaborate pattern of variation in sex ratio of the commercial catch was consistent between years in Western Australia. The authors stated further that during the closure period of the fishery since December 2006, the ratio of male and female crabs caught in traps at different times of the year has changed. For example, catches during the summer months are still dominated by male crabs, with 69 – 81% of the catch being male between January and March, while female crabs enter traps in March/April, males continue to make up the majority of the catch until June and are caught in significant quantities through to December when they become dominant in catches again.

La Sara *et al*. (2016a) explained that sex ratio differences may be affected by seasons change, habitat characteristics differences (spatial differences), differential life span, migration pattern, food availability, changes in feeding behavior of female BSCs during spawning seasons **(Potter and de Lestang, 2000, de Lestang *et al*., 2003)**, methods of capture and fishing gears used **(Xiao and Kumar, 2004, La Sara *et al*., 2016c)**, gillnet catchability between sexes **(Ingles, 1996)**, sampling frequency, growth and mortality rates, geographical position (tropical and subtropical regions) **(Kumar *et al*., 2000, La Sara, 2001a)**, and differences in fishing skills and modes of operation of individual fishers **(Xiao and Kumar, 2004)**. According to **Archambault *et al*. (1990)** and **Ault *et al*. (1995)**, water salinity fluctuation affected size distribution on American blue crab *C. sapidus*, while **La Sara *et al.* (2016a)** stated that water temperature may also affect feeding behavior and activities searching for food leading to the fishing gears rely on bait (such as traps) or migration of BSCs (such as gillnets).

Previous study explained that changes in feeding behavior can also reduce the attractiveness of commercial pots to female crabs during the spawning period **(Xiao and Kumar, 2004)**. They also demonstrated that sex ratio of BSC in commercial catches varied strongly with season in Australia, possibly because male and female crabs seem to prefer different habitats (characteristic of salinity and temperature differential distributions) at different times of the year **(Meagher, 1971)**. Those water parameters also affect strongly the reproductive cycle of BSCs as shown in Cockburn Sound **(de Lestang *et al*., 2010)** which in turn will affect distribution pattern of each phase of larvae, juveniles, matures, and adults in its life cycle. **Kumar *et al*. (2000)** stated that growth and reproduction activities may affect sex ratio. Monthly sampling frequency of BSCs in off southern Australia waters was found males juvenile were outnumbered females namely male-to-female ratio 1: 0.71 **(Xiao and Kumar, 2004)**. Similar studies in Karnataka, southern India showed 51% males and 49% females **(Dineshbabu *et al*., 2008)** and in Trang, Thailand showed males outnumbered females of 1.17 : 1 **(Nitiratsuwan *et al*., 2013)**. According to **Sumpton *et al*. (1994)** that a low percentage of female crabs in commercial catches in Moreton Bay during the spawning period has been attributed to the migration of mature females onto sand banks for extrusion of eggs.

It has been reported that a sandy substrate is required for successfully extruding their eggs from its pleopods to be released to sea water. Those studies are different with the previous study on BSC taken from Tiworo Strait using rectangular collapsible traps and bottom gillnets which showed generally sex ratio of females preponderated over males (male: female = 1 : 1.032) **(La Sara *et al*., 2016a)**. Similar results were showed a study on BSC taken in ecosystems of mangroves, seagrass, and coral reefs in Salemo Island, South Sulawesi which males preponderated over females namely in the respective 1.1 : 1, 1.7 : 1, and 1.01 : 1 **(Nurdin *et al*., 2016)**. Other studies on Portunid in different regions also may show differences or biased sex ratio due to species differences, sampling frequency, locations, and fishing gears used **(Table 4)**. The present study gives wide variation of sex ratio due to different sampling stations (spatial) and variation of monthly sampling (temporal). Archambault *et al*. (1990) explained that spatial separation of both sexes can explain part of the differences, as shown in *C. sapidus* at Charleston Harbor. The present study showed fluctuation of sex ratio according to growth phase of BSC in Tiworo Strait, Southeast Sulawesi. The data of sex ratio (Table 4) are very important to be used as an indicator to assess the ability of the blue swimming crab maintains the running recruitment **(Ault *et al*., 1995)**.

Table 4. Sex ratio of Portunids from different regions.

No.	Locations	Species	Sex ratios	References
1.	Lawele Bay, Indonesia	*Scylla serrata* *S. tranquebarica*	7.25 : 1 1.14 : 1	La Sara (2001b)
2.	Ragay Gulf, Philippines	*P. pelagicus*	23 : 1	Ingles and Braum (1989)
3.	Bantayan waters, Philippines	*P. pelagicus*	1 : 1.63	Ingles (1996)
4.	Bandar Abbas, Persian Gulf	*P. pelagicus*	1 : 1.2	Kamrani *et al* (2010)
5.	Karnataka waters, India	*P. sanguinolentus*	1.13 : 1	Dineshbabu *et al* (2007)
6.	Leschenaukt Estuary, Australia	*P. pelagicus*	1 : 1.8	Potter and de Lestang (2010)
7.	Tiworo Strait, Indonesia	*P. pelagicus*	1 : 1.032	La Sara *et al* (2016a)
8.	Tiworo Strait, Indonesia	*P. pelagicus*	1 : > 1	Astuti *et al* (2019)
9.	Tiworo Strait, Indonesia	*P. pelagicus*	Tables 1, 2, and 3	Present study

CONCLUSION

It is apparent that abundance of juvenile BSCs found in entire habitats of Tiworo Strait from intertidal zone up to deep water of > 30 m is higher in intertidal zone in all year around which they prefer to habitat closed to mangrove forests with sandy substrate. Such habitat characteristics are suggested to be protected as nursery ground. The abundance of mature BSCs in this waters does not performance regular pattern, while adult BSCs tends to increase in deep water in all year rounds which mainly relates to female BSCs psychological extrude their eggs. Those abundance patterns affect BSC sex ratio distribution. It is found that male juvenile BSCs preponderated over females in all stations and all year rounds. In contrary, sex ratio of female mature BSCs preponderated over males in all stations except in station E, while sex ratio of adult BSCs varied at each station but the overall sex ratio of females preponderated over males as well as mature BSCs. This is a fact that female adult BSCs prefer saline water to extrude their eggs.

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