Journal of Animal and Veterinary Advances 8 (12): 2530-2536, 2009
ISSN: 1680-5593

Fisheries and Shrimp Economy, Some Biological Properties of the Shrimp *Metapenaeus monoceros* (Fabricus, 1798) in the Gulf of Antalya (Turkey)

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Abstract: In this study, economy of the fisheries were examined using secondary production and trade data. Additionally, the sex, length and weight distribution, length-weight relationship, length at first sexual maturity and spawning season of *Metapenaeus monoceros*, which is usually caught from the Antalya Gulf and one of the most important shrimps and which has an economical value shrimps were also investigated. Three hundred and twenty three individuals were obtained by monthly sampling between August 2002 and July 2003 and then they were examined. Females and males made up 72 and 28%, respectively. The total length values were from 7.5-16.5 cm and weight were from 5-39 g. Spawning period occurred between December and January, length at first maturity was 11.5 and 7.5 cm for females and males, respectively. The weight and total length relationship for combined sexes were estimated as: Log W = -2.05 + 2.97 × Log Tl (r = 0.915).

Key words: *Metapenaeus monoceros*, growth, reproduction, fisheries, economy, Gulf of Antalya, Turkey

INTRODUCTION

Shrimp make up an important portion of crustaceans, which have an important commercial value in aquaculture fishery. They have a wide spread zone from Equator to the Poles. Annual World production is 1.5 million tons, of which 2,000 tons is from Turkish fisheries. In Turkey, 5.2% of this production is from the Aegean Sea, 16.4% is from the Mediterranean, 78.2% is from the Marmara Sea and 0.2% is from the West Black Sea (Anonymous, 2007). Although, shrimp aquaculture is carried out intensively throughout the world, it is not yet widespread in Turkey. This is one reason, why shrimp remains an expensive food in Turkey.

Shrimp fishing in the Antalya Gulf is performed with trawls, traps and gillnets. Even though, >60 species of shrimp have been identified in Turkey, there are only 7 species that are commercially important. These are *Penaeus japonicus*, *P. semisulcatus*, *P. kerathurus*, *Parapenaeus longirostris*, *Trachypenaeus curvirostris*, *Metapenaeus monoceros* and *M. stebbingi* (Kocatas *et al*., 1991). When, the economically important invertebrates from consideration are removed. The Aegean and Mediterranean seas are the richest in terms of species diversity. On the other hand, even though other species are certainly extant in Turkey's seas, *M. monoceros* is found mostly in the Mediterranean region. Shrimp aquaculture has an increasing importance in the fishing industry of Turkey, especially in the Aegean and Marmara regions.

Although, the biology and fisheries of these penaeid shrimps have been studied in other Mediterranean countries (Carbonell *et al*., 1999; Ragonese *et al*., 2002; Cagiltay, 1999; Turkmen, 2005). Studies carried out in the country are mainly focused on trawl net selectivity and studies on shrimp population structure are very limited (Can and Sereflisan, 2000; Kumlu *et al*., 1999; Metin *et al*., 2008).

In this study, it is aimed to analyze the biological and economic characteristics of the pinto shrimp, taking an important place among the shrimp types encountered in Turkey. Besides, the production amount, assessment modes as well as growth and reproduction properties of *M. monoceros* will be examined.

MATERIALS AND METHODS

In this study, economy of the fisheries were examined using secondary production and trade data. And data were presented in the tables. *M. monoceros* samples were caught monthly between August 2002 to July 2003.

Samples were caught using gillnets and bottom trawl nets (Fig. 1).

The samples were weighed to the nearest ±1 g and carapax and abdomen length were measured on a measuring plate with an accuracy of ±1 mm. The gonads were weighed using a scale with an accuracy of 0.01 g. Sex identification of the samples was carried out by observing the telcum and petesma and the sex ratio was calculated

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for the samples. Length and weight frequency distribution and length/weight relationship of the samples were calculated.

Sex and length at first sexual maturity of *M. monoceros* were established by the examination of their gonads. The Gonadosomatic Index (GSI) was calculated using the Eq:

$$GSI = (GW/BW) \times 100$$

Where,
GW = The gonad weight
BW = The total body weight (King, 1995)

The relation between length (mm) and weight (g) were determined by Log W = a + b × log TL allometric growth equation (Avsar, 1998; Ricker, 1975).

The statistical significance of data obtained was checked by χ^2. In common with most biological research, a confidence level of (p = 0.05) was used (Elbek *et al*., 2002).

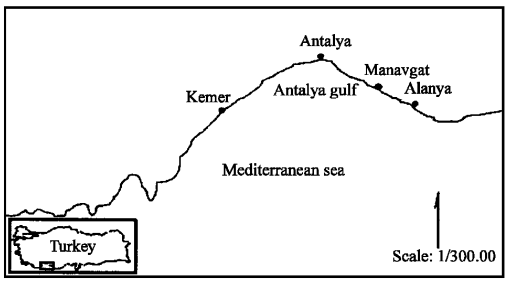

Fig. 1: Gulf of Antalya

RESULTS

Fisheries and economy of shrimp: While, Turkey had a 0.04% share of the world's fishery production in the year 2005, the world's fishery production was realized as 141 million tones. Based on the recent data, 65.9% of the world's fishery productions are provided by fishing and 34.1% by aquaculture (FAO, 2007). For the same year, total fishery production in Turkey was approximately, 545,000 tons (Table 1) and its about 426,000 tons (78.3%) from is fishing and 118,000 tons (21.7%) from is aquaculture.

In the year 2006, a total of 662,000 tons of fishery products were produced in Turkey, 533,000 tons of which were from fishing and 129,000 tons were from cultivation. Fishery production of Turkey showed 21,5% increase in 2006 compared to previous year. For the relevant period fishing and aquaculture production in showed 25, 1 and 9% increases, respectively. Approximately, 61.9% of Turkish fishery products consist of sea fish and 11.9% from other marine products. While, the other marine products increased at a rate of 71.7% and reached to 79,000 tons, it has been observed that the largest increases were in marine products such as the white sand mussel, whelk, dark haired mussel and shrimp.

Shrimp composes the most economically important class of decapots, which are in the crustacean class. As a matter of fact, by the year 2006, the amount of shrimp produced in the world was 6 624,000 tons with a value of 24 250 million $. While, 52.2% of world shrimp production is from fishing and 47.8% is produced by aquaculture, it has been observed that farm-raised shrimp brings more income (6%) than fishing (Table 2).

Table 1: Production of fishery products in Turkey (1000 tons)

							2006	
Items	2000	2001	2002	2003	2004	2005	Quantity	%
Fishing of marine fish	441.7	465.2	493.4	416.1	456.8	334.2	409.9	67.1
Other marine fish (crustacean. mollusk)	18.8	19.2	29.3	46.9	48.1	46.1	79.0	9.2
Aquaculture production	79.0	67.2	61.2	79.9	94.0	118.3	128.9	18.1
Freshwater fish aquaculture	43.4	37.5	34.3	40.2	44.1	48.6	56.7	42.2
Marine fish aquaculture	35.6	29.7	26.9	39.7	49.9	69.7	72.2	57.8
Fishing in freshwater fish production	42.8	43.3	43.9	44.7	45.6	46.1	44.1	5.6
Total	582.4	595.0	627.8	587.7	644.5	544.8	662.0	100.0

Anonymous (2007)

Table 2: World shrimp production (Fishing + Aquaculture)

	Fishing			Aquaculture		
Years	Quantity (1000 tons)	Value ($/ton)	Total value (million $)	Quantity (1000 tons)	Value ($/tons)	Total value (million $)
2000	3087	3620	11175	1162	6292	7310
2001	2955	3520	10401	1347	5563	7492
2002	2966	3300	9788	1496	5266	7879
2003	3543	3280	11621	2129	3924	8355
2004	3527	3220	11357	2446	3898	9536
2005	3420	3350	11458	2716	3866	10501
2006	3460	3400	11764	3164	3946	12486
Ratio (%)	52.2	-	48.5	47.8	-	51.5

FAO (2007)

Table 3: Amount of shrimp production as regions in Turkey (ton) (Fishing + Aquaculture)

Years	Black sea	Marmara	Aegean	Mediterranean	Total
1996	-	648	100	352	1,100
1997	53	642	229	456	1,380
1998	33	675	325	367	1,400
1999	5	342	284	259	890
2000	2	1,655	210	133	2,000
2001	63	2,357	366	214	3,000
2002	12	2,706	732	550	4,000
2003	18	4,059	1,098	825	6,000
2004	16	3,571	966	726	5,279
2005	-	3,542	1,837	960	6,339
2006	20	2,370	989	477	3,856

Anonymous (2008)

Table 4: Turkey's external trade for shrimp (kg, TL, $) and its share in external trade (%)

	Quantity		Value		
Exported species	Tons	%	1000 $	1000 TL	%
Other shrimps (frozen)	746	1.78	7950	11535	3.46
Shrimps from penaeus family (frozen)	129	0.31	1435	2050	0.61
Shrimps from crangon family (fresh/frozen, cooked in water steam)	6	0.02	14	21	0.01
Total fisheries export	41973	100.00	233385	336723	100.00
Imported species					
Shrimps from penaeus family (frozen)	160	0.29	406	611	0.51
Other shrimps from crangon family (not frozen)	25	0.05	147	215	0.18
Shrimps from crangon family (other not frozen)	2	0.01	9	13	0.01
Other shrimps (frozen)	432	0.80	813	1,193	0.99
Total fisheries import	53563	100.00	83410	120593	100.00

Anonymous (2007)

Shrimp production in Turkey has, until recently, been dominated completely by fishing and only recently shrimp aquaculture been introduced. Between the years 1996-1998, the total production was realized as 1,100-1,400 tons and reached to 6,339 tons in the year 2005. Even though, a serious decrease was recorded, especially in the year 1998, it is mainly resulted from the drawbacks experienced with the EU in that period (Table 3).

As can be seen from Table 3, a rapid decrease in shrimp production the year in 2006 is realized. The main reason of this situation is due to extending permitted shrimp fishing period, the majority of the species are in their reproduction period and with are carrying eggs (Turkmen, 2006).

The circular order that covers 2 years periods (generally) and manages the commercial fishery production in the seas of Turkey and fresh waters published every year by the General Directorate of Protection and Control in the Ministry of Agriculture and Rural Affairs. In this circular order, it is specified where, when and how shrimp can be fishing and cannot be fishing. However, although during the last two periods a forbidden size definition has been identified in fishing for some fishery products, no forbidden size definition has been defined for any type of shrimp.

According to the circular, in all of territorial waters except Marmara, shrimp fishing with Algarna is prohibited. Despite this, illegal fishing still has been continuing continues. However, as it is obvious that over fishing cannot last long term in any ecosystem, so decisions should be taken accordingly and shrimp must be given the opportunity to maintain in a healthy population. It is necessary to manage shrimp fishing according to the most suitable fishing period by considering both the intensity of fishing and the phases that the population goes through in reproduction and participation phenomenon (to protect the young from fishing, to give the chance of ovulation to the females, to protect the stock levels, to prevent bio-economic losses in terms of the fishing economy).

Shrimp is one of the fishery products that is a very important subject for foreign trade across the world (Celiker, 2004). Indeed, as seen in Table 4, while the world's shrimp export amount and its share of total exports is increasing in a stable manner, the income has been also increasing (Table 5). In Turkey however, a reduction both in production and exports is observed. Yet, when shrimp prices are analyzed, it can be seen that the prices in Turkey and the world are almost at the same level.

The TSI records, shrimp exports were realized as 881.5 tons and provided about 9.4 million dollars export revenue in 2006. While, the share of shrimp exports among total fishery products was 2.11%, its share of imports was 1.15%. While, the ratio of shrimp export income to total export revenue was 4.03%, the ratio of import income to total revenue was 1.65% (Table 4).

Table 5: World shrimp export and its share in total export

	Export quantity		Export value		Unit value
Years	1000 tons	(%)	1 000 $	(%)	(kg^{-1})
1986	938,102	3.18	4,740,789	20.71	5.05
1996	1,601,147	3.68	9,957,324	18.87	6.22
2006	3,244,871	6.03	14,138,751	16.47	4.36

FAO (2007)

Marketing system of shrimp in Turkey shows a complex structure among the manufacturers, processors, marketers and consumers. In fact, according to a study, the majority of fishermen, who carry on shrimp fishing in Turkey are the ones, who have average and small boats and their education level is low. Small boat owners often sell the majority of the shrimp to the agents in exchange for the prepayment that they have. A small amount of shrimp, however, is sold to the fans and restaurants at an agreeable price. This situation continues as long as the agents allow. Sales through cooperatives are only in some regions in very low quantities and cooperatives usually take a 2% commission on the price of the shrimp.

On the other hand, the minimization of damaged shrimp landed in shrimp fishing has a great importance in the selection of fishing apparatus. Significant increases in the number of damaged shrimp occurred because of problems arising from the structural characteristics of trawl nets used in shrimp fishing and the excess of the operation length. This situation lowers the market value of shrimp. Fishermen usually throw the damaged shrimp back to the sea after they sort them on the boat. Shrimp fishermen complain about the scarcity of income caused by excessive expenses, the fuel problem, length of the fishing season and not putting up with the inhibitions caused by the negativities. However, according to one study, the cost of 1 kg of shrimp is between 2.49-2.68 TL and when the average sales price is taken into consideration, losses to shrimp fishermen is not exist. Besides in shrimp fishing, various fish species other than the main product can be caught even if the amount is low (Zengin *et al*., 2004).

The results about population of *M. monoceros*

Sex distribution: A total of 323 specimens of *M. monoceros* were sampled between August 2002-July 2003 from the Gulf of Antalya. Seventy two percent of the samples were female (239) and 28% male. This ratio was significantly different from the 1:1 (χ^2, $p<0.05$) in the samples observed.

Length and weight distribution: The length of *M. monoceros* ranged from 7.5-16.5 cm. Among the *M. monoceros* caught, 92.7% were within the range 10.5-14.5 cm (Fig. 2). The length of females ranged from

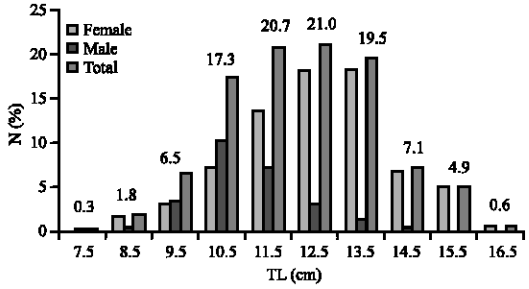

Fig. 2: Length frequency of *M. monoceros*

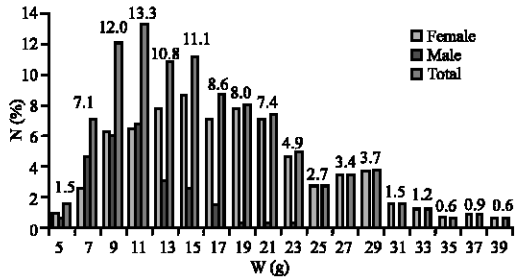

Fig. 3: Weight frequency of *M. monoceros*

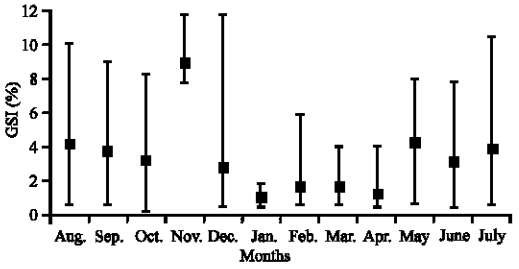

Fig. 4: Monthly changes of the gonadosomatic index for female of *M. monoceros*

8.5-16.5 cm, with 61.5% being between 10.5-14.5 cm. The length of males ranged from 7.5-14.5, with 20.4% being between 10.5-13.5 cm. The weight of *M. monoceros* ranged from 5-39 g, with 78.2% being between 7 and 19 g (Fig. 3). The weight of females ranged between 7 and 23 g, with 24% being between 7 and 19 g.

Length distribution at first maturity: The smallest size at first maturity of *M. monoceros* was examined and given in Table 6. The sexual maturity of females and males were in the 11.5-7.5 cm length class, respectively.

Spawning season and GSI: The GSI was calculated for females and males. Amongst females, the highest GSI value was 8.89 during November and the lowest GSI value was 1.00 during January (Fig. 4). Amongst males, the highest GSI value was 4.28 during December and the

Table 6: Length distribution at first maturity of females and males of *M. monoceros*

		Female				Male			
		Mature		Immature		Mature		Immature	
Total length groups (cm)	Mean (cm)	No.	%	No.	%	No.	%	No.	%
7-7.9	7.5	-		-	-	1	100	-	-
8-8.9	8.5	1	33	2	67	2	100	-	-
9-9.9	9.5	1	25	3	75	3	100	-	-
10-10.9	10.5	7	70	3	30	4	100	-	-
11-11.9	11.5	8	80	2	20	3	100	-	-
12-12.9	12.5	28	64	16	36	8	100	-	-
13-13.9	13.5	21	75	7	25	3	100	-	-
14-14.9	14.5	17	77	5	23	1	100	-	-
15-15.9	15.5	8	100	-	-	-	-	-	-
16-16.9	16.5	2	100	-	-	-	-	-	-

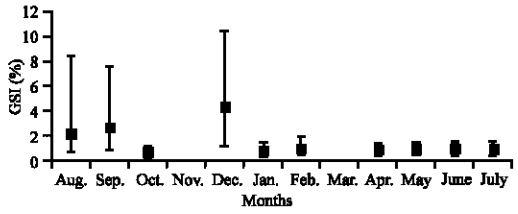

Fig. 5: Monthly changes of the gonadosomatic index for males of *M. monoceros*

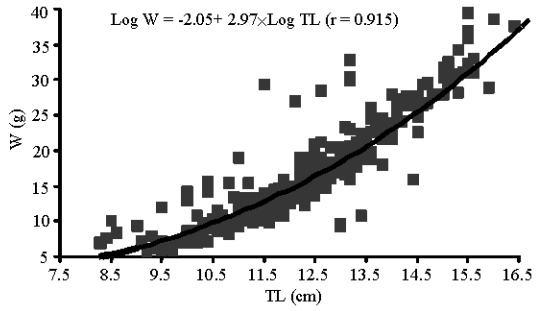

Fig. 6: Length-weight relationship for combined sexes of *M. monoceros*

lowest GSI value was 0.76 during January (Fig. 5). The GSI values for females were usually higher than males. The GSI results revealed that spawning occurred after November, when the GSI for female reached its highest level. The spawning season was determined as occurring between December and January. In both sexes, the GSI values increased again after May.

Length-weight relationship: The equation used to calculate the length-weight relationship for combined sexes of *M. monoceros* is determined as:

$$\text{LogW} = -2.05+2.97 \times \text{Log Tl}\,(r = 0.915)$$

The length-weight relationship curve for combined sexes is given Fig. 6.

DISCUSSION

Between August and September, *M. monoceros* are caught from the shore with gillnets in 5-10 m deep water; Between October and December, they are caught in 30-80 m deep with trawl nets. It can be concluded from this, that *M. monoceros* migrates to greater depths as the temperature of the water decreases. During the study period, it was observed that speckled shrimp did not appear in the nets as much as *Penaeid* shrimp. In a study, in Iskenderun Gulf, Kumlu *et al.* (1999) concluded that few *M. monoceros* were observed. Based on the fact that *M. monoceros* is a lessepsian species, which is newly established in the Mediterranean and Turkey's shores, we conclude that the *M. monoceros* population is currently relatively small.

M. monoceros samples were comprised of 72% females and 28% males. This is in agreement with a previous study by, which found that *M. monoceros* individuals in India Cochin waters consisted of 73% females and 27% males (Nandakumar and Srinath, 1999). The sex ratio in shrimp populations is related to growth and mortality rates. In addition, we conclude that the sex ratio varies seasonally and was influenced by the low number of samples and the type of nets used. Natural mortality rates amongst males are known to be higher that females. Therefore, it is assumed that females are more highly represented in the population (Can and Sereflisan, 2000).

The total length of *M. monoceros* varied from 7.5-16.5 cm. It was found that length of female individuals varies from 8.5-16.5 cm, whereas the length of male individuals varied from 7.5-14.5 cm. The 61.5% of the female individuals were between 10.5-14.5 cm, whereas 20.4% of male individuals were between 10.5-13.5 cm. The overall weight of the *M. monoceros* individuals varied between 5 and 39 g. The weight of females ranged between 7 and 39 g, whereas the weight of males ranged between 5 and 23 g. Forty eight percent of the female *M. monoceros* population was found to weigh between

11-23 g, whereas 24% of the males were between 7-19 g. Overall, the female individuals were larger than male individuals. Fischer *et al.* (1987) concluded that the average length of *M. monoceros* individuals was 12 cm, with a maximum length of 20 and 15 cm for females and males, respectively. They reported the maximum weight to be 170 g. Based on high mesh selectivity, it was found that females grow faster.

The standard market size of shrimp also affects their market value. The companies that process shrimp according to export and domestic markets, separate the shrimp into 6 size groups. These size groups and the number of shrimp per kg in each size group are as follows: 1st group (15>cm): 50-60 shrimp kg^{-1}, 2nd group (14-14.5 cm): 60-80 shrimp kg^{-1}, 3rd group (13-13.5 cm): 80-100 shrimp kg^{-1}, 4th group (12-12,5 cm): 100-120 shrimp kg^{-1}, 5th group (11-11.5 cm): 120-150 shrimp kg^{-1} and 6th group (10-10,5 cm): 160-180 shrimp kg^{-1}. Among these size groups, the smallest shrimp is supplied in domestic market with lower prices.

Based on the data, a special unit should be established for shrimp in the administrative structure created for fishery products and it should be implemented by prohibition programs according to the origins of the species. In fishery product research institutes, the faculty's natural stocks should be followed, while researching about economic stocks of shrimp. To get real data, records should be kept at least for the commercially important shrimps. Fishermen should be educated about shrimp by cooperatives and producer associations; moreover, the fishermen who release babies to their natural habitats should be rewarded. Fishery product research institutes in certain centers should contribute information about the economic types, shrimp consumption should be increased by informing the community and studies about production that is more sensitive to natural resources should be launched.

Sexual maturity lengths of female and male *M. monoceros* w ere determined. Amongst females, it was found that the length at first sexual maturity was 11.5 cm. Amongst male individuals, the minimum length at sexual maturity was found to be 7.5 cm. Ramamurthy (1994) determined that *M. monoceros* in Indian coastal regions were 11.6 cm (female) and 9.6 cm (male) length at sexual maturity. The length at first reproduction varies according to region and studies within the same region show variability according to the sampling season.

It has been that GSI values in October (3.39) increased in November (8.89) and decreased in December (2.86). The spawning period of *Penaeus semisulcatus* and *Metapenaeus stebbingi* is reported to be between August and October (Turkmen, 2005). Cha *et al.* (2002) determined that the Spawning period of *Metapenaeus joyneri* along West Korean shores was between July and August. It was observed that *Penaeid* shrimp have two reproduction seasons/year. Reproduction behavior is affected by local environmental factors.

The length-weight relationship for female, male and overall *M. monoceros* samples were calculated and it was found that the growth shows positive allometry. The length-weight relationship of *M. monoceros* varies with environmental factors, sexual development, nutrition and sex. In the present study of the Antalya Gulf, the b value for all individuals was found to be 2.97. Rao (1989) reported b values in Kakinada for females and males of 3.15 and 2.95, respectively.

CONCLUSION

The present study examined, the length and weight of *M. monoceros* shrimp populations in the Antalya Gulf. These populations were found to be similar to other populations around the world. It was established that the length of *M. monoceros* at sexual maturity was 11.5 cm for females and 7.5 cm for males. It is suggested that these length values should form the minimum size limit for *M. monoceros*.

On the other hand, fishermen cooperatives should play more important role in marketing of shrimp. Analysis of the contribution of the structural features of the existing cooperatives to fishery management reveals a negative image. These cooperatives have usually been established with limited capital and the inadequacy of administrative and legal structures hence, it is clear that the members do not have a common shrimp fishery consciousness. With this inefficient structure, which is being managed by bureaucrats and in which fishermen do not have an efficient role, any solution to the existing shrimp fishery problems will not be effective. Therefore, fishing cooperatives should take an active role in the management of shrimp fishing, with some fundamental changes made in terms of administrative and functional organization.

ACKNOWLEDGEMENT

This study was supported by Scientific Research Administration Unit of Akdeniz University.

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