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RESEARCH ARTICLE **ARAŞTIRMA MAKALESİ**

Quantitative and qualitative observations of European sea urchin (*Paracentrotus lividus,* Lamarck 1816) gonad in Cesme Bay, Izmir, Turkey

Çeşme Körfezi'ndeki Avrupa Deniz Kestanesi gonadının (*Paracentrotus lividus,* Lamarck 1816) kalitatif ve kantitatif incelenmesi

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Abstract: This study examined fecundity, by means of the gonad index of the most common and abundant echinoderm species (*Paracentrotus lividus)* of the Aegean Sea (western Turkey). *Paracentrotus lividus* samples were collected monthly at the coast of Cesme for six months and biometric parameters were measured and then the animals' dissected. Gonad indices were calculated. The mean fecundity (number of eggs) was determined and eggs diameter were measured. Mean egg diameter was 91.14±1.46 µm. There was a peak in fecundity in March (346.582 eggs/female) that correlated with the observed peak in GSI (11.02±0.54 %) and egg size (95.68±01.98 µm). The results presented here show that a significant different was found in egg numbers and egg sizes between months (p<0.05).

Keywords: *Sea urchin, Paracentrotus lividus, gonad index, fecundity, egg size*

Öz: Bu çalışmada, Ege Denizi'nde (Türkiye'nin batısı) yaygın bulunan echinoderm türlerinden *Paracentrotus lividus*'un fekondite ve gonad indeksi özetlenmiştir. Çeşme kıyısal alandan aylık olarak *Paracentrotus lividus* toplanarak biyometrik ölçümleri yapıldıktan sonra kesme işlemi gerçekleştirilmiştir. Gonad indeksleri hesaplanmıştır. Ortalama fekondite (yumurta sayısı) belirlendi ve yumurta çapı ölçülmüştür. Ortalama yumurta çapı 91.14±1.46 µm. Fekondite Mart ayında pik yaptı (346.582 eggs/female) ve ilişkili olarak gonad indeksi (11.02±0.54 %) ve yumurta boyu da (95.68±01.98 µm) bu ayda en yüksekti. Buradaki sonuçlar, aylara göre yumurta sayısı ve yumurta boyunda önemli bir farklılık (p<0.05) olduğunu göstermiştir.

Anahtar kelimeler: *Deniz kestanesi, Paracentrotus lividus, Gonad indeks, fekondite, yumurta boyu*

INTRODUCTION

Sea urchins are known to be very reproductive (prolific) marine invertebrates, and females of some species, for example, can release as many as 100 million eggs in a single spawning period (Randall et al., 2002). Sea urchin gonad is consumed as food so gonad weight and content affect food quantity and quality (Xu and Barker, 1990). The field and laboratory studies indicate that the number of eggs produced tend to decrease when food level deteriorate (Bayne et al., 1975; Lucas and Crisp, 1987; Hirche, 1993). Gago and Luis (2010) observed that irrespectively of the broodstock stock density, mean number of eggs was always higher than 508±118x10^3 in *P. lividus*. Luis et al. (2005) indicated that *P.lividus* egg number was 788±119x10^3 and sea urchins emitted small and large oocytes (~65 µm, ~90 µm in diameter, respectively) during the maturation season. Fenaux et al. (1985) recorded average 90 µm diameter in eggs of *P. lividus*.

Most life history models (McGinley et al., 1987; Roff, 1992) assume an interchange between egg size and number, i.e. females produce more, but smaller eggs in favorable environments and few, but larger eggs in unfavourable environments. Previous studies have predicted that bigger females with more resources for reproduction should produce bigger eggs and large numbers of eggs (McGindley, 1989 Sargent et al., 1987 and Venable 1992). For example, a female of 40mm in diameter generally produces around 5 to 7 millions of eggs (Grosjean et al., 1998). George (1990) observed that the egg diameter of *P. lividus* (body weight was between 46g and 71.6g) was between 89.6 µm and 92µm. in field studies.

Gonad indices (GSI) were changed according to species and regions, such as lower than 8 % (Spirlet et al., 1998) and 6-12 % (Spirlet et al., 2000) in Brittany, France, 4.1-5.6 % in Algeria (Soualili and Guillou, 2009), 6 % in Turkey (Köse, 2005).

According to most experts, aquaculture of sea urchins is the best solution for sustainablitiy of this valuable and expensive food resource with high demand whereas its natural stocks are drastically depleted due to overfishing. For sea urchin cultivation purposes, it is necessary to have an appropriate knowledge on the dynamics of the sea urchin reproduction. Our aim was to investigate the reproductive cycle of *P. lividus* in Cesme from wild, through the monthly examination of its gonad index and fecundity variations.

MATERIALS AND METHODS

Sea urchin individuals, *P. lividus*, were gathered between December 2004 to May 2005 from (038^{0}12"77'N; 026^{0}25"46'E), Cesme, Izmir (Fig 1). Sea urchin samples kept in these months in order to get gamete because Kose (2005) referred this time period for natural spawning for this populations. (Agatsuma, 1998).

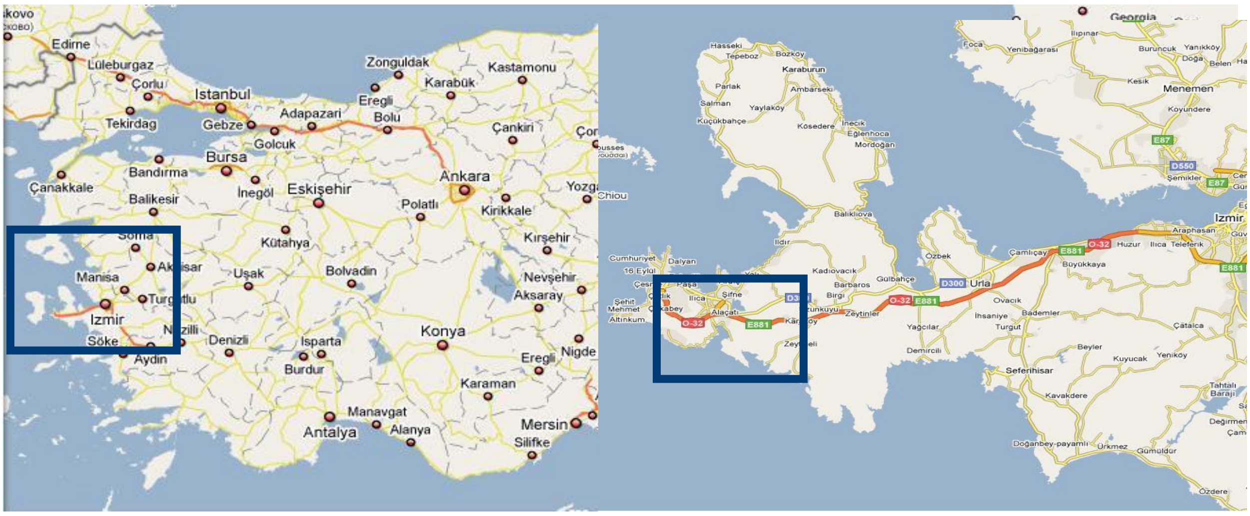

Figure 1. Geographical situation of the sampling site located in the Aegean Sea coast

On each sampling time, 30 specimens with test diameter (19-21mm) were collected by hand at 0.5-1m depth. The biometric measurments done were (test diameter and total weight). In addition, the surface water temperature was measured with a mercury thermometer. Following their removal, *P. lividus* samples were immediately taken to the laboratory where they were measured and dissected. Fecundity was determined by counting eggs were from each spawned females and the diameter of eggs was measured. In these samples, wet gonad index (WGI) was calculated as the ratio between the wet weight of the internal organs (WWI) and the total wet weight of the sea urchin (TWW) expressed in mg:

WGI (%) = (Wet weight of gonad / Total wet weight of sea urchin) x 100

Statistical Analysis

Results are expressed as the mean±standard error. The biometric calculations and the physiological indices were made using Microsoft Excel Program. Indices of the gonad were normalized using the arcsine transformation because gonad indices are percent values. The values were subject to the analysis of Kruskal Wallis to compare indices between months. All statistical significance tests were at the $p<0.05$ levels (Watts et al., 1998).

RESULTS

The total weight of sea urchins varied between 21.34±1.09g and 27.58±1.27g. The lowest gonad weight was measured in January and the highest was in March. The maximum egg size was measured in March (95.68±1.98µm). Mean egg size was 91.14±1.46 µm. A significant difference was found in egg numbers and egg sizes between months ($p<0.05$) (Table 1).

The GSI fluctuated during the study. There was an increase from January to March then it decreased. The GSI had two peaks in March (11.02±0.54 %) and in December (9.42±0.47). It was minumum in January (2.21±0.90 %). The fecundity was highest in March (346.582 eggs/female) and was lowest in January (44.000 eggs/female) (Figure 2).

Table 1. The biometric features of *Paracentrotus lividus* (mean±SD)

	Diamaeter ±SD (mm)	Total weight ±SD (g)	Gonad weight±SD (g)	Gonad index ±SD (%)	Eggs number ±SE	Eggs size ±SD (µm)
Dec	20.35±1.11	24.19±2.11	2.28±0.12	9.42±0.47	44.000±13.245	91.20±0.87
Jan	21.90±0.96	27.58±1.27	0.61±0.13	2.21±0.90	36.581±9.589	89.60±0.69
Feb	19.50±0.85	21.34±1.09	0.94±0.10	4.40±0.72	203.615±57.928	94.98±1.45
March	19.20±1.66	22.68±2.82	2.50±0.15	11.02±0.54	346.582±61.074	95.68±1.98
April	19.70±1.05	22.90±1.78	1.75±0.18	7.64±0.63	111.125±39.064	86.24±0.50
May	19.60±1.95	22.70±0.04	1.50±0.83	6.60±1.57	153.649±59.729	89.25±1.37
Total	20.00±0.41	23.56±0.88	1.59±0.30	6.88±1.28	149.256±47.303	91.14±1.46

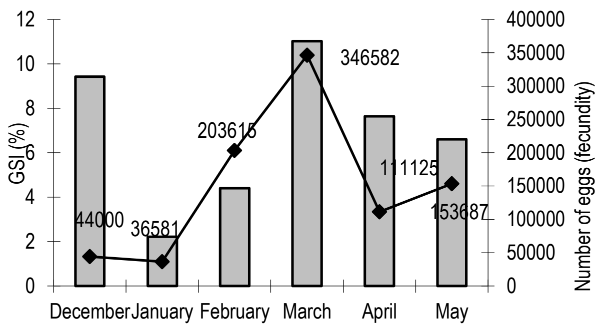

Figure 2. Time course of the gonadosomatic index and number of eggs in sea urchins during the study period

The surface water temperature at the sampling site did some variation within months. It ranged from 14ºC to 19ºC. The water salinity was stable (36 ‰) during the study (Figure 3).

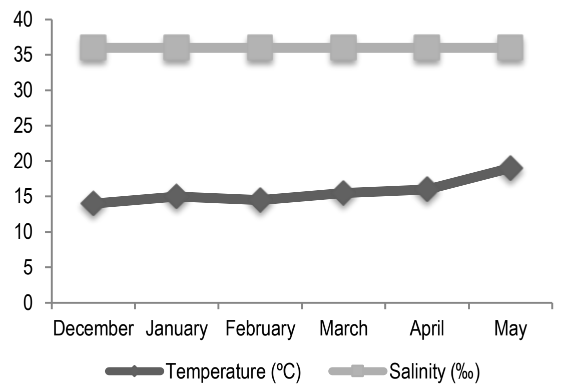

Figure 3. Variations temperature and salinity monthly

DISCUSSION

Egg size and number varies within and among females at a site and between sites (Emlet et al., 1987). Luis et al. (2005) indicated that wild *P.lividus* egg number was 788±119x10³ in Portugal. Gago and Luis, (2011) obtained that *P. lividus* female spawning was between 23±10x10³ and 178±59x10³ with different mechanical shock techniques. In this study, egg numbers were higher (36.58±9.58x10³ and 346.582±61.07x10³) than Gago and Luis (2011). Several factors such as temperature, photoperiod, dietary resources availability and water turbulence are pointed out as controlling gametogenesis of wild *P. lividus* populations (Fenaux, 1968) but taking spawning into account the main environmental trigger is not clearly known (Lopez et al., 1998). Fenaux (1968) indicated temperature as the main trigger of spawning episodes in field populations of *Paracentrotus lividus*, but this effect was not detected in present study because the temperature was not significiantly different during the study. The differences in egg size or number observed in field studies might be due to differences in the abundance of preffered algae at the different sites. The field and laboratory studies indicate that the number of eggs produced tend to decrease when food conditions deteriorate (Bayne et al., 1975; Lucas and Crisp, 1987; Hirche, 1993). Morris (1992) predicted that adult and offspring survival might not be independent of environmental conditions, but increase as environmental conditions improve and decrease as environmental conditions deteriorate (McGinley et al., 1987).

Grosjean et al. (1998) observed that a female of 40mm in diameter produces around 5 to 7 millions of eggs. In the current study sea urchin individuals were smaller (19-21mm) and number of eggs were fewer (149x10³) than the Grosjean et al. (1998) study. The present results are in agreement with Begon and Parker (1986) who predicted that bigger females should produce bigger eggs and a larger number of eggs. George (1990) observed that egg diameter of *P. lividus* (body weight 58.8g) was 90.8 µm. in field studies. In the current study, body weight was lower (24.9g), egg diameter was higher (92.4 µm.) than in the George (1990) study. These differences might be down food which influences both somatic growth and reproductive condition in sea urchins (Beddingfield and McClin tock, 1998).

Gonadosomatic index of *P. lividus* in natural condition ranges between 6 % and 12 % (Spirlet et al., 2000). Luis et al. (2005) referred to pooled data for captive fed urchins and showed that 49.0±0.55mm and 31.3±0.8g individuals had 10.5% gonad index. In the present study, 20.00±0.41mm. and 23.56±0.88g. *P. lividus* had a GSI of 6.8 %. The variations in body size and gonadosomatic index of sea urchins could be related to quantity and quality of feed. The algal community in the area of study is consist of only *Posidonia sp*. and a little macralgae such as *Padina sp*. Therefore it could be reason for a low GSI.

Fenaux (1968) *Paracentrotus lividus* egg diameter was 90 µm assimiliar to Luis et al., (2005). In present study, mean egg size (91.14±1.46 µm) was close the values of other studies (George, 1990; Fenaux, 1968). The egg size and content increases irrespective of mode of development when environmental conditions improve (George, 1996). In most of individuals examined, egg size remained constant and in a few cases decreased when food conditions deteriorated (George, 1996). In current study, we observed that the egg size and number were higher in February and March. In these months, sea urchins might live favourable conditions such as food and water or might be spawning season.

Aquaculture of sea urchins is the best solution for sustainability of this valuable and expensive food resource with high demand whereas its natural stocks are drastically depleted due to overfishing. Therefore these conclusions can be used to develop increasing sea urchin aquaculture for human consumption.

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