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Some Consideration on Overexploitation of Coral Reef Fish in Relation to Coral Reef Degradation in El-Tour, South Sinai, Egyptian Red Sea Coast

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ABSTRACT

This study was carried out to throw light on the expected negative effect of fish overexploitation on the Red Sea coral reef healthy. *Lethrinus nebulosus* is represented the most important coral reef fishes commercially and economically. Age, growth, mortality of *L. nebulosus* was estimated using the fish otoliths reading as well as the feeding behavior was analyzed. Estimated life span was ten years. Estimated growth parameters were, asymptotic length ($L\infty$) = 81.6 and growth co-efficient (K) = 0.161 year^{-1}. Total, natural and fishing mortality rates were Z = 0.722, M = 0.237 and F = 0.485, respectively. Exploitation ratio was estimated as E = 0.67. Analysis of stomach contents revealed that *L. nebulosus* is a heavily carnivore's fish, feed on Crustaceans, Fish, Echinoderms and Mollusks. Small fish ≤25.0 cm feed mainly on crustaceans. Crustaceans, fishes, Cephalopods and mollusks are recorded in lengths ≥35.0 cm while the lengths ≥55.0 cm, Echinoderms dominate as the fish gets larger. Results raveled that large individuals of *L. nebulosus* feeding mainly on Echinoderms are exposed to a heavily overexploitation. The decline of large individuals lead to the over spreading of acanthasters which has a feeding ability to attack coral polyps affecting coral reefs healthy. Results expected that the depletion of functionally important consumer's by over-exploitation can indirectly influence coral reef ecosystem.

Key words: *Lethrinus nebulosus,* age and growth, feeding behavior, coral reef degradation

INTRODUCTION

The Egyptian Red Sea coast including Suez and Aqaba Gulfs extends approximately 1800 km and is bordering by reefs. Red Sea is characterized by the most beautiful coral reef and the unique diversity of fishes and invertebrates. Coral reefs fisheries or the artisanal fishery in the Red Sea is of an important socio-economic industry. Coral reef structures are threatened naturally by outbreaks of the Acanthaster planci, sea urchin and coral diseases, as well as human activity pollution and overexploitation (Williams *et al*., 2007; Munday *et al*., 2008; Pratchett *et al*., 2008). Family Lethrinidae constituting *Lethrinus nebulosus* are plentiful in tropical and subtropical Indo-West Pacific from the Red Sea (Young and Martin, 1982). 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 (Carpenter and Allen, 1989).

Age, growth, mortality and population structure on *L. nebulosus* was studied by many authors in some regions (Kulmiye *et al*., 2002; Grandcourt *et al*., 2006; Currey *et al*., 2009; Marriott *et al*.,

2010; Motlagh *et al*., 2010a; Munro, 2007). Detailed diet information is useful to tropho-dynamic models (Pauly *et al*., 2002), to estimate trophic levels (Stergiou and Karpouzi, 2002; Froese and Pauly, 2007) and enter in the composition of ecosystem indicators (Bozec *et al*., 2005; Gascuel *et al*., 2005). The feeding habits of *L. nebulosus* and its relation with the coral reef degradation are poorly documented. Spangled emperors especially the large individuals are one of the main predators of the acanthester and the sea urchin live in the coral reef areas (Fisher and Bianchi, 1984; Carpenter and Allen, 1989; Kulbicki *et al*., 2005).

Decreasing in the *Lethrinus* catch along the Egyptian Red Sea coast was namely as a result of improper fisheries management and illegal fishing practices. The objectives of this study are to provide better scientific information on the status of the most commercial coral reef fish resources and the impacts of fishing on coral reef habitats.

MATERIALS AND METHODS

Study area: El-Tour city is located at the Sinai Peninsula, South Sinai coast, Red Sea (Fig. 1). The investigated area covers various biota (coral reefs, sandy areas, soft-bottoms, estuaries and mangroves). Fishing is mainly conducted by local commercial fisheries, artisanal fisheries or the coral reef fisheries (hand lines, long lines and gill nets). The most commercially species of the coral reef fisheries are: emperors (*Lethrinus* sp.); groupers (*Epinephelus* sp.) and parrot fish (*Scarus* sp.) snappers, sweet lips, surgeon fish and rabbit fish.

A total of 314 individuals of *Lethrinus nebulosus* were collected seasonally from the commercial catches taken from the landing site along El-Tour city during June 2005 to May 2007. Samples

Fig. 1: Map of the fishery area

were ranged in length between 15.0±0.27 and 66.7±1.95 cm. Total weight ranged between 55.3±5.36 and 3750±125.9 g. There was no significant statistical difference between males and females of *L. nebulosus* using t-test, so the analyzed data were pooled.

Each fish was measured to the nearest 0.1 mm for total length and weighed to the nearest 0.1 g for body weight. Fishes were dissected and sagittal otoliths were removed, cleaned and stored dry for later age determination. Age determination was done by otolith reading. Growth parameters were investigated by fitting the Von-Bertalanffy (1938) growth constants to size at age data which is defined as follows: $l_t = L\infty(1-e^{-k(t-t_0)})$, where, l_t is length at time t, L_∞ is the asymptotic length, k is the growth coefficient and t_0 is the hypothetical time at which length would be equal to zero. Length-weight relationship was determined by using the commonly equation:

$$W = a L^b$$

where, W is defined as the total weight in grams, L is the total length of the fish in cm and the parameters a and b are constants.

The maximum age (t_{max}) was determined according to Beverton and Holt (1966):

$$t_{max} = 3/k + t_0$$

The annual instantaneous rate of total mortality (Z) was estimated using the length converted catch curve method (Sparre and Venema, 1992). Length frequency samples were converted into a relative age frequency distribution using the parameters of the von Bertalanffy growth function. Annual natural mortality (M) was estimated using Rikhter and Efanov (1976) formula:

$$M = \{(1.52/t_{mass})^{0.72}\}-0.16$$

where, t_{mass} is the mean age at massive maturity. The exploitation ratio (E) was calculated according to Pauly (1983):

$$E = F/Z$$

Stomachs with food contents were removed and preserved in 4% formalin solution. Stomach contents were extracted, sorted, separated by item and groups. The food items were grouped into taxonomic categories (Family or Order) or in large groups. Percentages occurrence and percentage composition (Hyslop, 1980) were calculated:

- Percentage occurrence:

$$O(\%) = \frac{\text{No. of stomachs with prey item I}}{\text{No. of full stomachs}} \times 100$$

- Percentage composition:

$$C(\%) = \frac{\text{No. of prey item I in all stomachs}}{\text{Total No. of food items in all stomachs}} \times 100$$

Statistical analysis: SD (±) was calculated using Microsoft office excel 2007 while the significance difference and chi-test between males and females was calculated by t-test incorporated in Microsoft office excel 2007.

RESULTS

Catch description: *Lethrinus nebulosus* comes in the second category after groupers in the artisanal fishery of the Red Sea. Figure 2 shows the annual catch of *L. nebulosus* landed in El-Tour fishing ports during the fishing seasons from 2000-2010. It is evident that there was a trend of decreasing from season to another, where the catch was 280 tons during 2000 and became 40 tons during 2010. It was clear that, the *L. nebulosus* catch decreased gradually during the last ten years and the decreasing reach its maximum value 70% in 2010. Figure 3 compare the length frequency distribution of *L. nebulosus* coughed during the fishing seasons 2000, 2005 and 2010, respectively.

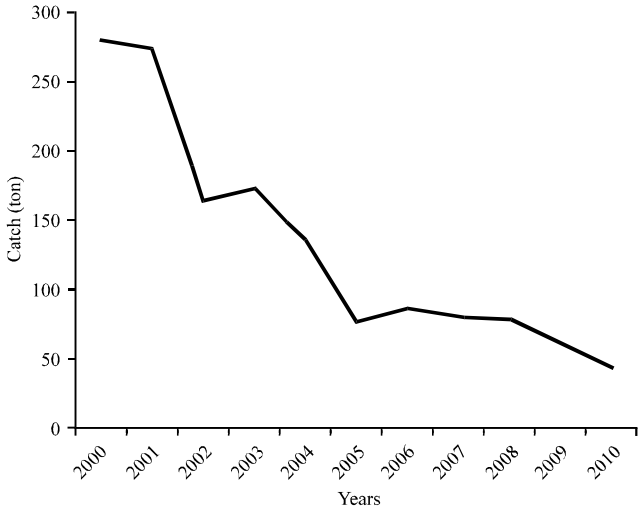

Fig. 2: *L. nebulosus* catch in ton during the fishing seasons from 2000-2010

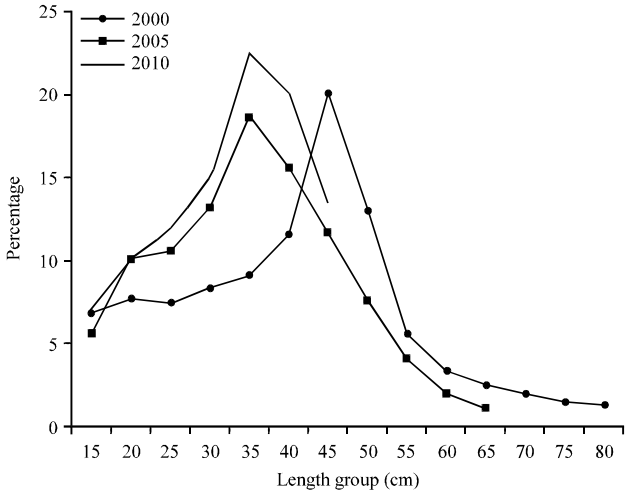

Fig. 3: Length frequency distribution of *L. nebulosus* from El-Tour, South Sinai, red sea, Egypt during the fishing seasons 2000, 20005 and 2010

It is clear that the lengths were shifted from fishing season to anther and the large individuals were removed from the coral reef catch while the small individuals are increased through the recent years.

Length/weight relationship: As the regression equations relating total length and total weight for female and male *L. nebulosus* did not differ significantly ($p>0.05 = 0.108$) so, the length-weight data for the two sexes were pooled. Figure 4, showed the length weight relationship and the resulting equation was $W = 0.018L^{2.925}$ with $r^2 = 0.988$. It was clear that the growth in weight relative to length was almost isometric, approximately $b \approx 3$, the value of b was not significantly different from 3 (t-test; $p = 0.51$).

Age and growth: Ten age groups were determined by the otolith reading, with mean lengths of 17.23, 27.42, 35.49, 41.25, 47.17, 52.7, 56.49, 59.77, 64.6 and 66.7 cm, respectively. The values of the parameters that describe the length growth of *L. nebulosus* were: $L\infty = 81.65$ cm and $k = 0.161$ year and $t_0 = -0.472$ year^{-1}. Therefore, the Von Bertalanffy growth equation can be described as follow:

$$Lt = 81.65[1-e^{(-0.161(t-0.472))}]$$

L. nebulosus considered to be long lived fish that reach to $t_{max} = 18.2$ years.

Mortality rates and exploitation ratio: The length converted catch curve (Fig. 5) gave a value of annual total mortality $Z = 0.722$ year^{-1} (95% of confidence interval CI = 0.03-1.44, SD of the slope = 0.164 and r =0.954), with relative age of 4.0-7.0 years. The annual natural mortality $M = 0.237$ year^{-1} and the annual fishing mortality rate $F = 0.485$ year^{-1}. The fishing mortality rate was considerably greater than the natural mortality rate over 50%. The exploitation ratio E was 0.67. Regarding the high value of the fishing mortality and by applying $E_{opt} = 0.5$ criterion (Pauly and Munro, 1984) implies that *L. nebulosus* is overexploited.

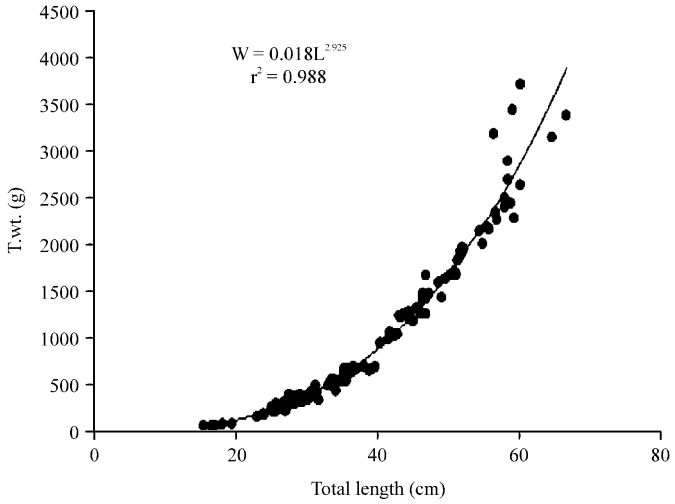

Fig. 4: Length weigh relationship of *L. nebulosus* from El-Tour, South Sinai, red sea, Egypt

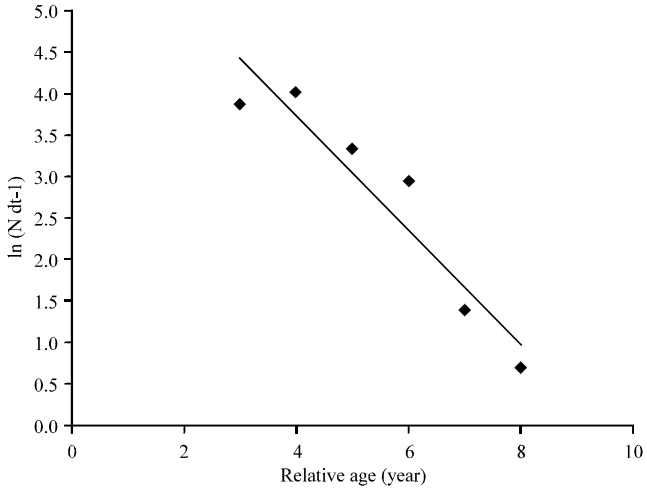

Fig. 5: Length converted catch curve of *L. nebulosus* from El-Tour, South Sinai, red sea, Egypt

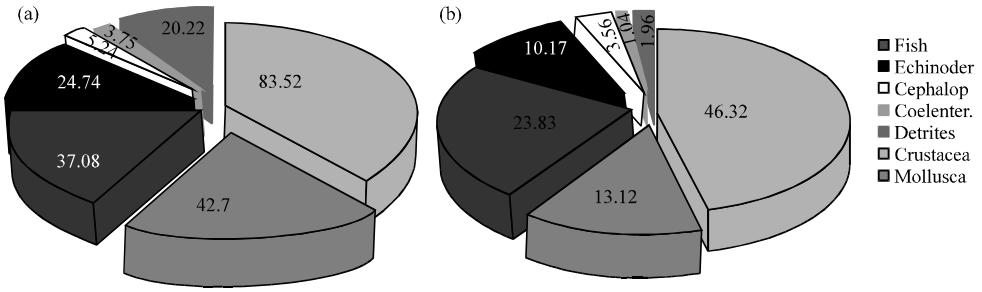

Fig. 6(a-b): (a) Percentage occurrence and (b) Percentage composition of different food items of *L. nebulosus* from El-Tour, South Sinai, Red Sea

Food and feeding habits: In general, emperors are carnivorous species; consume a wide range of prey including mollusks (gastropods, bivalves), Echinoderms (sea urchins, sand dollars and starfish), crustaceans (crabs, shrimps) and fishes. During the study period 135 *L. nebulosus* stomachs containing food items were sampled, with total length ranged between 15.0 and 65.0 cm.

Diet composition: The diet of *L. nebulosus* is consisted of a wide variety of items for males and females which have the same food items, as there is no significant difference between them ($p = 0.194>0.05$). Crustaceans, mollusks and fishes were dominated the diet of Lethrinus. Figure 6a and b represented the % occurrence and % composition of the study fish. Crustaceans were clearly the most consumed item scoring the highest values of percentage occurrence (83.52) and percentage composition (46.32). Mollusks were second, being mostly composed by broken shells of bivalves and gastropods. Fishes especially *Sardinella gibbosa, Trachurus indicus* and Juveniles of family Lethrinidae were the third most important prey group. Echinoderms were frequently consumed (24.74% O and 10.17% C) represented the fourth most important prey group, particularly sea urchins, sea stars and sea cucumbers. Cephalopods and coelenterates were also eaten by the *L. nebulosus* but at lower levels.

Relation between food items and fish sizes: In order to study the relation between the fish size and the different food items of *L. nebulosus,* the fish samples which stomachs have been examined, were grouped into 6 length groups (10 cm intervals). Figure 7a-f showed each length group with its percentage of food item composition. The length groups from 15.0-34.9 cm characterized by the abundance of crustaceans by high percentage over 80%. Mollusks, fishes and cephalopods are the major food items recorded in length groups from 35.0-54.9 cm. Echinoderms were appear for the

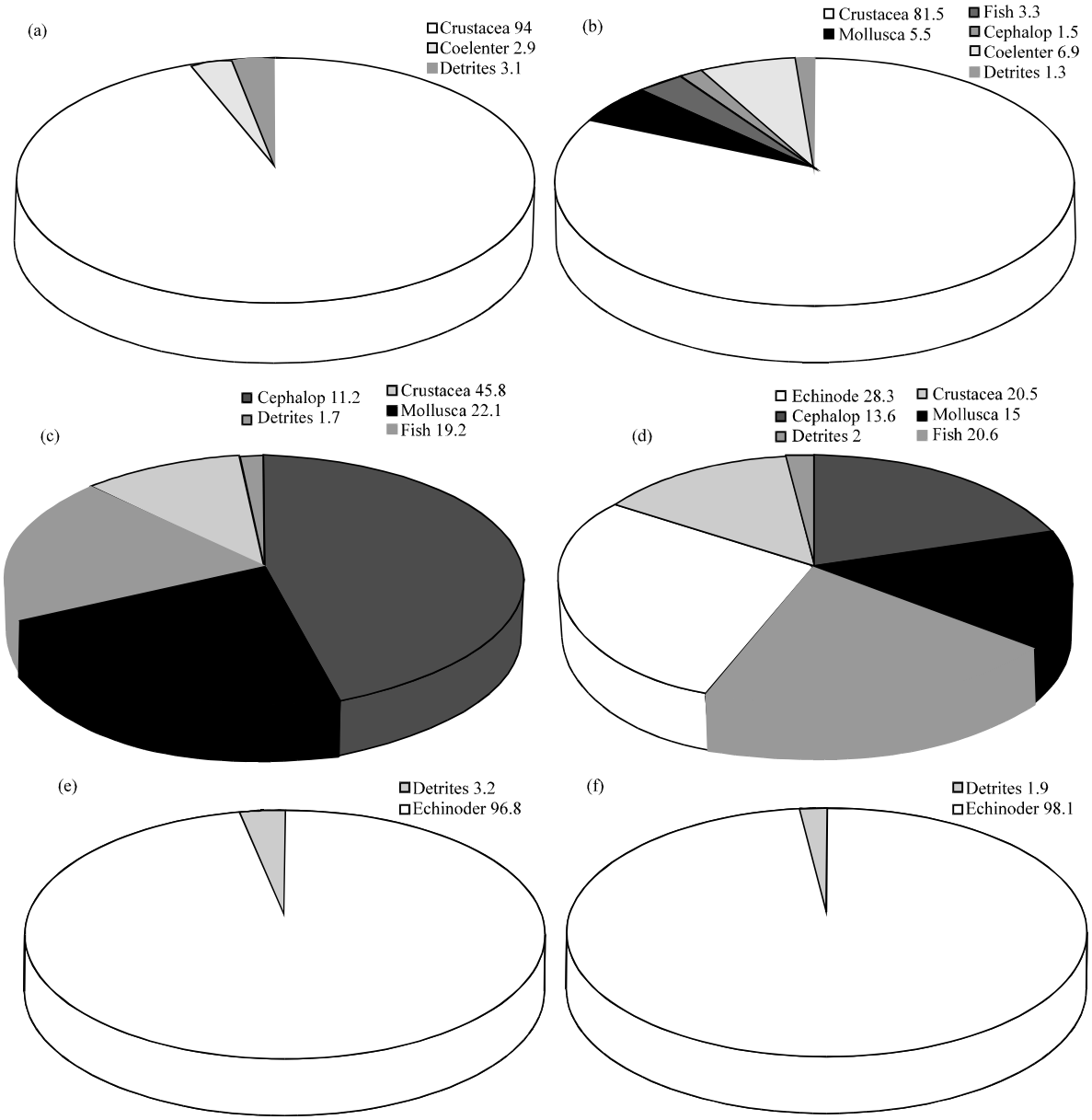

Fig. 7(a-f): Percentage composition of different food items in relation to, Length groups (a-f) *L. nebulosus* from El-Tour, South Sinai, Red Sea (a) 15.0-24.9 cm, (b) 25.0-34.9 cm, (c) 35.0-44.9 cm, (d) 45.0-54.9 cm, (e) 55.0-64.9 cm and (f) 65.0-74.9 cm data collected from (Sabrah, 1998)

first time by a relatively high ratio (28.3%) in fishes of length group 45.0-54.9 cm and were recorded in a high percentage by over 95% in fish group's ≥55.0 cm. It is clear also that the Echinoderms absent from the small length group's ≤45.0 cm. Statically there was no significant difference, between food items among the fish sizes, where the t-test analysis $p>0.05 = 0.640$ and $\alpha = 0.05$.

DISCUSSION

Coral reefs are among the most diverse and valuable ecosystems on earth. Coral reefs provide economic and environmental services as shoreline protection, areas of natural beauty, pharmaceuticals, recreation and tourism. Coral reef fisheries are represented the sources of food, jobs and revenues. Variability in the abundance of targeted resources can be attributed to many factors, including density-dependence, the environment and overfishing. Coral reef fisheries are notably influenced by overfishing stress during the recent 10 years through the impact on the large individual and recruitment. *Lethrinus nebulosus* is one of most commercially important coral reef fish species of the Red Sea; it has recently been subjected to important decrease.

In this study, *L. nebulosus* catch was gradually decreased by 70% throughout ten years (2000-2010) from 280-40 tons (GAFRD, 2010) and the length frequency distribution revealed that large individuals were removed from reefs, results in an increase of the small individuals. Large individuals of *L. nebulosus* are among the most heavily exploited reef fishes, as the longevity and the slow growth along their behavior of forming aggregation targeted by fishermen render them vulnerable to overfishing. Overfishing results in shifts in fish size and species composition within reef communities which may precipitate large-scale ecosystem changes. Interestingly, these findings are in accord with the finding by Colin (1992). On the other hand these may be attributed to the relationships between the catch production and environmental changes which have been described for several species and fisheries around the world, this means that these organisms can respond quickly to environmental or ecosystem change (Pecl and Jackson, 2008; Rodhouse, 2005).

Spangled emperors *L. nebulosus* is a slow-growing and long-lived species, with longevity up to 18 years. The growth parameters of *L. nebulosus* were estimated as: $L\infty = 81.65$ cm, $K = 0.161$ year^{-1} and $t_0 = -0.472$ year^{-1}. Total, natural and fishing mortality rates were estimated as $Z = 0.722$, $M = 0.237$ and $F = 0.485$ years^{-1}, respectively and the exploitation rate $E = 0.67$. The results revealed that, fishing mortality F > natural mortality M by about 51.1% indicating that there is currently risk to the sustainability of that stock. In addition the exploitation ratio E>optimum level 0.5 by 34%, indicating that this stock is exposed to heavily over-exploitation. Table 1 showed, several authors, who studied the age, growth and mortality rates of *L. nebulosus* in different regions around the world and the results confirming our conclusions. There were some variation in the authors results that is may be due to seasonal fluctuations in environmental parameters, physiological conditions of the fish at the time of collection and gonadal development.

Studies of feeding habits and diet are fundamental to understand many aspects of the biology, ecology and behavior of fish, particularly those involving the upper trophic level species are especially important due to their recent global declines and the potential for associated ecosystem-level effects on species composition and diversity (Pauly *et al*., 1998). Spangled emperor is a carnivore species, mainly feed on Crustaceans, Mollusks, fishes and Echinoderms. Walker (1978) and Fisher and Bianchi (1984) reported that the diet of *L. nebulosus* is mainly composed of mollusks, crustaceans, polychaetes, worms and Echinoderms. Large individuals of *L. nebulosus* are mainly feeding on Echinoderms. Hanson and Chouinard (2002) and Nakamura *et al*. (2003)

Table 1: Growth parameters and mortality rates of *L. nebulosus* recorded by several authors in different regions around the world

		Parameters						
Regions	Sources	L_∞	K	t_0	Z	M	F	E
Gulf of Suez, Egypt	Sabrah (1998)	89.50	0.131	-0.540	0.510	0.098	0.412	0.80
Gulf of Aden	Al-Sakap and Esseen (1999)	87.00	0.090	-0.540				
Coastal area of Mauritins	Rathacharen *et al.* (1999)	78.50	0.227	-0.010	0.668	0.510	0.158	0.24
Emirate Abu Dhabi	Grandcourt *et al.* (2003)	61.80	0.140	-2.340				
South Persian Gulf	Grandcourt *et al.* (2006)	66.20	0.110	-3.000	0.560	0.200	0.360	0.64
Okinawa	Ebisawa and Ozawa (2009)	57.90	0.305	-0.011				
Australia	Marriott *et al.* (2010)	61.60	0.179	-1.602	0.394	0.146	0.181	0.46
Persian Gulf and	Motlagh *et al.* (2010b)	67.20	0.160	-1.161	1.130	0.570	0.560	0.50
Oman Sea	Present study	81.65	0.161	-0.472	0.722	0.237	0.485	0.67
El-Tour, Red sea								

L_∞: Asymptotic length; K: Growth rate coefficient, t_0: Hypothetical time at which length would be equal to zero, Z: Total mortality, M: Natural mortality; F: Fishing mortality and E: Exploitation ratio

indicated that there may be important changes of diet with size, many species switching from smaller, easier to access prey, to larger prey or to prey more difficult to catch or extract but of higher nutritive value. This indicates that fish choose their food items and do not necessarily feed on the most abundant items even if the latter are suitable. This is confirmed by Egretaud (1992) and Beukers-Stewart and Jones (2004) and they concluded that the smaller *Lethrinus nebulosus* were found in the shallowest parts of the Ouvea lagoon where they fed on relatively small sand dwelling prey, whereas the larger specimen were found in the deeper parts, fed on larger mobile prey. More interestingly, the feeding schedule of these fish suggested that adult fish would travel great distances to feed whereas the smaller fish tended to stay within the same area. In other words, larger fish can cover wider feeding grounds and choose amongst a wider category of prey, the smaller fish being limited by factors such as their swimming abilities or predation by larger fish. Letourneur *et al.* (2000) and Kulbicki *et al.* (2005) reported that reef urchins and sea stars were not a preferred food and they were prey items only for the largest Lethrinidae. Large individuals of spangled emperor are one of the main predators and heavily feeding on Echinoderms specially acanthester species (*Acanthaster planci*) and sea urchins. The fast removal of top predators *L. nebulosus* as a result of the overexploitation, participated in the spreading of *Acanthaster planci* and sea urchins causes direct physical and biological damaged to corals. *Acanthaster planci* and sea urchins are the major coral predator widely distributed in the Indo-Pacific region, where population outbreaks have caused dramatic impacts on coral reefs.

Corals predation and storm damage by A. planci were recorded in Red Sea, Egypt by Ormond and Banaimoon (1994), Abou Zaid and Kotb (2000) and Ammar (2005), in Farasan Islands Saudi Arab and the Gulf of Oman (Glynn, 1993; PERSGA/GEF, 2003), on the Great Barrier Reef , Fiji, Indonesia, Japan, Costa Rica, USA and Australia by Cameron *et al.* (1991), Lourey *et al.* (2000), Quinn and Kojis (2003), DeVantier *et al.* (2006) and Narvaez and Zapata (2010). Fenchel and Uiblein (2011) and Omori (2011) reported that predation on corals by crown of-thorns sea stars is, for unknown reasons, a major problem around Okinawa and attempts to eradicate the sea star populations have so far been ineffective. Pratchett (2005) concluded that significant declines in the abundance of coral reef fishes and even localized extinctions, following extensive depletion of hard coral, especially among fish species that rely on coral for food or shelter. On the other hand El-Ganainy *et al.* (2008) studied the effect of fish collecting and removing from

the Red Sea corals and they reported that the hard corals cover 59.9% in the protected area while in open areas decreased to 34.6%. Whereas, the dead corals cover 4.91 and 21.0% in the protected and open areas, respectively. Previous studies are in accord with our study and in conclusion overexploitation of some coral fishes is considered to be one of many problems that causing degradation of coral reefs.

CONCLUSION

The spangled emperors *L. nebulosus* is a large carnivore's, slow-growing and long-lived species, with longevity up to 18 years. It is among the most heavily exploited reef fishes specially the large individual, as their behaviors in forming aggregation targeted by fishers render them vulnerable to overfishing. It has recently showed a decreasing in the total catch and the Lethrinus catch as a result of the improper fisheries management and illegal fishing practices. Large individuals of *L. nebulosus* are the main predators and heavily feeding on Echinoderms specially acanthasters as (*A. planci*) and sea urchins. The sea stars and sea urchins predators are declined, these leads to the over spreading of acanthasters species which has a feeding behavior ability to attack coral polyps affecting the coral reefs healthy.

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