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Some Reproductive Biology Studies of Rabbit fish *Siganus canaliculatus* (Park,1797) from the Southern Coastal Waters of Jeneponto, South Sulawesi, Indonesia

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The rabbitfish *Siganus canaliculatus* population has been exploited intensively in the Jeneponto Regency South Sulawesi by fishermen used non selective fishing gear, throughout the year even the spawning season. The intensive fishing without management policy can caused decreasing of the rabbit fish population, and if it continues population will be collapse. This study was conducted to investigate some of the reproductive biological study of this species. A total of 1821 specimens of *S. canaliculatus* consisting of 1436 males and 385 females were randomly collected on a monthly from fishers in the coastal waters of the Jeneponto, South Sulawesi. The fecundity and gonad stage were studied for 39 female individuals varied between 85 and 284 mm total length (TL). Egg diameters were determined using the microscope. The overall sex ratio (Males: Females) ranged from 1.7: 1 to 8.2:1 The estimation of fecundity was between 5416 and 130760 eggs.ind^{-1}, and increased with fish length, body weight and gonad weight. Egg diameter of *S. canaliculatus* in this study ranged from 0.1-0.5 of stage III. 0.35-0.45 of stage IV, 0.1-0.55 of stage V, and 0.35-0.55 of stage VI. Egg diameters increased with increased fish length. Egg diameters increased with increased fish length.

Keyword: *Rabbitfish, sex ratio, fecundity, egg diameter.*

The white-spotted spinefoot, *Siganus canaliculatus* is distributed throughout the Indo-Paciûc from the Arabian Gulf to the Indo-Malay region, Western Australia and north to Hong Kong and Taiwan (Randall, 1995). One of the fisheries resources in the waters of the Flores Sea of South Sulawesi is white-spotted rabbit fish (*Siganus canaliculatus,* (Park 1797). This fish can be developed as an activity of economy of fishermen communities and also as source of district revenue. Although *Siganus* fishes have relatively small sizes, they have a taste delicious and much demand in the markets, especially is South Sulawesi, Indonesia.

This rabbit fish population has been exploited intensively in the Jeneponto Regency South Sulawesi by fishermen used non selective

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fishing gear, throughout the year especially even the spawning season. This condition is due to the demand for *Siganus canaliculatus* in south Sulawesi has increased continuously over the years. The intensive fishing without management policy can caused decreasing of the rabbit fish population, and if it continues population will be collapse.

Some biological study of S. *canaliculatus* has been undertaken by some experts from over the world. Biological Studies and Gonadal Development of *S. canaliculatus* in Mid Arabian Gulf has been dealt with (Wassef and Hady, 2001), Population biology and assessment in the southern Arabian Gulf (Grandcourt *et al*., 2007). Variations in size and catch distribution at Luwu District, South Sulawesi, Indonesia. (Suardi *et al*., 2016). Reproductive Biology in the Gulf of Mannar region, India. (Anand and Reddy, 2017), Fecundity and Oocyte Development in Palompon, Leyte, Eastern Visayas, Philippines (Paraboles and Campos. 2018). On the otherhand, there is no detailed biological study of *S. canaliculatus* in South Sulawesi Indonesia has been made.

The present study was undertaken on some of the reproductive aspects of *S. canaliculatus* such as fecundity and egg sizes in relation to female size along the southern coast of Jenepotno, South Sulawesi. The findings on the study will provide to assess the status of the fishery for useful inputs in the formulation of suitable management plans and policies for sustainable harvest of the resource and to avoid collapse of the stock in Jeneponto and similar waters in the Indonesia.

MATERIALS AND METHODS

The marine waters of South Sulawesi consists of three fishing area including Makassar Strait, Flores Sea and Bone Bay (Musbir *et al*., 2017). The study was conducted from February 2017 to January 2018 in southern Jeneponto coastal waters, Flores Sea, South Sulawesi, Indonesia (Fig. 1).

Samples Rabbit fish (*Siganus canaliculatus*) were collected monthly. A total of 1821 specimens of *S. canaliculatus* consisting of 1436 males and 385 females were randomly collected on a monthly from fishers in the coastal waters of the Jeneponto, South Sulawesi.

The specimens were brought to the laboratory then washed. Each specimen was measured for total length (TL) using a fish measuring board to the nearest 1 mm and the total wet weight (TW) using an electronic balance to the nearest 1 g. Afther that, each specimen was cut open fo determination of the sex and maturity stage.

The male and female fishes were assessed according to testes and eggs in the body cavity by macroscopic examination. The female maturity stages were assessed according to the macroscopic development of eggs in the body cavity. The gonad developmental stages were identified following the criteria described by Al-Marzouqi *et al*., (2011). Six stages of maturity (I-Immature; II-Maturing 1; III-Maturing 2; IV-Mature; V Ripe/Running and VI-Spent).

The eggs were removed and weighed using an electronic balance to the nearest 0.01 g. Mature eggs of were preserved in 10% formalin solution for determination of fecundity. To determine the sex distribution in relation to fish size.

Sex ratio from the expected 1:1 ratio was tested by using the Chi-square test (Wooton,1998). The fecundity of *Siganus canaliculatus* in the present study was determined from the examination of 49 fishes with a total length range of 85 to 284 mm. Ovaries of the stages III, IV, V, and VI (ripe and spent) were only used for fecundity estimation. Estimates of the fecundity of each individual female was obtained from the average of the three subsamples of eggs from different parts of the ovary (Murua *et al*., 2003):

Fecundity = [CnO/Wn]/ n

Cn = counted number of eggs in sub-sample n, O = ovary weight, Wn = subsample weight and n = number of subsamples.

The linear regression of fecundity on both length and weight was calculated. Egg diameters were determined by taking pictures of randomly selected eggs in each ovary under low magnification (100X) in a compound microscope

RESULT AND DISCUSSION

Sex Ratio

The overall sex ratio (Males: Females) of the present result during the year was from

1.7: 1 to 8.2:1 (Table 1 and 2). The sex ratio (Males: Females) of the rabbitfish in southern coastal waters of South Sulawesi shows a high n in February, May, October and November. The number of males shows a rapid increase.

The sex ratio ratio of this species agrees with other on the other species Black-Banded Seabream, *Mylio bifasciatus* in Qatar that was found to be male:female ratio was from 2:1 to 8:1. (El-Sayed and Bary. 1994). On the other hand, there was a predominance of females amongst the the fish. The sex ratio of of rabbitfish Siganus *canaliculatus* (Siganidae) in mid Arabian Gulf was 1.4:1 to 2.3:1 (Wassef and Hady, 1997). The overall sex ratio (Males: Females) of of the rabbit fish *Siganus canaliculatus* in Saudi Arabia. was 1: 1.13 (Tharwat, 2004). There was 1:1.8 male to female sex ratio of *Siganus canaliculatus*, in the southern Arabian Gulf (Grandcourt *et al*., 2007). The annual male to female ratio the White-spotted Rabbitfish, *Siganus canaliculatus* (Park, 1797) in the Arabian Sea coast of Oman was 1:0.81 during 2005-2006

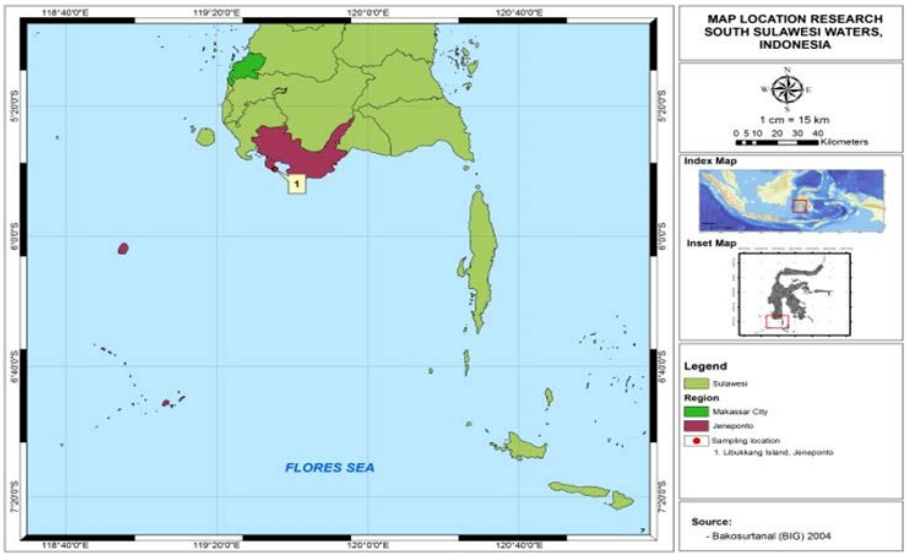

Fig. 1. Positions of the major landing beaches of rabbit fish (*Siganus canaliculatus* along the southern coastal of Jeneponto, South Sulaweesi

Table 1. Monthly sex ratio of Rabbit Fish (*Siganus canaliculatus* Park,1797*)* from southern coastal waters of Jeneponto, South Sulaweesi.

Months	Male ((%) (*N*))	Female ((%) (*N*)	Total (*N*)	Sex Ratio
February	89.2 (116)	10.8 (14)	130	8.2:1
March	74.1 (89)	27.9 (31)	120	2.8:1
April	68.2 (84)	31.8 (39)	123	2.1:1
May	89.1 (90)	10.9 (11)	101	8.1:1
June	73.7 (104)	26.3 (37)	141	2.8:1
July	75.2 (85)	24.8 (28)	113	3.0:1
August	78.1 (104)	21.9 (29)	133	3.5:1
September	63.4 (80)	36.6 (46)	126	1.7:1
October	84.7 (195)	15.3 (35)	230	5.5:1
November	86.1 (106)	13.9 (17)	123	6.2:1
December	76.6 (190)	13.4 (58)	248	3.2:1
January	82.8 (193)	17.2 (40)	233	4.8:1
Total	78.7 (1436)	21.3 (385)	1821	3.7:1

and 1:1.15 during 2006-2007, (Al-Marzouqi *et al*., 2011). The overall sex ratio (Males: Females) of *Siganus rivulatus* Inhabits Bitter Lakes in Egypt during the 201 was 1: 1.079 and did not differ significantly from 1:1. (El-Drawany, 2015).

Fecundity. In this study that the total lengths of individuals used for the observation of fecundity varied between 85 and 284 mm, and their weights were 98.4-284.6. The egg count in *S. canaliculatus* ranged from 5 x 10^3 to 130 x 10^3 eggs (Table 3). Its fecundity increased with increase in length and weight. The hghest fecundity was 130.760 occurred in September with total length 284 m and body weight 283 g. The lowest fecundity was 6215 eggs occurred in February with total length 132 mm and body weight 109 g.

The fecundity in this study is lower than those reported for other stocks in other tropical countries (Jayasankar 1990; Wassef and Hadey 1997; Tharwat 2004; Marzouqi *et al*. 2011). Fecundity in S. *canaliculalus* from the Gulf Of Mannar India varied from 33,711 to 284,516 measuring total length from 164 to 250 mm. (Jayasankar, 1990). Eggs per female Siganus *canaliculatus* in mid Arabian Gulf ranging from 42,253 to more than one million, for fish between 17 and 41 cm long (Wassef and Hady. 1997). The egg count in *S. canaliculatus* in the Arabian Sea coast of Oman ranged from 242 x 10^3 with total length 265 mm and body weight 294 g to 608 x 10^3 eggs with total length 375 mm and body weight 1025 g (Marzouqi *et al*., 2011). Fecundity of S.*canaliculalus* in Palompon, Leyte, Eastern Visayas, Philippines ranged from 18,350–306,850 in fish ranging in size from 7.1–15.5 cm SL (Paraboles and Campos, 2018).

Fecundity in S. *canaliculalus* from the Gulf Of Mannar *India* varied from 33,711 to 284,516 measuring total length from 164 to 250 mm. (Jayasankar, 1990). Eggs per female Siganus *canaliculatus* in mid Arabian Gulf ranging from 42,253 to more than one million, for fish between 17 and 41 cm long (Wassef and Hady. 1997).

In the present study, Highest fecundity of S. *canaliculalus* occurred in September but lowest in January. The appearance of the fish with larger sizes (284 mm) in the September catch may suggest that older fish move inshore to spawn. On the other

Table 2. Sex ratio of Rabbit Fish (*Siganus canaliculatus* Park,1797*)* based on gonadal maturity stages from southern coastal waters of of Jeneponto, South Sulawesi

Stage of maturity	Male((%) (*N*))	Female ((%) (*N*))	Total (*N*)	Sex Ratio
I	79.1 (982)	20.9 (259)	1241	3.7:1
II	78.8 (325)	21.(287)	412	1.1:1
III	91.3 (84)	8.7 (8)	92	10.5:1
IV	85.1 (23)	14.9 (4)	27	5.7:1
V	47.7 (21)	52.3 (23)	44	1:1.09
VI	20 (1)	80 (4)	5	1:4
Total	78.7 (1436)	21.3 (385)	1821	3.7:1

Tablel 3. Monthly fecundity of rabbit fish (*Siganus canaliculatus* Park,1797*)* from southern coastal waters of of Jeneponto, South Sulawesi

Month	Total length(mm)	N	Body Weigth (g)	Fecundity	Average Fecundity
February	132–142	2	109.01-119.39	6215–11068	8641± 432
March	156–194	2	105.84-121.51	70056–71221	7063±824
April	185	1	146.45	56024	56024
July	234	1	118.36	90723	90723
August	122–116	2	110.42-122.43	26790–50181	38486± 16540
September	85–284	21	98.45-284.63	5416–130760	64313±40766
December	186	1	150	77196	77196
January	194–245	9	106.61–181	10549–69751	49322± 21350

hand, studys were conducted by by Wassef and Hady (1997) that the appearance of larger sizes of fish with highest fecundity occurred in the spring (March-May).

Four of the six gonad maturity stages (I-Immature; II-Maturing; III-Maturing; IV-Mature; V-Ripe/Running and VI-Spent) could be established in male and female fish based on macroscopic observations (Table 4). The lowest total eggs was 130 760 eggs occurred in stage V. The highest total eggs was 5416 eggs occurred in stage III.

Relationship between fecundity and total length, body weight, and ovary weight of *Siganus canaliculatus* in southern coastal waters of South Sulawesi presented in Fig. 3,4,5.

Regression analysis of the relationship between fecundity and total length with coefficient of determination ($R^2 = 0.603$) showed a significant (Fig. 3). Analysis of regression showed also that there were significant relationship between the fecundity with body weight (Fig. 4) and ovary weight (Fig. 5) as coefficient of determination R^2 =0.512 and 0.574 . The results indicated that the number of eggs per female increased with increasing length, body weight and ovary weight.

Similar findings was also reported by by Jayasankar (1990). that the fecundity *Siganus canaliculatus* from The Gulf Of Mannar. India varied irrespective of the length or body weight of the fish and increased with ovary weight. It was also observed by Wassef and Hady (1997) that both absolute and relative fecundities of Siganus *canaliculatus* in mid Arabian Gulf increased with the increase in fish length. It was also (Paraboles and Campos, 2018) showed that the fecundity increased significantly with increased standard length, body weight and ovary weight and it increased significantly.

Egg Diameter

Egg diameter of *S. canaliculatus* in this study ranged from 0.1-0.5 of stage III. 0.35-0.45

Table 4. Fecundity of rabbit fish (*Siganus canaliculatus* Park,1797*)* based on gonadal maturity stages from southern coastal waters of of Jeneponto, South Sulawesi

Stage of Maturity	Range of Total Length (mm)	N	Range of Weight (g)	Range of Fecundity	Average Fecundity
III	85–142	8	98.45-122.43	5 416-50 181	20 265±15 242
IV	111–234	4	118.36-145.05	17 258–90 723	41 407±33 421
V	125–284	23	105.84-283.63	10 549–130 760	72 363±32 740
VI	209–245	4	111.70-181.00	61 252–69 751	65 463±4 578

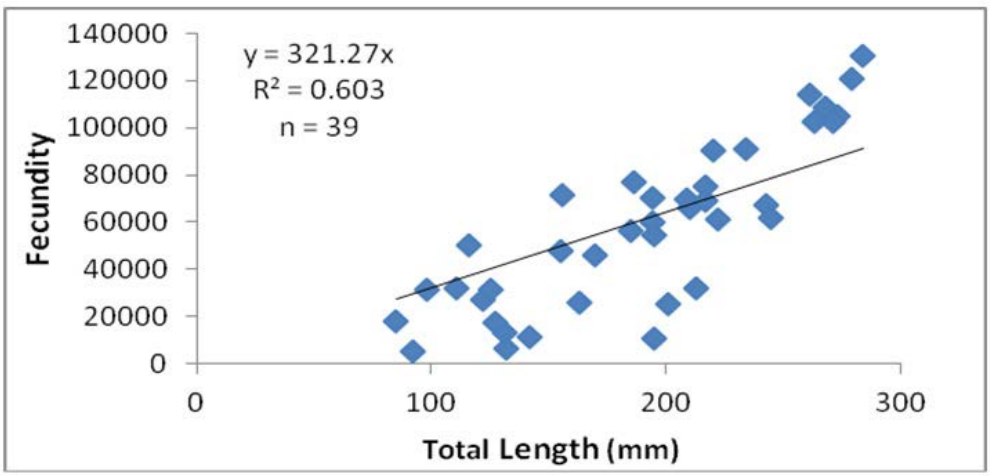

Fig. 2. Relationship between fecundity and total length of *Siganus canaliculatus* from southern coastal waters of of Jeneponto, South Sulawesi

of stage IV, 0.1-0.55 of stage V, and 0.35-0.55 of stage VI (fig. 5).

The highest frequency (31.74%) of diameter of female Gonad stage III was range between 0.30 to 0.35 with 857 eggs. The highest frequency (98.42%). of diameter of female Gonad stage IV was range between 0.35–0.40 with 1181 eggs. The hghest frequency (40.16%). of diameter of female Gonad stage V was range between 0.40–0.45 with 4960 eggs.. The hghest frequency (54.48%) of diameter of female Gonad stage VI was range between 0.45–050 with 1471 eggs (fig. 5).

Egg diameter of *S. canaliculatus* in this study was not different from other studies. Mean egg diameter of *S. canaliculatus* in Palau. was 0.475-0.530 mm (Hasse *et al*., 1977). The ripe eggs of *Siganus canaliculatus* in the Arabian Gulf Saudi Arabia ranging from 0,30-0.40 mm and the smaller eggs ranging from 0,10-0.25 both constitute about 88 % and 12 % from the total eggs in the ripe ovaries in the Arabian Gulf Saudi Arabia (Tharwat, A.A. 2004).

Egg diameters in the present study increased with increased fish length as a mature egg diameter increased significantly with increased standard length, in Palompon, Leyte, Eastern Visayas, Philippines (Paraboles and Campos, 2018).

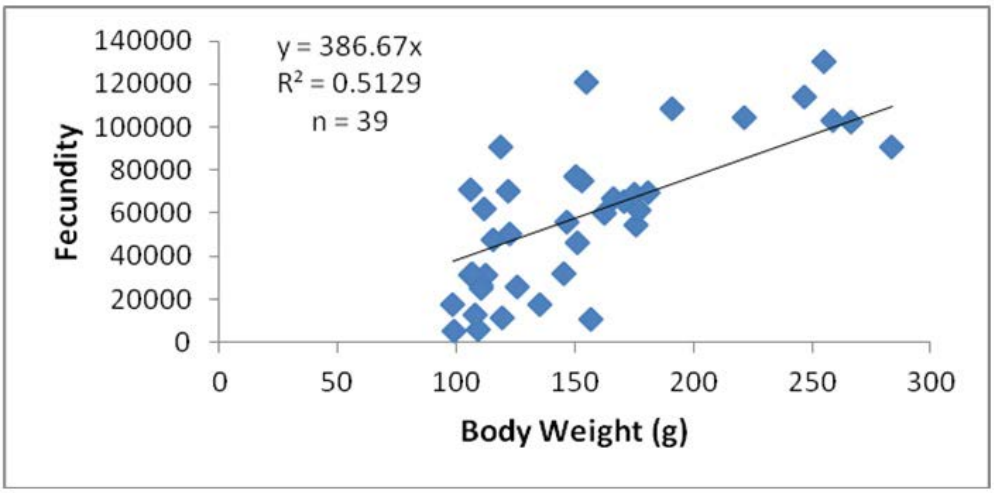

Fig. 3. Relationship between fecundity and body weight of *Siganus canaliculatus* from southern coastal waters of of Jeneponto, South Sulawesi

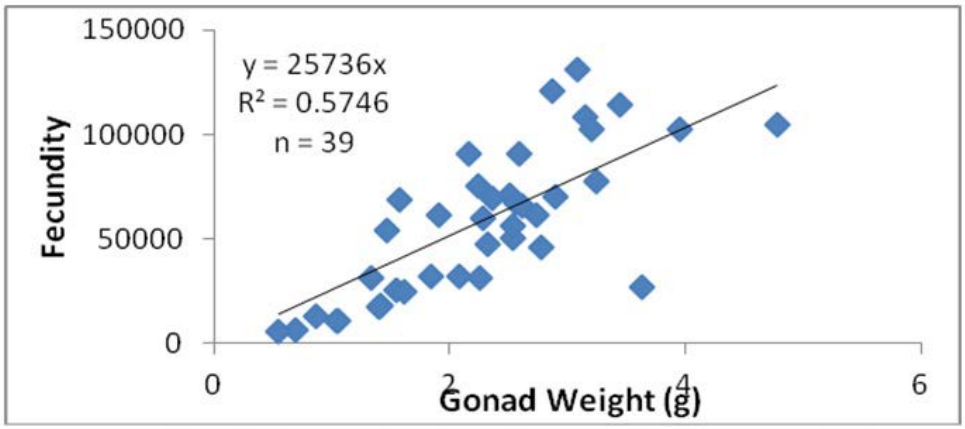

Fig. 4. Relationship between fecundity and ovary weight of *Siganus canaliculatus* from southern coastal waters of Jeneponto, South Sulawesi

CONCLUSIONS

A total of 1821 specimens of *S. canaliculatus* consisting of 1436 males and 385 females were randomly collected on a monthly during a year. The overall sex ratio (Males: Females) was from 1.7: 1 to 8.2:1. The estimatrion of fecundity was between 5 416 and 130 760 eggs. ind^{-1}, and increased with fish length, body weight and gonad weight. Egg diameter of *S. canaliculatus* in this study ranged from 0.1-0.5 of stage III. 0.35-0.45 of stage IV, 0.1-0.55 of stage V, and 0.35-0.55

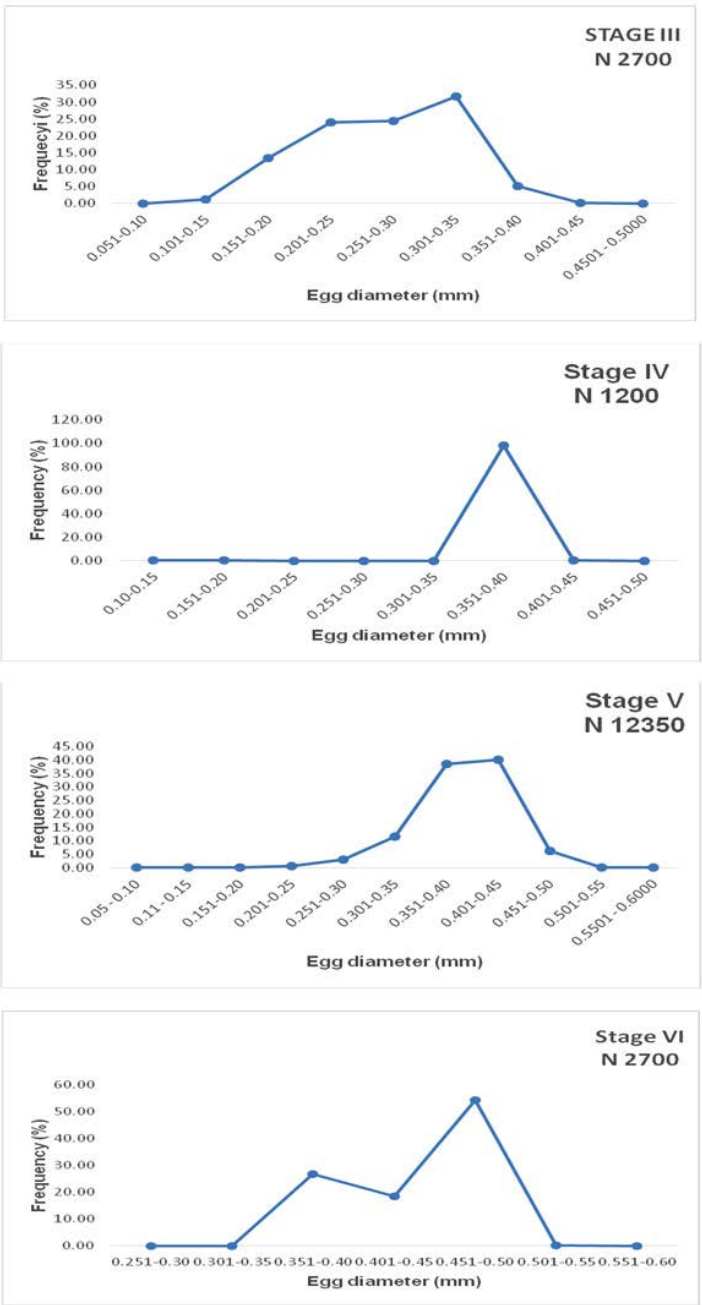

Fig. 5. Distribution of egg diameter of rabbit fish (*Siganus canaliculatus* Park,1797*)* based on gonad stage from southern coastal waters of of Jeneponto, South Sulawesi

of stage VI. Egg diameters increased with increased fish length.

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