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Some reproductive traits, fishery status, and the degree of r-selection of the squaretail coral grouper *Plectropomus areolatus* (Rüppell, 1830) and the roving coral grouper *Plectropomus pessuliferus* (Fowler, 1904) in the Red Sea

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Abstract
Some reproductive traits, fishery status, and the degree of r-selection were established in the Red Sea groupers, *Plectropomus areolatus* and *P. pessuliferus*, using monthly random samples and secondary data from the previous studies. Aging was done by counting vertebral annuli, and egg count by a colony counter. The average lengths of *P. areolatus* and *P. pessuliferus* were 40.76±1.03 and 61.55±2.34cm. Four and seven age groups were observed in the two fish in order. The sex ratio was in favor of females in *P. areolatus* and males in *P. pessuliferus*. Both fish aggregated and bred in the summer; the males matured first. The absolute and relative fecundities of *P. areolatus* were higher than those of *P. pessuliferus* even though it was the smaller fish. Both fish were heavily fished. *P. pessuliferus* is relatively less r-selected (r-strategist) than *P. areolatus* and, therefore, is potentially more vulnerable to fishing pressure. Means of fishery management were suggested.

Keywords: *Plectropomus*, *areolatus*, *pessuliferus*, reproduction, fishery status, r-selective strategy, Red Sea

1. Introduction
Groupers are members of the subfamily Epinephelinae, family Serranidae. They are medium-sized to large fish that are very important in the artisanal fisheries of tropical and subtropical regions. *Plectropomus areolatus* and *Plectropomus pessuliferus* (Sub species *marisburi* which is different from the Indo-Pasific *pessuliferus*) [1], are the most common, demanded, and expensive fish [2] along the entire Red Sea. The IUCN listed *P. areolatus* as a 'Threatened Species' [3] and *P. pessuliferus* as a 'Least Concern' [4]. However, in the Red Sea, both fish are exposed to intensive fishing, especially since the fishers, motivated by the high prices, target their spawning aggregates at times and locations known to them.
The aim of the present study was to provide some information on the reproductive biology, fishery status, and the degree of r- of *P. areolatus* and *P. pessuliferus* in the Red Sea, as exemplified by Sudan that is helpful in setting up sound management plans for the fisheries of the two fish. Grouper fisheries in Sudan are, so far, not regulated.

2. Material and Methods
2.1. The study sites
The fish samples used in the present study were collected from two sites on the Sudanese Red Sea: Port Sudan (Site 1) and Mohammed Qol (Site 2). Port Sudan (Coordinates 19.5903° N, 37.1902° E, Fig. 1), the main port of Sudan and the capital of the Red State, is in the middle of the western Red Sea coast. It is also the most important fishing ground and landing site. Mohammed Qol (Coordinates 20.9052° N, 37.1587° E, Fig. 1) is a large village in the vicinity of the entrance of Dongnab Bay, the largest bay on the Red Sea and the site of the mother-of-pearl oyster culture. Mohammed Qol is the most important fishing ground and landing site along the northern part of the Sudanese Red Sea.

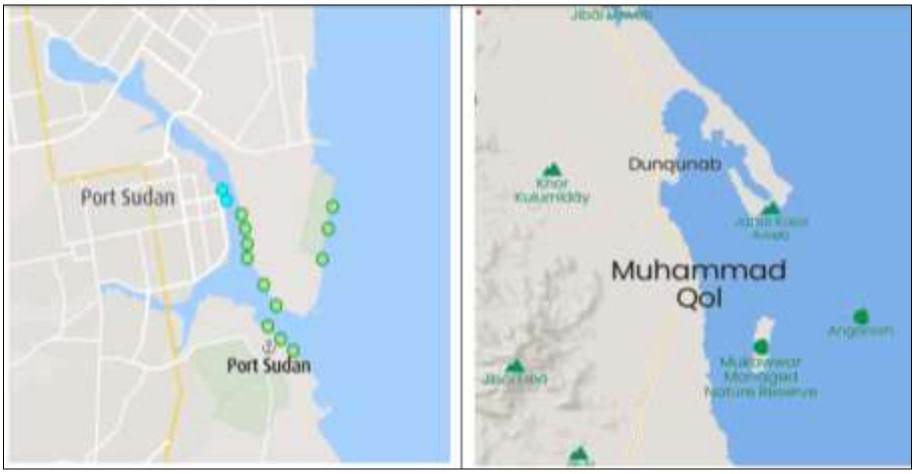

Fig 1: Site 1: Port Sudan (19.5903° N, 37.1902°), and Site 2: Mohammed Qol (20.9052° N, 37.1587°), from which the study fish samples were collected.

2.2. Collection of the fish samples
Twenty *P. areolatus* and 20 *P. pessuliferus* were collected randomly, monthly, from the artisanal catch of Port Sudan and Mohammed Qol (Fig. 1) from November 2001 to October 2002. These fish were identified according to FAO species identification sheets for fisheries [5] and the FAO species catalog [2].

2.3. Taking the morphometric measurements
The total length and corresponding weight of individual fish were measured to the nearest 0.1cm and 0.1 g respectively. The eye diameter was measured with a digital Vernier caliper.

2.4. Determination of the sex and maturity stages
The sex of individual fish was determined after opening the abdominal cavity, as no reliable external bodily features could help in the determination. The stages of gonadal development were identified according to Babiker (1984) [6].

2.5. Determination of the fish's age
In the present study, among scales, otolith bone, spines, opercular bones, and vertebrae, commonly used for determining fish age, vertebrae proved to be the most reliable [7]. At least five vertebrae of the individual fish were used for aging. They were boiled gently for fifteen minutes, cleaned, dried, and examined under the low power of a microscope for counting the annuli.

2.6. Estimation of the fecundity
Absolute fecundity, F, is the number of ripe eggs (oocytes) in the mature ovary of a fish of a specific size in a specific breeding season [8]. Relative fecundity (specific fecundity), RF, is the number of ripe eggs per centimeter of fish length, or eggs per gram of fish weight. The first *P. areolatus* used for estimating the fecundity was encountered in May and the last in September, while for *P. pessuliferus*, the first sample used was obtained in April and the last in July.
Individual ovaries that had reached semi-final gonadal development (ready-to-spawn ovaries, or ovaries with semi-mature or mature eggs) were cut longitudinally and preserved in Guilson’s fluid. Guilson’s fluid hardens the eggs and liberates them by breaking down the ovarian tissue [9]. The fluid was then decanted and replaced with water, which was eventually removed, and the ovaries were weighed individually. For each ovary, the eggs present in small sub-samples were counted with a colony counter. The fecundity, F, was calculated as:

F = (mean number of eggs in the sub-sample X weight of the whole ovary) / (mean weight of the sub-samples)

RF = F / (fish length (cm) or weight (g))

F was related to fish length, age, and egg diameter by linear, logarithmic, and power regressions. In these regressions, the axes y = F, and x = fish length, age, or egg diameter, and "a" and "b" are the regression constants, "a" is the intersection of the regression line on the y axis, and "b" is the slope.

2.7. Establishing the egg diameter
The egg diameter in microns was measured under the microscope for 70 eggs taken from each fish used in the fecundity estimation, and then the mean and standard deviation were calculated.

2.8. The fishery status, and the degree of r-selection of the two fish
The procedure used and the outcome is explained two items were treated in the discussion section.

3. Results
3.1 The morphometric measurements
Plectropomus areolatus was significantly smaller than *P. pessuliferus* (Tables 1 and 2). Average lengths of the two species (mixed males and females) in order were 40.76±1.03 and 61.55±2.34 cm, corresponding to total weights of 885.53±35.3 and 2050.3±38.09 gm. Males of *P. areolatus* tend to be larger than females, while females of *P. pessuliferus* tend to be larger than males, but the differences were not significant. The effect of the site was not significant.

Table 1: Sex, average length (L±SE cm) and weight (W±SE g), age (years), and sex ratio of *P. areolatus* in the two sites.

Species	Site	Sex	Average L	Average W	Sex %
P. areolatus	Site 1	M	40	972.4	39.6
		F	38.6	858.3	60.4
	Site 2	M	40.2	905.2	34.8
		F	38.3	806.2	65.2
	Site 1+2	M+F	40.76±1.03	885.53±35.3	

Table 2: Sex, average length (L±SE cm) and weight (W±SE g), age (years), and sex ratio of *P. pessuliferus* in the two sites.

Species	Site	Sex	Average L	Average W	Sex %
P. pessuliferus	Site 1	M	44.6	1635.8	56.7
		F	51.8	1856.6	43.3
	Site 2	M	50.0	1533.8	61.5
		F	61.8	3175	38.5
	Site 1+2	M+F	61.55±2.34	2050.3±38.09	

3.1 The sex ratio

The sex ratio of *P. areolatus* was in favor of females (60.4 – 65.2: 34.8 – 39.6 depending on the site, Table 1); that of *P. pessuliferus* was in favor of males (65.7– 61.5: 38.5 – 43.4 depending on the site, Table 2). Breeding aggregation was observed for both fish, initially, sexes more or less separate.

3.2 The fish age: The age of *P. areolatus* males at site (1) ranged from +0 (less than one year) to 4 years (Table 3) with a dominance of age 2 years, while in the females it ranged from +0 to 3 years with a dominance of age 2 years. In the males and females at site (2), it ranged from +0 to 3, and 4 years, consecutively, with the dominance of age 3 years.

The age of *P. pessuliferus* males at site (1) ranged from +0 to 4 years with a dominance of 3 years' age (Table 4), that of the females ranged from 0+ to 6 years with a dominance of 4 years' age. At site (2), the males age ranged from 0+ to 4 years with a dominance of age 3 years, while that of the females ranged from 0+ to 7 years with a dominance of age 5 years.

The effect of sex and site on the mean length and weight of both groupers were not clear.

Table 3: Mean length (L cm) and weight (W g) at age (years) of *Plectropomus areolatus* at site 1 and 2 (±St. d.).

Age	Site 1				Site 2			
	Males		Females		Males		Females	
	L	W	L	W	L	W	L	W
<1	28.7	290	-	-	-	-	28.7	300
1	34.5±4.2	537.3±180.6	32.7±3	523.9±229.3	33	505	36.2±2.8	631±169
2	39±3.2	878.3±340.2	40.3±3.1	945±234.2	40.1±4.2	1082.3±319.9	37.6±1.8	718.3±107.8
3	44.4±1.7	1201±165.7	44.2±1.8	1188.6±210.3	47.9±3.2	1535.6±366.9	44.7±4	1254±289.9
4	51.5±1.4	1943.3±138.2	-	-	-	-	44.1	1275

Table 4: Mean length (L cm) and weight (W g) at age of *Plectropomus pessuliferus* at site 1 and 2 (±St. d.).

Age (year)	Site 1				Site 2			
	Males		Females		Males		Females	
	L	W	L	W	L	W	L	W
<1	30	300	-	-	-	-	-	-
1	-	-	35.1	525	-	-	-	-
2	47.6	1200	-	-	-	-	37	585.5
3	47.2±3.9	1347±326.2	49.8±2.6	1510±216.5	49.3±2.5	1500±274.2	51	1800
4	52±5.7	1816.7±5.7	57.2±3.6	2185±282.9	55	1800	63.7	3075
5	-	-	64.5	3220	-	-	63.9±0.8	3237.5±162.5
6	-	-	70.5	4500	-	-	-	-
7	-	-	-	-	-	-	66.7	4100

3.3 The breeding season

Based on observations on gonadal development of the dissected fishes, it is concluded that the breeding season of *P. areolatus* was May to September, and that of *P. pessuliferus* was April to July, for both study sites. Both species aggregated during the breeding season, initially with sexes separate; many of ths samples collected during this period consisted mostly of males or females specimens only, while samples examined during the other months were usually of mixed sexes.

3.4 The maturity stages and age at first maturity

Maturity stages by total length and age for the two species at the two sites are presented in Tables 5 and 6, respectively.

At site (1), males and females *P. areolatus* reached first maturity at a minimum age of one year and an average length of 36.6, and 34.9 cm, respectively (Table 5). At site (2) the two sexes also reached first maturity at the age of 1+ year, and the total length of 33, and 36.6 cm, in order, but more commonly at 2 to 3 years. Males of *P. pessuliferus* reached maturity at a minimum age of 1+ year when they were 30 cm long, but more commonly at 2 to 3 years at lengths of 37.8 to 46.6 cm (Table 6), while for the females, the common length was 34.8 to 42.6 cm at an age of 2 to 3 years.

Table 5: The maturity stages of *P. areolatus* by average length (L cm) and age (Years).

Maturity stages	Site 1				Site 2			
	Males		Females		Males		Females	
	L	age	L	age	L	age	L	age
1	31.5	1	43.3*	2	33	1	36.6	1
2	36.6	1	34.9	1	37.8	2	37.8	2
3	41.6	2	42.6	2	46.6	2	42.3	2
4	49.8	3	42.4	3	47.9	3	-	-
5	-	-	-	-	-	-	-	-

* Dormant

Table 6: The maturity stages of *P. pessuliferus* by average length (L cm) and age (Years).

Maturity stages	Site 1				Site 2			
	Males		Females		Males		Females	
	L	age	L	age	L	age	L	age
1	30	0+	-	-	-	-	-	-
2	-	-	35.1	1	45.5	3	-	-
3	47.3	2	53.4	3	50.7	3+	57.1	4
4	52.8	3	67.5	5	-	-	65	5
5	-	-	-	-	-	-	-	-

3.6 Fecundity

Absolute fecundity differed between and within the two species (Table 7), with the effect of the site being not significant for *P. areolatus* (p>0.05) but significant for *P. pessuliferus*. *P. areolatus* significantly (p> 0.05) produced more eggs than *P. pessuliferus.* Its fecundity ranged from a minimum of 58320 eggs for a 2-year-old, 38.6 cm-long fish (Table 7) to a maximum of 2362365 eggs for a 2-year-old, 43.6 cm-long one at site (1). For *P. pessuliferus*, the fecundity range was 384366 eggs for a 6-year-old, 70.5 cm-long fish at site (1) to 1843450 eggs for a 5-year-old, 64.6 cm-long one at site (2).

Absolute fecundity of *P. areolatus* strongly correlated positively and significantly with fish length (r: 0.723, P: 0.008, Table 8), and moderately with age and eye diameter (r: 0.556, P: 0.061, and r: 0.585, P: 0.046 in order). The linear, logarithmic, and power regressions of absolute fecundity of *P. areolatus* versus total length, age, and eye diameter are presented in Table 9 and Figs 2, 3, and 4. All the regressions were significant, but the coefficient of determination, R^2, ranged from low to moderate. No conclusion could be drawn as to which regression (linear, logarithmic, or power) was better at describing the relationship.

The absolute fecundity of *P. pessuliferus* however, did not correlate with fish length (r: 0.007, P: 0.987, Table 10), age, or eye diameter (r: -.021, P: 0.961, and r: -.584, P: 0.128 in order); all the correlation coefficients, r, ranged from very low for fish length and age to moderate for the eye diameter. These correlations were, however, insignificant (Table 10); therefore, their regressions were not generated.

At site (1), the relative fecundity of *Plectropomus areolatus* ranged from 1510.88 eggs/cm for a 2-year-old, 38.6 cm-long fish to 54182.68 eggs/cm for a 2-year-old, 43.6 cm long one. For *P. pessuliferus*, it ranged from 5452 eggs/cm for a 6-year-old, 70.5 cm-long fish at site (1) to 28536.38 eggs/cm for a 5-year-old, 64.6 cm-long fish at site (2).

Table 7: Absolute (F) and relative (RF) fecundity of the two species at the two sites by fish length (L cm), age (years), and egg diameter (Ed micron).

Species	Site	L	Fish age	F	RF	Ed
Plectropomus areolatus	1	38.6	2	58320	1510.88	186.0±5.0
	2	39.7	2	259420	6534.51	198.1±4.7
	1	35.6	2	325727.2	9149.64	122.8±2.1
	1	38.6	2	480794.3	12455.81	343.1±4.4
	2	35.5	2	544625.9	15341.57	249.2±3.9
	1	43.6	2	555019.0	12729.79	325.5±2.8
	2	38.1	2	852950.0	22387.13	292.2±3.9
	1	42.4	3	1098103.0	25898.65	287.8±4.4
	1	42.4	3	1484780.0	35018.39	330.1±30.1
	1	46.0	3	1621883.1	35258.32	275.3±5.0
	2	45.0	3	1727380.8	38386.24	303.2±5.1
	1	43.6	2	2362365.0	54182.68	329.2±3.4
Plectropomus pessuliferus	1	70.5	6	384366.3	5452.00	479.9±4.8
	1	64.5	5	668360.0	10362.17	301.3±4.9
	1	52.5	3	695128.5	13240.54	470.6±4.3
	1	52.9	4	815734.5	15420.31	369.2±10.2
	2	66.7	7	1020800.4	15304.35	376.7±8.9
	1	57.0	4	1353844.0	23751.64	323.6±4.0
	2	63.7	5	1569428.0	24637.80	378.5±3.2
	2	64.6	5	1843450.0	28536.38	309.7±4.0

Table 8: Pearson's binary correlations between age (A), eye diameter (Ed), length (L), and fecundity (F) of *P. areolatus* (*: p 0.05; **: p 0.01).

Variables	L	A	Ed
A	.664*		
Ed	.571	.311	
F	.723**	.556	.585*

Table 9: Linear, logarithmic, and power regressions of absolute fecundity (F) of *Plectropomus areolatus* versus corresponding fish length (L), age (A), and eye diameter (Ed). *significant at 0.05, ** significant at 0.01.

Variables	Regression	Equation	R^2	P
F vs. L (Fig. 2)	Linear	F= 144911.22*L-4958725.81	0.523	0.008
	Logarithmic	F= -20521328.70+5795933.96*log(L)	0.513	0.009
	Power	F= 1.996e-006*L**7.1599	0.370	0.036
F vs. A (Fig. 3)	Linear	F= 803134.05*A-926365.425	0.309	0.061
	Logarithmic	F= -693064.05+1980772.29*log(A)	0.309	0.061
	Power	F= 57009.012*A**2.953	0.325	0.053
F vs. Ed (Fig. 4)	Linear	F= 6066.24*Ed-691534.597	0.342	0.046
	Logarithmic	F= -6397611.733+1320792.069*log(Ed)	0.326	0.052
	Power	F= 3.922*Ed**2.163	0.414	0.024

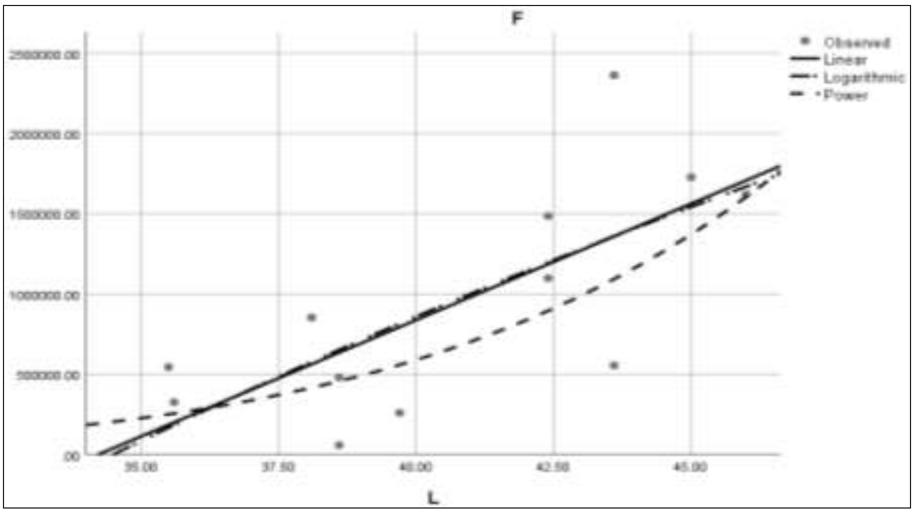

Fig 2: Linear, logarithmic, and power regressions of fecundity (F) of *P. areolatus* vs. corresponding length (L).

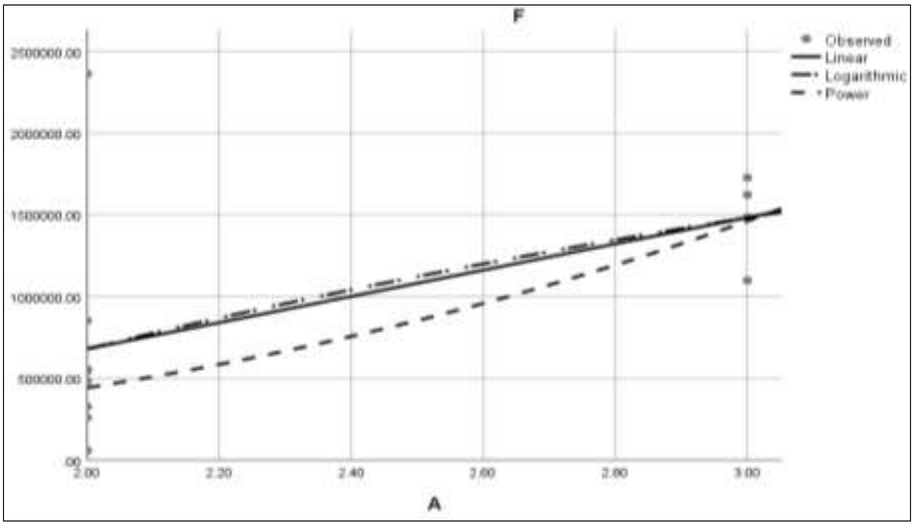

Fig 3: Linear, logarithmic, and power regressions of fecundity (F) of *P. areolatus* vs. corresponding age (A).

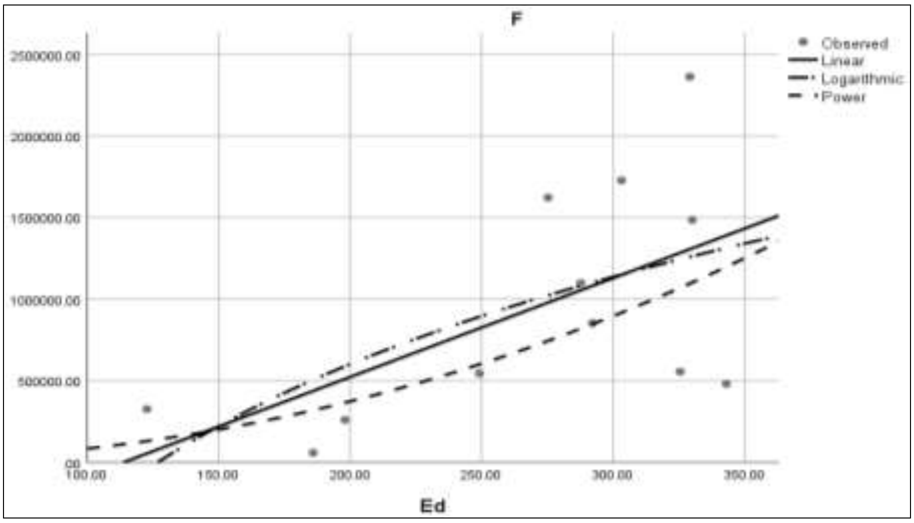

Fig 4: Linear, logarithmic, and power regressions of fecundity (F) of *P. areolatus* vs. corresponding eye diameter (Ed).

3.7 The egg diameter

The eggs of both fish were pale yellow and visible to the naked eye in the later gonadal stages. When mature, they were irregular in shape (Fig. 5), and their diameter ranged from 122.8±2.1 (±St. d.) microns for a 35.6 cm-long *P. areolatus* to 343.1±4.4 microns for a 38.6 cm-long fish (Table 7), and 301.3±4.9 microns for a 64.5 cm-long *P. pessuliferus* to 479.9±4.8 microns for a 70.5 cm-long fish.

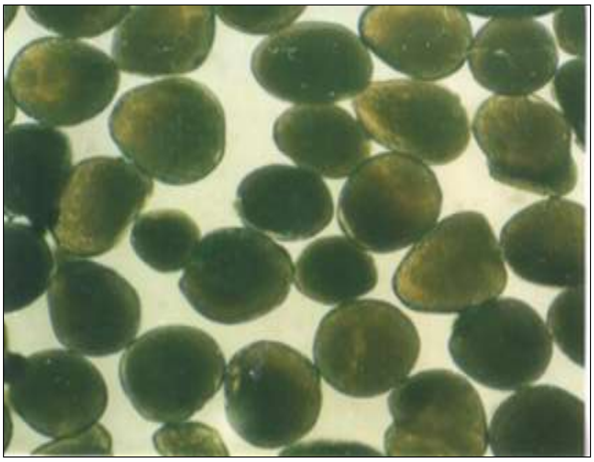

Fig 5: Variation in size and shape of fish egg (photo: Electronic Microscope Unit, Zoology Department, Khartoum University)

Table 10: Pearson's binary correlations between age (A), eye diameter (Ed), length (L). and fecundity (F) of *P. pessuliferus*.

Variables	L	A	Ed
A	.875**	.	.
Ed	-.013	-.041	.
F	.007	-.021	-.584

4. Discussion

Plectropomus areolatus of the present study was smaller than *P. pessuliferus*, with males being larger than females. Its average length was 40.76 cm, corresponding to a total weight of 885.53 grams, the dominant age being 2 to 3 years, while that of *P. pessuliferus* was 61.55 cm, corresponding to a total weight of 2050.3 grams, the dominant age being 3 to 5 years; the effect of sex and site on the size was not clear. Almost all the previous studies (see the table below) agreed that *P. areolatus* is smaller than *P. pessuliferus*. Both fish in the present study were smaller than those reported by Elamin (2012) [10], larger than Elamin *et al.* (2014) [11], and comparable to DesRosiers (2011) [12] for the Red Sea; this is also true for the age groups. In general, prolonged intensive fishing decreases the stock, which leads to a decreased catch per effort. This may eventually force the fishermen to seek new fishing areas away from the exhausted ones. The catch from the exhausted grounds contains more of the smaller and younger fish than before 'truncated size distributions' [13]. This leads to an increase in the prices of the smaller sized fish (as large fish are no longer provided to the market) and the lesser valued species [14], an increase in the ratio of immature to mature, a change in sex ratio because female groupers, which are generally larger than the males, are more likely to be caught in the fishing gear than the males, a decrease in the age and size of first maturation [15] - as fish with earlier maturity will have a better chance to be represented in the stock than fish with late maturation, a decrease in the population fecundity [16, 17], and sometimes behavioral changes. Overexploitation integrated over a large spatiotemporal extension may eventually lead to a change in the fish's status on the IUCN Red List. From examining the results of the present and previous studies (see the table below) and discussions with experts of the Red Sea Fisheries Research and Administration and the local fishers, one can conclude that the *P. areolatus* and *P. pessuliferus* fisheries in Sudan are being overexploited, and that the described succession is in its beginning.

Fishery science highly recommends that fish have the chance to breed at least once before being caught. One can conclude from comparing the sizes and ages of *P. areolatus* and *P. pessuliferus* in the present study with their estimated age of first maturity (in the present and previous studies; see the table below) that both fish marginally have this chance. However, as seen from the table, the contrast between the values of length at first maturity reported in the previous studies is large.

The present study concluded that *P. pessuliferus* is a relatively less r-selected species (r-strategist) than *P. areolatus*, though both fish are r-selected species with exponential growth. In general, r-selected species have a short life span (longevity/T_{max}), small body size (small L_∞), high growth rate (large K) but low survivability (high M), early sexual maturity, produce a large number of offspring (high fecundity), and are regulated mainly by density-independent factors. r-selected species have a better ability to adapt to changing environments than K-selected species because of their higher turn-over rate. It is clear from examining the table below that *P. pessuliferus* shows <u>all</u> these traits (in the present and previous studies) less than *P. areolatus. P. pessuliferus*, having a lower turn-over rate, is potentially more susceptible to high fishing pressure (and recovers at a slower rate) than *P. areolatus.* However, at present, the IUCN lists *P. pessuliferus* as a 'Least Concern' [4] and *P. areolatus* a 'Threatened Species' [3]. This should not be considered a disproof of our conclusion. It may be that factors other than fishing pressure also contributed to *P. areolatus* being listed as a 'Threatened Species'. *P. pessuliferus* is less common in the Indian Ocean and the Indo-Pacific than *P. areolatus*. Both fish are common in the Red Sea and are not endangered though they are exposed to alarmingly heavy fishing pressure. The IUCN 'date assessed: 2016' is old, a new study is needed. The exploitation rate (E) for *P. areolatus* in Dongonab Bay and Suakin, the Red Sea, in 2012 was 0.746 and 0.671, respectively; E for *P. pessuliferus* in the two sites was 0.685 and 0.712, in order [10]; all values were above the recommended optimum of 0.5. Today, there is a scarcity of fish in most of the fishing grounds near the towns and fisher villages in Sudan. The fishers are continuously shifting to new, distant fishing areas, but during the breeding season, they the grouper aggregates in their usual locations.

The mature eggs of both groupers in the present study were irregular. The absolute fecundity and relative fecundity of *P. areolatus* in the present study were higher than those of *P. pessuliferus* even though it was the smaller one, a consequence of being the more r-selected species. Theoretically, higher fecundity is associated with lesser survival, and vice versa. Regressions of fecundity vs. fish length, age, and eye diameter were calculated for *P. areolatus*. Elamin (2012) [10] reported comparable fecundities for both fish in the Red Sea (the table below).

In the present study, the breeding season was May to September for *P. areolatus*, and April to July for *P. pessuliferus* in both study sites. The local fishers, and the scalers at fish markets, confirmed that the general breeding season of groupers in the Red Sea is summer, with temporal displacement of the individual species, which probably helps in partitioning the food resources available for the hatching larvae. However, in the Indian Ocean and the Indo-Pacific, different durations were reported (see the table below); for example, in Indonesia (spans the equator), *P. areolatus* spawns from September to April [18]. *P. areolatus* and *P. pessuliferus* of the present study aggregated during the breeding season, initially with sexes separate. The fishermen target these aggregates because they encompass large numbers of mature groupers and because other commercial fish are usually present around them. Lindfield (2023) [19] mentioned that *P. areolatus* aggregations overlap, more or less, spatiotemporally with those of *Epinephelus polyphekadion* and *E. fuscoguttatus*.

In the Red Sea, the spawning aggregations were not studied. In the Indian-Pacific Ocean, an aggregate may contain 100 to a few thousand individuals according to the site, time, and of exposure to fishing, males typically arrive at the aggregate sites earlier than females [20, 21]. In the Red Sea, many factors possibly diluted overfishing of the aggregates. The Red Sea coast is sparsely populated, and the fishers are relatively few. The spawning aggregates are temporary and disperse after the spawning. However, the home range of groupers is small, and many fish stay close to their aggregation sites after the spawning [22, 19]. The aggregation sites are many, and spread over the entire coral reef (the fringing reef (and patch and barrier reefs) extends along the entire coast at a width of more than 1/2 to 1 km), a very vast area. Although the fishermen know the location and timing of many of the aggregate sites, fixing their exact positions is difficult (the sea doesn't have landmarks). The spawning of both fish occurred in the summer, a period that coincides with some strong winds of daily rhythm (sea/land breath and local monsoon-like winds called Haroar and Mugelli); which, sometimes, make navigation by small boats difficult. Elamin (2012) [10] stated similar results.

Table 11: Shows in magnitude site species parameter

Parameter	Species	Magnitude	Site	Reference
RTL (fish length)	*P. a	28.7-51.5 cm	Red Sea	**P s
RTL	***P. p	30-70.5 cm	Red Sea	**P s
ATL (aver. length)	*P. a	40.76 cm,	Red Sea	**P s
ATL	***P. p	61.55 cm,	Red Sea	**P s
RTL	*P. a	24.5-77.5 cm	Red Sea	[10]
RTL	***P. p	30-90 cm	Red Sea	[10]
RTL	*P. a	38.77-40.19 cm	Red Sea	[11]
RTL	***P. p	56.60-56.90 cm	Red Sea	[11]
ATL	*P. a	40.9 cm	Red Sea	[12]
ATL	***P. p	60.6 cm	Red Sea	[12]
ATL	*P. a	36.77 cm	Maldives	[14]
ATL	**P. p	36.18 cm	Maldives	[14]
ATW Aver. Weight	*P. a	885.53 g	Red Sea	**P s
ATW	***P. p	2050.3 g	Red Sea	**P s
MRL (maximum reported length)	*P. a	80 cm		[23]
MRL	***P. p	120 cm		[24]
Age/Life span	*P. a	1-4 years	Red Sea	**P s
Age/Life span	***P. p	1-7 years	Red Sea	**P s
LFM (Length at first maturity)	*P. a	♂ 33-36.6 cm ♀34.9-36.6 cm	Red Sea	**P s
Age/Life span	*P. a	8 and 6 years	Red Sea	[10]
Age/Life span	***P. p	10 and 11 years	Red Sea	[10]
Age/Life span	*P. a	9 years	Red Sea	[12]
Age/Life span	***P. p	19 years max.	Red Sea	[12]
Age/Life span	*P. a	12 years	Micronesia	[25]
Age/Life span	*P. a	8-12 years	Solomon Isl.	[26]
Age/Life span	*P. a	12-14 years		[19]
Age/Life span	*P. a	14 years	Torres Straits	[27]
LFM	*P. a	♂ 33-36.6; ♀ 34.9-36.6 cm	Red Sea	**P s
LFM	***P. p	♂ 37.8-46.6; ♀ 34.8-42.6 cm	Red Sea	**P s
LFM	*P. a	♂ 43.3-47.4; ♀ 42-45.3 cm	Red Sea	[10]
LFM	***P. p	♂61.4-64.5; ♀57.2-57.4 cm	Red Sea	[10]
LFM	*P. a	38.7 cm	Red Sea	[12]
LFM	***P. p	62.2 cm	Red Sea	[12]
LFM	*P. a	2.45 years	Red Sea	[12]
LFM	***P. p	4.6 years	Red Sea	[12]
LFM	*P. a	36.65 cm (771.2 g)	Indonesia	[18]
LFM	*P. a	♂ 32.9-35; ♀ 32.16-33.79 cm	Solomon Isl.	[26]
AFM (age at first maturity)	*P. a	3 years, both sex	Red Sea	**P s
AFM	***P. p	3 years, both sex	Red Sea	**P s
AFM	*P. a	♂ 3 years; ♀ 2.6-3.4 years	Solomon Isl.	[26]
Absolute fecundity	*P. a	58320-2362365 eggs/mat. ♀	Red Sea	**P s
Absolute fecundity	***P. p	384366-1843450 eggs/mat.♀	Red Sea	**P s
Absolute fecundity	*P. a	$5.9x10^5$-$4,1x10^6$eggs/mature ♀ (mean 1.6 x 10^6)	Red Sea	[10]
Absolute fecundity	***P. p	5.8 x 10^5-8 x 10^6 eggs/mature ♀(mean: 2.3 x 10^6)	Red Sea	[10]
Absolute fecundity	**P. p	5.8 x 10^5-3,4 x 10^6,mean: $1.3x10^6$	Red Sea	[10]
Relative fecundity	*P. a	1511-54183 eggs/cm	Red Sea	**P s
Relative fecundity	***P. p	5452-28536 eggs/cm	Red Sea	**P s
L_∞	*P. a	79.27-88.72 cm.	Red Sea	[10]
L_∞	***P. p	116.84-122.19 cm	Red Sea	[10]
L_∞	***P. p	L_∞ 78.1 cm	Red Sea	[12] a
K	*P. a	0.143-0.163 $year^{-1}$	Red Sea	[10]
K	***P. p	0.112-0.120 $year^{-1}$	Red Sea	[10]
K	***P. p	0.40 $year^{-1}$	Red Sea	[12] a
M	*P. a	0.295-0.344 $year^{-1}$	Red Sea	[10]
M	***P. p	0.215-0.235 $year^{-1}$	Red Sea	[10]
M	*P. a	M 0.30	Australia	[28]
L_∞	*P. a	46.8-51.1 cm	Solomon Isl.	[26]
L_∞	*P. a	45.48 cm	Pohnpei	[25]
L_∞	*P. a	57.2	Australia	[28]
K	*P. a	0.42-0.48 $year^{-1}$	Solomon Isl.	[26]
K	*P. a	0.635	Pohnpei	[25]
K	*P. a	0.35	Australia	[28]
T_{max}/Longivity	*P. a	12 years	Solomon Isl.	[26]
T_{max}/Longivity	*P. a	14	Australia	[28]
T_{max}/Longivity	*P. a	12	Pohnpei	[25]
T_{max}/Longivity	***P. p	19	Red Sea	[12] a

Spawning/Breading	*P. a	May to September	Red Sea	**P s
Spawning/ Breading	**P. p	April to July	Red Sea	**P s
Spawning/ Breading	*P. a	May to July; April to June	Red Sea	[10]
Spawning/ Breading	***P. p	March to July; March to May	Red Sea	[10]
Spawning/ Breading	*P. a	Mainly March to June	Solomon Isl.	[26]
Spawning/ Breading	*P. a	September to April	Micronesia	[18]
Spawning/ Breading	*P. a	Apr–May. Nov– Dec	Maldives	[29]

*P. a: *P. areolatus.* **P s: the present study. ***P. p: P. *pessuliferus* a: In [30]

5. Conclusion s and recommendations

Plectropomus areolatus and *P. pessuliferus* of the Sudanese Red See are exposed to alarming fishing pressure that necessitates establishing and enforcing proper management of the fisheries. The total prohibition of fishing and the sale of the two fish is the most promising alternative. Banned areas and fishing zones cannot be practically enforced. There is a need for new studies on the population dynamics, fisheries, and spawning aggregation of the two fish in the Sudanese Red Sea.

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