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Some Reproduction Characteristics and Weight-Length Relationships of the Spangled emperor, *Lethrinus nebulous* (Lethrinidae) of the South Coastal of Iran (Persian Gulf and Oman Sea)

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Abstract

Monthly data of length composition for Spangled emperor, *Lethrinus nebulosus* (Lethrinidae), landed between September 2007 to August 2008 along the Persian Gulf and Oman Sea were used to estimate the weight-length relationship, maturity stage, maturity length and spawning season of the stock. Macroscopically, *L. nebulosus* ovaries consisted of two cylindrical gonads of approximate equal size. The monthly calculated mean values of gonadosomatic index (GSI) of females were indicate to increase from february, reach the highest in march and decline in june. The peak spawning season of *L. nebulosus* occurred in march. More than 50% of Spangled emperors were mature at the size of 31 cm. Transitional *L. nebulosus* gonads were characterized by the concurrent degeneration of all oocytes and the proliferation of spermatocysts near the edge of the lamellae, an increase in blood vessels along strands of stromal tissue within the lamellae and the formation of multiple sperm sinuses. The weight-length relationship was estimated with a= 0.051 and b= 2.722, indicates that Spangled Emperor has alometric growth.

Keywords: *Lethrinus nebulosus,* protogyny, Maturity stage, Transitional gonad, allometric growth, Iran.

İran'ın Güney Kıyısında (Basra Körfezi ve Umman Denizi) Bulunan İmparator Balığı, *Lethrinus nebulous* (Lethrinidae)'in bazı üreme özellikleri ve Boy-Ağırlık İlişkisi

Özet

Bu çalışma, Basra Körfezi ve Umman Denizi'nden yakalanan imparator balığı *Lethrinus nebulosus* (Lethrinidae)'nın boy-ağırlık ilişkisi, gonad olgunlaşma safhalarını, olgunlaşma boyunu ve yumurtlama mevsimini tespit etmek için, Eylül 2007–Ağustos 2008 tarihleri arasında aylık olarak gerçekleştirilmiştir. Makroskopik olarak *L. nebulosus* ovaryumları, hemen hemen birbirine eşit iki silindirik gonaddan oluşmaktadır. Dişilerin gonadosomatik indeks (GSI) değerlerinin şubat ayından itibaren arttığı, mart ayında en yükseğe çıktığı ve haziran ayından itibaren de azaldığı tespit edilmiştir. *L. nebulosus*'un üremesi mart ayında maksimuma ulaşmıştır. İmparator balığının %50'sinden fazlası 31 cm büyüklükte cinsi olgunluğa erişmiştir. *L. nebulosus* gonadının histolojik analizinde; bütün oositler eşzamanlı olarak dejenerasyona uğramış ve lamellanın kenarına yakın spermatokistlerin tomurcuklanmasıyla lamelin içerisindeki stromal dokunun liflerinde kan damarları artmış ve çoğul sperm sinus oluşumu görülmüştür. Boy-ağırlık ilişkisinde a= 0,051 ve b= 2,722 olarak bulunmuştur. Bu durum İmparator balığının allometrik büyüme özelliği olduğunu göstermektedir.

Anahtar Kelimeler: *Lethrinus nebulosus,* olgunluk evresi, geçici gonad, alometrik büyüme, İran.

Introduction

The spangled emperor *L. nebulosus* (Forsskål, 1775), is distributed throughout the Indo-West Pacific from the Red Sea and East Africa to southern Japan and Samoa. It is found in a variety of habitats including coral reefs, sea grass beds and mangroves from near shore to a depth of 75 m (Randall, 1995). Emperors are demersal carnivorous feeders. In general, emperors consume a wide range of prey including polychaetes, molluscs (gastropods, bivalves, squid and octopus), echinoderms (sea urchins, sand dollars, starfish, brittlestars), crustaceans (crabs, shrimps) and fish (Carpenter and Allen 1989). Previous studies of reproduction in the lethrinids have identified several species as protogynous hermaphrodites (sex change from female to male) (Young and Martin, 1982; Carpenter and Allen, 1989; Wassef and Bawazeer, 1992; Ebisawa, 1990), and some have found both male and female tissue in the

gonads of juvenile fishes (Ebisawa, 1997), whereby individual mature first as females before changing sex later in life. One exception to this pattern is the spangled emperor, *L. nebulosus*, which was reported to exhibit juvenile hermaphroditism, whereby sex change occurred prior to reaching sexual maturity (Ebisawa, 1990). Emperors are presumed to spawn at dusk or after dark, most commonly during the new moon period (Carpenter and Allen 1989). This study describes the growth and reproductive characteristics of *L. nebulosus*, with a focus on quantifiable traits necessary for stock assessment modeling: spawning season, batch fecundity and size at maturity. Along the 4 Iranian coastal provinces in south part ((from east to west) Sistan and Baluchestan, Hormozgan, Bushehr and Khozestan), spangled emperor is one of target fishing and catch by local traditional and artisanal fishers who used different fishing methods such as traps (locally named gargoor). The amount of catch for spangled emperor during 2007 for south part water of Iran was 1480 tones.

Materials and methods

Sample Collection

In total, 307 fish were collected monthly from September 2007 to August 2008 from the Persian Gulf and Oman Sea, south coast waters of Iran. Fish were collected regularly and directly from artisanal fishermen at three landing station of Hormozgan Province (Jask, Kong and Gheshm). The fish were captured by hook and line and traps. The study area is shown in Figure 1.

Fork length (FL) was taken to the nearest cm for all fish, total weight (TW) of individual fish to the nearest 0.01kg and was measured wherever possible. At the laboratory, the 307 individuals are sampled. Finally, the gonad weight, in grams, is recorded.

Oocyte development was classified into five stages (Ferreira, 1995). The spawning period was established from the analysis of three variables (West, 1990): (1) percentage frequency of the maturity stages; (2) Gonadosomatic index (GSI = (GNW/BW)*100) and (3) hepatosomatic index (HSI = (LW/GW) 100). Total length of all individuals was used to estimate the size at first maturity. These are defined as the sizes (TL) at which 50 and 95%, respectively, of all fish sampled are at the relevant maturity stage (III, IV or V). The proportions were estimated at length classes of 2cm, and the data fitted to a logistic curve (Pope *et al*., 1983):

$$p = \frac{1}{1 + e^{-(a+b*L)}}$$

Where p is the percentage of mature individuals as a function of size class (TL).

The relationship between length (FL) and weight (TW) for 307 individual was estimated using linear regression analysis. To linearalize the power curve ($W=aL^b$) that best described this relationship, both variables were transformed using lnx. The line of best fit for the linear relationship was described by Pauly (1983):

$\ln TW = \ln a + b \ln FL$

Histological Analysis

219 ovaries were removed from females collected monthly between September 2007 and August 2008. Ovaries were placed in Bouin's solution for 48hrs and transferred to 70% ethanol. After fixation, the gonad tissues were dehydrated and embedded in paraffin and sections (5 µm thick) were stained with Mayer's haemalum and Young's Eosin balances (Winsor, 1994). The proportion of female to male was determined and the result was tested by Chi-square method.

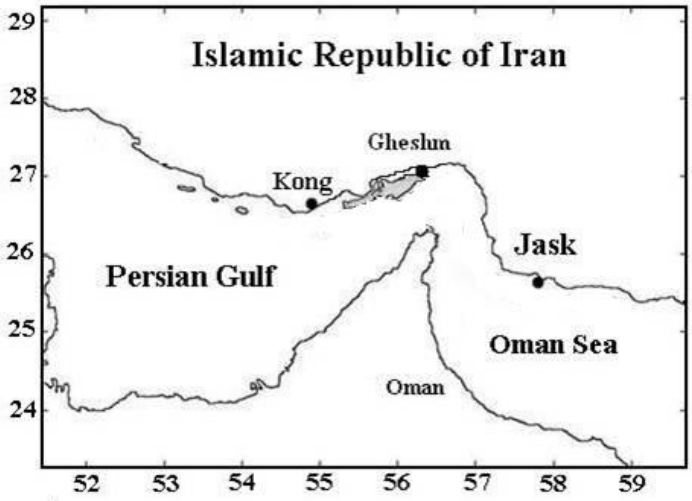

Figure 1. Location of three landing areas where *L. nebulosus* were sampled.

Results

Development of Sexual Cells

The staging of oocyte development is based on Histological criteria and is divided into five stages: (I) Primary growth of a single layer of follicle cells surrounding the oocyte; the oocyte cytoplasm is strongly basophilic during this period and the nucleus contains many easily distinguishable nucleoli next to the nuclear membrane (Figure 2a); (II) Developing virgin stage, in which nucleus increased in size in the average with a numerous number of nucleoli about 7 to 11; the nucleolei arranged in the periphery of the nucleus (Figure 2b); (III) Vitellogenesis, which begins with the appearance of oil droplets, yolk vesicles and cortical alveoli vesicles surrounding the nucleus (Figure 2c); (IV) Oocyte maturation stage, during which the oil droplets are concentrated around the nucleus; then they fuse into an oil drop that migrates towards the animal pole, together with the nucleus; the yolk vesicles progressively fuse to form a continuous mass of fluid yolk (Figure 2d); (V) Mature egg. The ooplasm, restricted to a narrow rim, lies beside the zona radiata at the oocyte periphery (Figure 2e).

Transitional phase: Gonads undergoing sex change, consisting of crypts of dispersed spermatids, were among degenerating vitellogenic oocytes. A total of 17 transitional gonads were examined, also present in all males was vestigial non-functional lumen and remnant oocytes (Figure 3).

Spawning Season and Maturity Sizes

Table 1 gives our results on the sex of the 307 specimens of *L. nebulosus* collected during the study period, grouped by month. The sex ratio of the

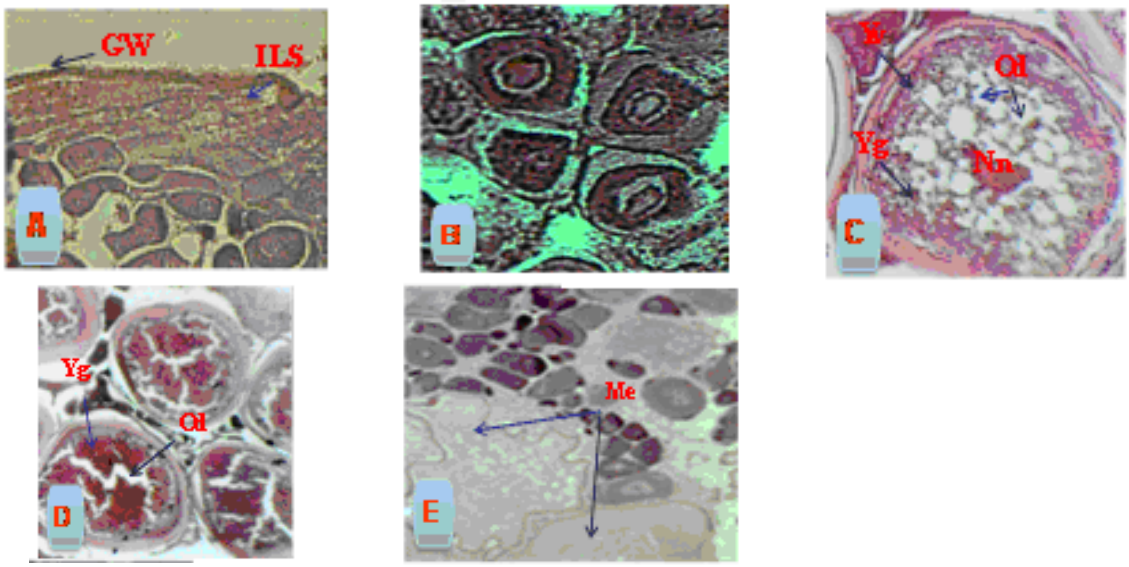

Figure 2. (A) section of ovary and cyst of oocytes in pre-follicle phase of primary growth or stage I; (B) oocytes in cortical alveoli formation stage or stage II; (C) oocyte in vitellogenic stage or stage III; (D) final mature-stage oocytes or stage IV showing the yolk vesicles and yolk globules and (E) observation of mature egg or stage V.
Nu, nucleus; Od, oil droplets; Yg, yolk vesicles; Yv, cortical alveoli vesicles and Me, mature eggs

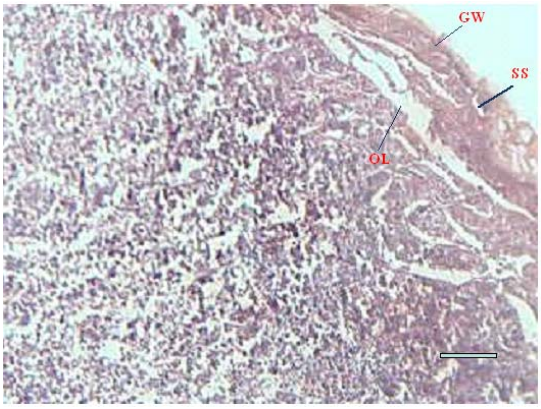

Figure 3. Remnant features of female gonad structure of *L. nebulosus*.
GW, gonad wall; OL, ovarian lumen; SS, sperm sinus.

Table 1. Sex ratio of *Lethrinus nebulosus* in monthly samples during the study peroid (Sep 2007–Aug 2008)

Month	Sample observed	N. unsexed	N. males	N. females	%of males	%of females	Sex ratio M:F
Apr-08	36	2	14	20	39	55.50	1:1.47
May	26	2	9	15	34.60	57.60	1:1.66
Jun	21	0	8	13	38.09	61.90	1:1.62
Jul	24	4	1	19	4.16	79.16	1:19
Aug	18	5	3	10	16.60	55.50	1:3.3
Sep	25	5	3	17	12	68	1:5.6
Oct	29	2	1	26	3.44	89.65	1:26
Nov	29	3	1	25	3.44	86.20	1:25
Dec	20	3	2	15	10	75	1:7.5
Jan-07	29	6	4	19	13.79	65.51	1:4.75
Feb	25	5	1	19	4	76	1:19
Mar	25	1	3	21	12	84	1:7
Total	307	39	49	219	16	71.17	1:4.46

collected samples was 4.46:1 females to males, respectively ($c2=1.9517$, $P<0.05$).

The percentage occurrence of different stages of maturity in females in each month throughout the study period was calculated and presented in Figure 4. The highest percentages of fish with maturing gonads (stage III) were found in samples caught in December, January, February, and March. Similarly, high proportions of fish with ripe gonads (stage IV) were obtained in April, May, June and March. The lowest number of fish with spent ovary (stage V) was observed in September. However, from October this number increased reaching a peak in July. The highest percentages of fish with developing or recovering gonads (stage II) were obtained in September, October, November, January and February. Immature fish (stage 1) were represented in the catches throughout the year except for February, April and July.

The calculated mean monthly gonad-index and hepatosomatic index for females are presented in Figure 5. The monthly calculated mean values of gonadosomatic index (GSI) of females were indicate to increase from February, reach the highest in March and decline in June. The HSI presented irregular value during the annual cycle.

The Figure 6 shows that 50% of females reach maturity at total body lengths of 31 cm.

Length – Weight Relationship

The linear regression analysis of the length-weight data allowed the estimation of the constants, a and b of the length–weight relationship represented by the equation

$W= 0.051\ FL^{2.722}$ with a regression coefficient $R^2= 0.91$ (Figure 7). Where W is the total weight in g and L is the Fork length in cm

Discussion

In the present study, we elucidated the spawning season and size at sexual maturity of female *L. nebulosus* on the basis of GSI and histological examination of ovaries.

Female were more than males in the landings during the period with the highest spawning activity during the spawning season. Although 17 individual fish with both ovarian and testicular tissues were observed in our histological studies, Loubens (1980) suggests that sex reversal from female to male happens soon after females attain sexual maturity that is according to present research. The identification of 17 transitional *L. nebulosus* individuals, as well as the presence of transitional within the size range at which 100% of the female population was mature, indicates that *L. nebulosus* is most likely a protogynous hermaphrodite. The simultaneous presence of developing sperm crypts and degenerating mature female tissue, peripheral sperm sinuses and a remanent ovarian lumen as described here suggest that sex change in *L. nebulosus* is consistent with patterns described for other protogynous hermaphroditic species of coral reef fishes (Sadovy, 1996). In contrast, the presence of other features such as strands of stromal tissue within the lamellae, increased number of blood vessels both along stromal strands and within degenerating female tissue during sex change, and the absence of female tissue in males differs considerably from features of many protogynous reef fishes (Hastings, 1981). Protogynous hermaphroditism has been reported among some lethrinid species. Wassef and Bawazeer (1992), working on *L. elongatus* in the Red Sea, found that females predominated the younger groups while males were preponderant amongst the older ages and suggested sex reversal from females to males. Similarly, Young and Martin (1982) working on eight lethrinid species from Australian waters found evidence of protogynous hermaphroditism in all the species under investigation and strongly suggested that protogynous hermaphroditism is the usual mode of sexuality in lethrinid fishes and also Ebisawa (1990) studying the reproduction of *L. nebulosus* in Okinawa waters (Japan) reported juvenile hermaphroditism although he did not rule out

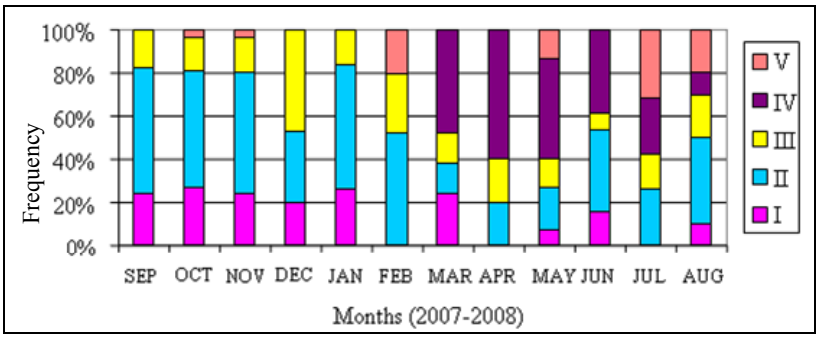

Figure 4. Monthly occurrence of the maturity stages of *Lethrinus nebulosus*, Roman numerals (I–V) represent maturity stages of gonads.

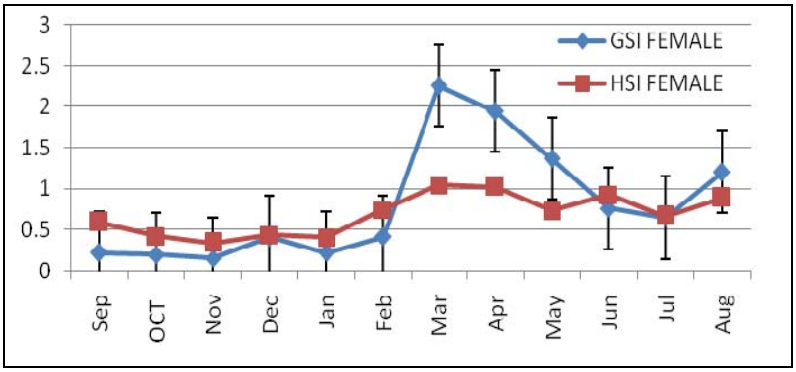

Figure 5. Seasonal variation of the gonadosomatic and hepatosomatic index for *L. nebulosus* males and females.

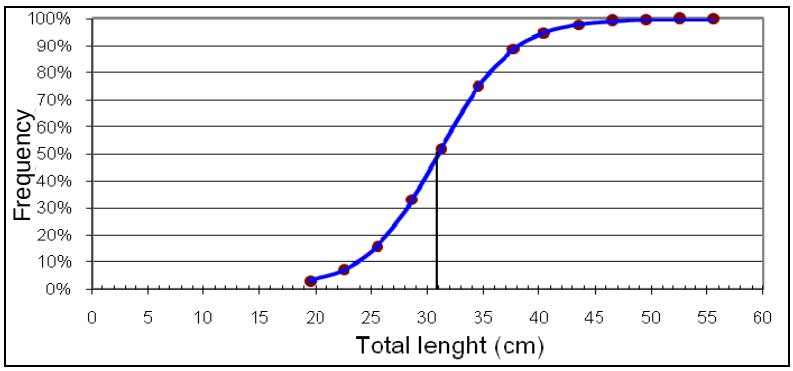

Figure 6. Changes in the proportion of mature *L. nebulosus* females with size.

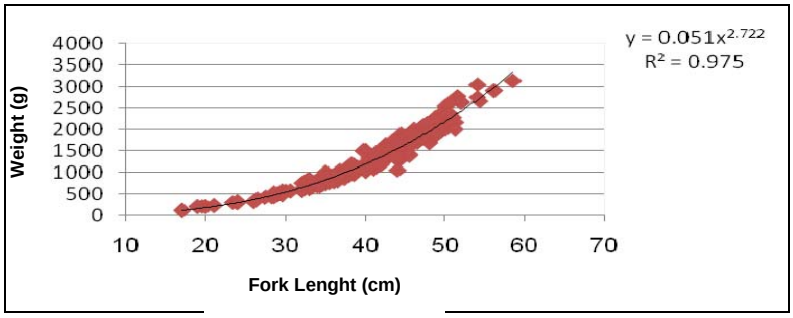

Figure 7. The length-weight relationship curve for *L. nebulosus*.

the possibility of protogyny. The development and regression of visceral fat stores preceding increases in ovary weight are a pattern that has been observed in other reef fishes. These patterns suggest that the stored lipid is fuelling the energetic costs of spawning (Ferreira, 1995). The overall sex ratio was 4.46:1 females to males. This means that females were preponderant in the population during the sampling period. The size of the males ranged from 30.7 cm to 51.3 cm and size of the females ranged from 24 cm to 60.5 cm.

Length at sexual maturity for females was estimated to be 31cm during spawning season. Table 2 shows the length of sexual maturity of *L. nebulosus* for the area 51 (Indian Ocean) reported in different works. Given the distance among the areas, these differences might be due to inherent genetic differences among the populations, effects of temperature, turbidity or other environmental factors could be driving the differences (Allsop and West, 2003).

There was well defined peak in March for reproductive cycle of spangled emperor (*L. nebulosus*) in the Southern Iranian waters (Persian Gulf and Sea of Oman). Comparing the results of the present study with those of the study by Grandcourt *et al*. (2006), in the Southern Persian Gulf (Abu Dhabi waters), it reveals that the spawning season for this species in Southern Persian Gulf (Abu Dhabi waters) occurred from April to May, but in the Iranian Waters (Hormozgan province waters) occurred from March and ended in June, which supports the view that seasonal reproductive cycles are nearly common among tropical fishes (Grandcourt *et al*., 2006).

The b parameter values in the weight-length model, $W= aL^b$ are 2.722 for the *L. nebulosus* in Area 51 (Table 3), indicating allometric negative growth (King, 1995).

The account of a in the present paper was maximum in relation to other research that nutritive conditions can be suitable in south coastal of Iran. The reasons for the variation of b in the different regions are said to be due to seasonal fluctuations in environmental parameters, physiological conditions of the fish at the time of collection, sex, gonadal development and nutritive conditions in the environment of fish (Biswas, 1993). Maximum fork length and weight were 58.5 cm and 3.150 kg respectively. Minimum fork length was 16 cm.

For protogynous species, in which males tend to be larger than females on average, there are indications that size-selective fishing mortality may result in the differential loss of larger males and the possibility that insufficient males remain in the reproductive population to fertilize eggs from all females. *L. nebulosus* may be particularly vulnerable to such effects because the female-biased sex ratios were consistent throughout all the age categories and size classes (Grandcourt *et al*., 2006). Therefore, there is an urgent need for deeper studies on the biology population of the Spangled emperor in order to develop an effective management plan.

References

Al-Sayes, A., Al-Sedfy, H. and Al-Mulla, A. 1988. Some biological characters of *Lethrinus nebulosus* (Forskal) in the Arabian Gulf. Bulletin of the National Institute of Oceanography and Fisheries (Egypt), 14: 227-237.

Allsop, D.J. and West, S.A. 2003. Constant relative age and size at sex change for sequentially hermaphroditic fish. Journal of Evolution Biology, 16: 9.

Baddar, M.K. 1987. A preliminary study of the population dynamics of a sheiry, the starry pigface bream, *Lethrinus nebulosus*. Kuwait Bull. Mar. Sci., 9: 215-220

Biswas, S.P. 1993. Manual of methods in fish biology, South Asian Publishers, New Delhi, 157 pp.

Carpenter, K.E. and Allen, G.R. 1989. FAO species catalogue Emperor Fishes and large-eye breams of the

Table 2. Summary of the Maturity Studies for *L.nebulosus* in FAO Area 51

Area	Type of Measurement	Sex of fish	Lm (cm)	References
South of Iran	TL	Female	31	Present paper
Southern Persian gulf	TL	Female	28.6	Grandcourt *et al.*, 2006
Mauritiu	TL	Female	29.5	Rathacharen *et al.*, 1995
Okinawa	TL	Female	40	Ebisawa, 1990
Ghatar	TL	Female	37	Al-Sayes *et al.*, 1988
Northwest Australia	TL	Female	25	Kuo and Lee, 1986
New Caledonia	TL	Female	28	Walker, 1975

Table 3. Length- weight relationship of *L. nebulosus* in FAO Area 5 (Type of Measurement was Fork Lenght)

Area	a	b	References
South of Iran	0.051	2.722	Present paper
Gulf of Aden	0.0161	2.9700	Sanders *et al*, 1984
Kuwait	0.0173	3.01	Baddar, 1987
southern Persian gulf		2.88	Grandcourt *et al*, 2006

world (Family Lethrinidae). An annotated and illustrated catalogue of lethrinid species known to date. FAO Fisheries Synopsis, 125(9).

Ebisawa, A. 1997. Some aspects of reproduction and sexuality in the spotcheek emperor,*Lethrinus rubrioperculatus*, in waters off the Ryukyu Islands. Ichthyological Research, 44: 201–212.

Ebisawa, A. 1990. Reproductive biology of *Lethrinus nebulosus* (Pisces: Lethrinidae) around the Okinawan waters. Nippon Suisan Gakkaishi, 56: 1941–1954.

Ferreira, B.P. 1995. Reproduction of the common coral trout *Plectropomus leopardus* (Serranidae: Epinephelinae) from the Central and Northern Great Barrier Reef, Australia. Bulletin of Marine Science, 56(2): 653-669.

Grandcourt, E.D., Thabit, Z. and Al Shamsi, F.F. 2006. Biology and assessment of the painted sweetlips (*Diagramma pictum* (Thunberg, 1792)) and the spangled emperor (*Lethrinus nebulosus* (Forsskål, 1775)) in the southern Arabian Gulf Fish. Bull., 104: 75–88.

Hastings, P.A. 1981. Gonad morphology and sex succession in the protogynous hermaphrodite *Hemanthias vivanus* (Jordan and Swain). Journal of Fish Biology, 18: 443-454.

King, M. 1995. Fisheries Biology, Assessment and Management. Fishing News Book, London, 342 pp.

Kuo, C.L. and Lee, S.S. 1986. Age and growth of common porgy, *Lethrinus nebulosus* (Forsskål) in shelf waters off northwest Australia. J. Fish. Soc. Taiwan, 3: 39-57.

Loubens, G. 1980. Biologie de quelques espèces de Poissons du lagon néo calédonien. II. Sexualité et reproduction. Cahiers de l'IndoPacifique, 2: 41-72.

Pope, J.A., Marggets, A.R., Hamley, J.M. and Akyuz, E.F. 1983. Manual of methods for fish stock assessment. Pt. 3. Selectivity of fishing gear. FAO Fishery Technical, Rome, 41 pp.

Rathacharen, S., Venkatasami, A. and Degambur, D. 1995. Growth parameters And rates of mortality *Epinephelus fasciatus, Lethrinus nebulosus, Siganus sutor, Naso unicornis* and *Mugil cephalus* from the coastal areas of Mauritius as estimated From analyses of length frequencies Albion Fisheries Research Centre, 12 pp.

Randall, J.E. 1995. Coastal Fishes of Oman. University of Hawaii Press, Honolulu, Hawaii, 439 p.

Sanders, M.J., Kedidi, S.M. and Hegazy, M.R. 1984. Stock assessment for the spangled emperor (*Lethrinus nebulosus*) caught by small scale fishermen along the Egyptian Red Sea coast. Project for the Develpoment of Fisheries in the areas of the Red Sea and Gulf of Aden, FAO/UNDP RAB/83/023/01. Cairo, 41 pp.

Sadovy, Y.J. 1996. Reproduction of reef fishery species. In: N.V.C. Polunin and C.M. Roberts (Eds.), Reef Fisheries. Chapman & Hall, London: 15–59.

Walker, M.H. 1975. Aspects of the biology of emperor fishes, family Lethrinidae north Queensland Barrier Reef waters. Ph.D. thesis, James Cook: University of Townsville, Australia.

Wassef, E. and Bawazeer, F. 1992. Reproduction of longnose emperor, *Lethrinus elongatus,* in the Red Sea. Asian Fish. Sci., 5: 219–229.

Winsor, L. 1994. Tissue processing. In: A.E. Woods and E.C. Ellis (Eds.), In Laboratory Histopathology: a Complete Reference, Edinburgh: Churchill Livingston, Section, 4(2): 1-44

West, G. 1990. Methods of assessing ovarian development in fishes: a review. Aust. J. Mar. Freshwater. Res., 41: 199−222.

Young, P.C. and Martin, R.B. 1982. Evidence for protogynous hermaphroditism in some lethrinid fishes. Journal of Fish Biology, 21: 475–484.