Sex Ratio Variation of the Omani Indian Oil Sardine *Sardinella longiceps* (Valenciennes, 1847)

Saud Musallam S. Al-Jufaili

Department of Marine Science and Fisheries, College of Agricultural and Marine Sciences, Sultan Qaboos University, PO Box 34, Al-Khod 123, Muscat, Sultanate of Oman.

Corresponding author email: sjufaily@squ.edu.om

**Abstract** During the period 2004–2008, a total of 1590 (1022 females and 568 males) Omani Indian oil sardines (*Sardinella longiceps*) were monthly sampled from a major landing site in Al-Seeb, Sultanate of Oman, to determine sex ratio. The results were compared with the results of a previous sampling study conducted in 1997–1998 in the same area, in which 1799 sardines (905 females and 560 males) were sampled, the rest were not sexed. During the period 2004–2008, the total length of female sardines ranged from 12.8 to 22 cm with a mean of 16.7 ± 1.72 cm and their total weight ranged from 16.8 to 94.6 g with a mean of 43.65 ± 0.46 g. Male sardines ranged from 12.3 to 21.5 cm in length with a mean of 16.42 ± 1.8 cm and their weights ranged from 16.32 to 79.8 g with a mean of 41.34 ± 0.57 g. During 1997–1998, female sardines ranged from 10 to 21.3 cm in length with a mean of 16.19 ± 2.16 cm and their weights ranged from 8.21 to 91.0 g with a mean of 38.33 ± 0.52 g. The male sardines ranged from 12 to 20.6 cm in length with a mean of 16.7 ± 1.8 cm and their weights ranged from 16.32 to 79.8 g with a mean of 41.34 ± 0.57 g. The monthly sex ratios fluctuated between 0.45 and 1 with a mean of 0.63 ± 0.04 in 1997–1998 samples and between 0.29 and 0.98 with a mean of 0.68 ± 0.02 in 2004–2008 samples. The overall sex ratios during 1997–1998 and 2004–2008 were 0.62 and 0.64, respectively. Both the sex ratios were different from the expected sex ratio of 0.5 according to the $\chi^2$ test ($P$-value $< 0.01$). The relationship between sex ratio and length was explained by the power function as $(\text{sex ratio} = 6.7 \times 10^{-6} L^{6.84}, r = 0.96)$ for 2004–2008. The results indicated faster female growth rate and higher abundance of female over the males in the fishing grounds.

**Keywords** Oman; Indian oil sardine; Sex ratio; Maturity stages

**Introduction**

The Omani Indian oil sardine *Sardinella longiceps* fishery is one of the important traditional fisheries along the Omani coast. Among other sardines found off the Omani waters, the Indian oil sardines contribute the most to the catch composition of the small pelagic (Dorr III et al., 1990). The sardine fishery in Oman is a market-driven business and fishermen usually target sardines using beach seines, gillnet, and occasionally purse seines. Sardines in Oman are used for human consumption, as fertilizer, and as food for cattle (Mahgoub et al., 2005).

Despite the importance of the Omani traditional coastal fisheries, less work has been done regarding the stock assessment of this fish. This paper analyses and compares the sex ratio of the Omani Indian oil sardine using data obtained by the author during 1997–1998 and 2004–2008. Sex ratio studies are important and provide basic yet vital information for assessing the reproductive condition of the fish stock (Wang et al., 2003; Vicentini and Araújo, 2003). In addition, sex ratio parameters are important in building up the knowledge of the fish sex distribution behaviour before, during, and after the spawning periods. Furthermore, studies related to fish sex determination are important for calculating the spawning stock biomass per size class (Foale and Day, 1997; Chiang et al., 2006). The results from studies conducted on sex ratios of the same fish vary due to many factors such as time of the study, sampling methods, and environmental conditions (Nikolsky, 1963).

**1 Material and Methods**

Sardine samples were collected from a beach seine fishery randomly and monthly from Al-Seeb landing
area during the period 1997–1998 and 2004–2008. Samples were collected from the fish market at Alseeb area and were directly preserved in cool box with ice flakes and were analysed on the same day of sampling. Length, weight, and maturity stages for each fish were recorded. The weight of the fish was recorded to the nearest 0.01 g using an electronic balance (Mettler PE 360) and the length was recorded to the nearest mm measuring from the tip of the mouth to the longest lobe of the caudal fin. Sex and maturity stages of the male and female *S. longiceps* samples were determined based on the macroscopic characteristics of the gonads (Nielsen and Johnson, 1995). Fish data were sorted based on sex, length (0.5 cm interval), weight, and maturity stages for both the sampling periods. The female ratio (F/(F + M)) was determined per month and per each length interval. All the sex ratios thus obtained were tested using chi square test ($\chi^2$) test at 5% significance level to find whether they were significantly or non-significantly different from the expected sex ratio of 1:1 or 0.5 rate (Zar, 1984). Similarly, the maturity stage (I, II, III, IV, V, and spent) distributions were analysed monthly and per class interval.

2 Results
During the period 1997–1998, a total of 1799 sardines were sampled and their total length ranged from 2.5 to 21.3 cm with a mean of 15.3 ± 3.4 cm. In all, 560 male sardines were sampled and their lengths ranged from 12 to 20.6 cm with a mean of 16.7 ± 1.8 cm. On the other hand, 905 female sardines were sampled and their lengths ranged from 10 to 21.3 cm with a mean of 16.19 ± 2.16 cm. Lengths of male and female sardines were statistically proved to be not different ($T_{0.05, df = 1463} = 4.79$, $P < 0.05$). For the 1997–1998 samples, the total weight for the combined sexes ranged from 0.14 to 91.0 g with a mean of 34.68 ± 0.41 g. The weights of the male sardines ranged from 16.32 to 79.8 g with a mean of 41.34 ± 0.57 g. The weights of the female sardines ranged from 16.8 to 94.6 g with a mean of 43.65 ± 0.46 g. Weights of male and female sardines were proved to be significantly different ($T_{0.05, df = 1507} = 2.92$, $P < 0.05$). The total weight for the 2004–2008 samples for the combined sexes ranged from 14 to 94.6 g with a mean of 42.44 ± 0.38 g. On the other hand, the weights of the male sardines ranged from 16.32 to 79.8 g with a mean of 41.34 ± 0.57 g. The weights of the female sardines ranged from 16.8 to 94.6 g with a mean of 43.65 ± 0.46 g. Weights of male and female sardines were proved to be significantly different ($T_{0.05, df = 1507} = 2.59$, $P < 0.05$). Unlike the 1997–1998 data, no sardines were found below 12.5 cm in the 2004-2008 data (Figure 1).

During both sampling periods, the female sardines outnumbered the males. The values of the $\chi^2$ significance test assuming the observed sex ratio is different from the expected 1:1 or 0.5 rate as given in Table 1. In the 1997–1998 data, the males dominated the lower length class from 10 to 11 cm with a significant difference in the expected sex ratio of 0.5 ($P < 0.01$). The females on the other hand dominated most of the remaining classes significantly (Table 2).
Table 1 Chi-square ($\chi^2$) test for a sex ratio of 0.5 for the Omani Indian oil sardine (S. longiceps) during the sampling months

| Months  | T   | F   | M   | Sex ratio | $\chi^2$ value | Months  | T   | F   | M   | Sex ratio | $\chi^2$ value |
|---------|-----|-----|-----|-----------|----------------|---------|-----|-----|-----|-----------|----------------|
| Jan-'97 | 127 | 70  | 57  | 0.55      | 1.330          | May-'05 | 41  | 27  | 14  | 0.66      | 4.12**         |
| Feb-'97 | 123 | 67  | 56  | 0.54      | 0.984          | Jun-'05 | 40  | 34  | 6   | 0.85      | 27.90**        |
| Mar-'97 | 101 | 55  | 46  | 0.54      | 0.802          | Jul-'05 | 40  | 30  | 10  | 0.75      | 10.00**        |
| Apr-'97 | 184 | 106 | 78  | 0.58      | 4.261*         | Aug-'05 | 30  | 20  | 10  | 0.67      | 3.33           |
| May-'97 | 110 | 59  | 51  | 0.54      | 0.582          | Sep-'05 | 41  | 21  | 20  | 0.51      | 0.02           |
| Jun-'97 | 106 | 48  | 58  | 0.45      | 0.943          | Nov-'05 | 40  | 26  | 14  | 0.65      | 3.60           |
| Jul-'97 | 52  | 36  | 16  | 0.69      | 7.690**        | Apr-'06 | 39  | 21  | 18  | 0.54      | 0.23           |
| Aug-'97 | 79  | 64  | 15  | 0.81      | 30.390**       | May-'06 | 42  | 30  | 12  | 0.71      | 7.71**         |
| Sep-'97 | 203 | 126 | 77  | 0.62      | 11.830**       | Jun-'06 | 40  | 34  | 6   | 0.85      | 19.60          |
| Oct-'97 | 94  | 94  | 0   | 1.00      | 94.000**       | Nov-'06 | 40  | 30  | 10  | 0.75      | 10.00**        |
| Nov-'97 | 75  | 55  | 20  | 0.73      | 16.330**       | Dec-'06 | 40  | 27  | 13  | 0.68      | 4.90*          |
| Dec-'97 | 119 | 79  | 40  | 0.66      | 12.780**       | Jan-'07 | 38  | 11  | 27  | 0.29      | 6.74**         |
| Jan-'98 | 60  | 27  | 33  | 0.45      | 0.600          | Feb-'07 | 40  | 23  | 17  | 0.58      | 0.90           |
| Feb-'98 | 29  | 19  | 10  | 0.66      | 2.793          | Mar-'07 | 40  | 29  | 11  | 0.73      | 8.10**         |
| Mar-'98 | 42  | 25  | 17  | 0.60      | 1.520          | Apr-'07 | 40  | 26  | 14  | 0.65      | 3.60           |
| Apr-'98 | 50  | 42  | 8   | 0.84      | 23.120**       | May-'07 | 40  | 34  | 6   | 0.85      | 19.60**        |
| May-'98 | 30  | 17  | 13  | 0.57      | 0.530          | Jun-'07 | 40  | 28  | 12  | 0.70      | 6.40*          |
| Jun-'98 | 34  | 19  | 15  | 0.56      | 0.470          | Sep-'07 | 40  | 27  | 13  | 0.68      | 4.90*          |
| Jul-'98 | 41  | 23  | 18  | 0.56      | 0.610          | Oct-'07 | 40  | 19  | 21  | 0.48      | 0.10           |
| Sep-'98 | 40  | 27  | 13  | 0.68      | 4.900*         | Nov-'07 | 40  | 32  | 8   | 0.80      | 14.40**        |
| Oct-'98 | 40  | 25  | 15  | 0.63      | 2.500          | Dec-'07 | 39  | 25  | 14  | 0.64      | 3.10           |
| Nov-'04 | 45  | 38  | 7   | 0.84      | 21.000**       | Apr-'08 | 40  | 39  | 1   | 0.98      | 36.10**        |
| Dec-'04 | 44  | 31  | 13  | 0.70      | 7.360**        | May-'08 | 40  | 28  | 12  | 0.70      | 6.40*          |
| Feb-'05 | 40  | 30  | 10  | 0.75      | 10.00**        | Jun-'08 | 40  | 25  | 15  | 0.63      | 2.50           |
| Mar-'05 | 38  | 35  | 3   | 0.92      | 27.00**        | Aug-'08 | 40  | 18  | 22  | 0.45      | 0.40           |
| Apr-'05 | 40  | 22  | 18  | 0.55      | 0.40           | Sep-'08 | 40  | 37  | 3   | 0.93      | 28.90**        |

Note: T: total; F: female; M: male; *P < 0.05, **P < 0.01

Table 2 Chi-square ($\chi^2$) test for a sex ratio of 0.5 for the Omani Indian oil sardine (S. longiceps) during the sampling months by size classes

| Size class (cm) lower length | 1997–98 |          |          | 2004–2008 |          |          |          |
|-----------------------------|---------|----------|----------|----------|----------|----------|----------|
|                             | Females (F) | Males (M) | Sex ratio | Females (F) | Males (M) | Sex Ratio |
| 10                          | 2        | 2        | 0.5      | 0        |
| 10.5                        | 1        | 10       | 0.09     | 7.36     |
| 11                          | 4        | 22       | 0.15     | 12.46**  |
| 11.5                        | 1        | 0        | 1        | 1        |
| 12                          | 4        | 0        | 1        | 4        |
| 12.5                        | 22       | 0        | 1        | 22**     |
| 13                          | 75       | 0        | 1        | 75**     |
| 13.5                        | 70       | 11       | 0.86     | 43**     |
| 14                          | 57       | 15       | 0.79     | 24.5**   |
| 14.5                        | 48       | 27       | 0.64     | 5.88*    |
| 15                          | 48       | 24       | 0.67     | 8**      |
| 15.5                        | 46       | 57       | 0.45     | 1.17     |
| 16                          | 71       | 66       | 0.52     | 0.18     |
| 16.5                        | 101      | 89       | 0.53     | 0.76     |
| 17                          | 103      | 62       | 0.62     | 10.19**  |
| 17.5                        | 76       | 48       | 0.61     | 6.84**   |
| 18                          | 45       | 31       | 0.59     | 2.58     |
| 18.5                        | 32       | 17       | 0.65     | 4.59*    |
| 19                          | 23       | 32       | 0.42     | 1.47     |
| 19.5                        | 20       | 20       | 0.5      | 0        |
| 20                          | 30       | 19       | 0.61     | 2.46     |
| 20.5                        | 21       | 6        | 0.78     | 8.33**   |
| 21                          | 4        | 0        | 1        | 4*       |
| 21.5                        | 3        | 2        | 0.6      | 0.81     |
| 22                          | 1        | 1        | 0.5      | 0        |

Note: T: total; F: female; M: male; *P < 0.05, **P < 0.01
Sex ratios for the 1997–1998 data fluctuated between 0.45 and 1 with a mean of 0.63 ± 0.04 (Figure 2). The overall sex ratio during 1997–1998 was 0.62, which was significantly different from the expected sex ratio of 0.5 ($\chi^2 = 82.8$ and $P$-value < 0.01). The female sardines dominated during all the months except in June 1997 and January 1998, in both months the sex ratio did not significantly differ from 0.5 ($P > 0.05$). During 2004–2008 sampling period, the females outnumbered the males in all the months and the sex ratios fluctuated between 0.29 and 0.98 with a mean of 0.68 ± 0.02 (Figure 2). The overall sex ratio during 2004–2008 was 0.64 which was significantly different from the expected sex ratio of 0.5 ($\chi^2 = 129.6$ and $P$-value < 0.01). The male sardines outnumbered the females in January 2007 [sex ratio significantly differed from the expected sex ratio of 0.5 ($P < 0.01$)], October 2007, and August 2008 [sex ratio did not significantly differ from expected sex ratio of 0.5 ($P > 0.05$)].

The sex ratio during 1997–1998 did not show a pattern for sardines with lengths below 19 cm and it increased afterwards and was explained by the power function (sex ratio = 0.002 $L^{2.03}$, $r = 0.92$). Similarly, the sex ratio for the period 2004–2008 showed a pattern starting from the same length interval and was explained by the following relationship (sex ratio = 6.7×10⁻⁶ $L^{6.84}$, $r = 0.96$) (Figure 3).

In the 1997–1998 samples, the occurrence of mature sardines (stage III and above) were higher than immature sardines (stages I and II) in February 1997 (61%), August 1997 (85%), January 1998 (55%), and February 1998 (97%). On the other hand, the mature fish dominated in 2004–2008 samples except in May 2004 (23%), March 2007 (26%), and May 2007 (42%) (Table 2). During the period 2004–2008, 62% of the samples were with 80–100% mature sardines, while only 15% of the samples showed the same results in 1997–1998. It is worth mentioning that spent sardines started to appear in large numbers in the samples starting from March 2005, this is almost exactly when the immature sardines (stages I and II) started to disappear from the samples (Table 3).

### 3 Discussion

The female Omani Indian oil sardines outnumbered the male sardines almost during all the sampling months. The mean sex ratio of two sets of data used in the current study of 1997–1998 and 2004–2008 were 0.63 ± 0.04 and 0.68 ± 0.02, respectively. This suggests that the Omani Indian oil sardines are multiple spawners. This result was supported by the multiple spawning peaks observed during the months; October, June and July, September, June, and January and September in 2004, 2005, 2006, 2007, and 2008, respectively. The Omani sardines are also reported to spawn in March, August, and February (Al-Jufaili, 2011) and April (Siddeek et al., 1994).
The relationship obtained between the sex ratio and total length of the Omani Indian oil sardine is considered to be reported for the first time in Oman. The power models (sex ratio = $8.9 \times 10^{-6} L^{3.79}$) for the 1997–1998 data and (sex ratio = $6.7 \times 10^{-6} L^{6.84}$) for the 2004–2008 data are useful in reconstructing the sex composition from catch data. In addition, this information is useful for the better fish management through the application of the sex based stock assessment models. Similar patterns for sex ratio versus length were observed in other fishes as well (Wang et al., 2003; Wei et al., 2006).

Higher abundance and dominance of females in different months and size classes are an indication of higher growth rate in the females over the males. Growth indices for female sardines were found to be higher than those for males in several studies as found by Athanassios, Tsikliras and Antonopoulou (2006). This significant difference in the growth rate between the sex results in an imbalance in the sex ratio of sardines caught, which in turn could increase the difficulty of sardine management in Oman.

During the period 1997–1998, small sardines dominated the catch (mean weight 34.68 ± 0.41 g) versus (mean weight 42.44± 0.38 g) for 2004–2008 samples. In addition, the percentage occurrence of the smaller immature sardines was higher than the larger mature sardines in 2004–2008 samples. This could be attributed to the change of sardine prices during the years. Fifty sardines were sold in pieces for RO 0.3 irrespective of the size. Currently, fishermen sell 40 large sardines for double or even triple the amount depending on the market, place, and time of the year. This change in the market price of the sardines led the fishermen to sort their catch and discard the little ones. The change in the size distribution also could be

### Table 3 Monthly percentage distribution of various maturity stages for the Omani Indian oil sardines collected during January 1997–September 2008

| Months | Maturity stages (%) | Months | Maturity stages (%) |
|--------|---------------------|--------|---------------------|
|        | I  | II  | III | IV  | V  | Spent |        | I  | II  | III | IV  | V  | Spent |
| Jan-97 | 21 | 30  | 18  | 30  |   |       | May-05 | 46 | 2   | 7   | 44  |   |       |
| Feb-97 | 11 | 27  | 30  | 31  |   |       | Jun-05 | 10 | 13  | 33  | 8   | 38 |       |
| Mar-97 | 31 | 22  | 14  | 33  |   |       | Jul-05 | 3  | 38  | 55  | 5   |   |       |
| Apr-97 | 43 | 37  | 11  | 8   |   |       | Aug-05 | 14 | 7   | 24  | 48  | 7 |       |
| May-97 | 44 | 52  | 4   |     |   |       | Sep-05 | 34 | 37  | 29  |     |   |       |
| Jun-97 | 6  | 35  | 49  | 10  | 1 |       | Nov-05 | 18 | 20  | 5   | 48  | 10 |       |
| Jul-97 | 27 | 63  | 10  |     |   |       | Apr-06 | 5  | 33  | 13  | 46  | 3 |       |
| Aug-97 | 1  | 14  | 55  | 30  |   |       | May-06 | 26 | 26  | 12  | 17  | 19 |       |
| Sep-97 | 63 | 14  | 17  | 5   | 1 |       | Jun-06 | 0  | 10  | 28  | 53  | 10 |       |
| Oct-97 | 96 | 4   |     |     |   |       | Sep-06 | 5  | 10  | 22  | 20  | 15 |       |
| Nov-97 | 7  | 35  | 40  | 18  |   |       | Dec-06 | 3  | 40  | 55  | 3   |   |       |
| Dec-97 | 21 | 36  | 19  | 12  | 13|       | Jan-07 | 5  | 13  | 55  | 26  |   |       |
| Jan-98 | 7  | 37  | 30  | 25  | 2 |       | Feb-07 | 13 | 10  | 13  | 15  | 38 |       |
| Feb-98 | 3  | 97  |     |     |   |       | Mar-07 | 40 | 18  | 5   | 3   | 10  | 25 |
| Jan-04 | 5  | 7   | 17  | 21  | 50|       | May-07 | 15 | 38  | 10  | 8   | 30 |       |
| Apr-04 | 36 | 30  | 33  | 2   |   |       | Jun-07 | 11 | 3   | 26  | 37  | 11  | 11 |
| May-04 | 53 | 20  | 23  | 3   |   |       | Aug-07 | 0  | 10  | 28  | 25  | 38 |       |
| Jun-04 | 9  | 38  | 47  | 6   |   |       | Sep-07 | 8  | 18  | 25  | 30  | 18  | 3 |
| Jul-04 | 20 | 44  | 37  |   |   |       | Oct-07 | 8  | 30  | 23  | 18  | 8  | 15 |
| Sep-04 | 8  | 35  | 35  |   |   |       | Dec-07 | 3  | 40  | 55  | 3   |   |       |
| Oct-04 | 8  | 15  | 38  | 28  | 13|       | Jan-08 | 3  | 31  | 31  | 36  |   |       |
| Dec-04 | 2  | 48  | 32  | 18  |   |       | Apr-08 | 8  | 28  | 35  | 30  |   |       |
| Feb-05 | 45 | 55  |     |     |   |       | May-08 | 15 | 25  | 10  | 13  | 38 |       |
| Mar-05 | 5  | 29  | 45  | 21  |   |       | Jun-08 | 4  | 13  | 29  | 33  | 18  | 4 |
| Apr-05 | 23 | 20  | 40  | 18  |   |       | Aug-08 | 36 | 41  | 23  |   |   |       |
| Sep-08 | 5  | 3   | 90  | 3   |   |       | Sep-08 | 5  | 3   | 90  | 3   |   |       |
attributed to the use of fishing nets with bigger mesh sizes which could explain the disappearance of the immature sardines in favour of mature ones starting from March 2005.

Acknowledgements
I thank Mr. Suleiman Al-Shueili for helping in collection of samples. I also thank Dr. Anish Govender, Department of Marine Science and Fisheries, for his advices. I am grateful to Sultan Qaboos University for the award of the following research grants which enabled me to undertake and publish this research paper among others: IG/AGR/FISH/07/03 and IG/AGR/FISH/04/02.

References
Al-Jufaili S.M., 2011, Weight–length relationships, gonadosomatic indeces, sex ratios and relative weight of the Omani-Indian oil sardine, Sardinella longiceps (Valenciennes 1847) from Al-Seeb area; Sultanate of Oman. Advanced Journal Of Food Science and Technology, 3(4): 238–244
Athanassios C., Tsikliras, and Antonopoulou E., 2006, Reproductive biology of round Sardinella (Sardinella aurita) in North-Eastern Mediterranean, Science Marina, 70(2): 281–290
Chiang W.C., Sun C.L., Yeh S.Z., Su W.C., Liu D.C. and Chen W.Y., 2006, Sex ratios, size at sexual maturity, and spawning seasonality of sailfish Istiophorus platypterus from eastern Taiwan. Bulletin of Marine Science, 79(2): 727–737
Dorr III J.A., Al-Bulushi M., Al-Hijri M., and Al-Lawatiya M., 1990, Stock assessment and management of Sardinella longiceps in the Sultanate of Oman, Research Report. Marine Science and Fisheries Center, Ministry of Agriculture and fisheries, Muscat, Sultanate of Oman.
Foale S., and Day R., 1997. Stock assessment of Trochus (Trochus niloticus) (Gastropoda: Trochidae) Fisheries at West Nggela, Solomon Islands. Fisheries Research, 33: 1-16
Mahgoub O., Kadom I.T., Al-Jufaili S.M., Al-Saqy N.M., Annamalai K., and Ritchie A., 2005. Evaluation of Sun-Dried Sardine as a Protein Supplement for Omani sheep, Department of Animal and Veterinary Sciences and Department of Marine Science and Fisheries, College of Agriculture, Sultan Qaboos University, Muscat, Oman. PMCID:PMC3726202
Nielsen L.A., and Johnson D.L., (Eds.), 1995, Fisheries Techniques, Southern Printing Company Inc., Blacksburg, VA, USA.
Nikolsky GV., 1963, The Ecology of Fishes, 6th Ed., Academic Press, London: pp. 353
Siddeek M.S.M., Al-Habsi H.N., Al-Jufailly S.M., and Al-Ghafry I.N., 1994. In: Chou, L.M., et al., (Eds.), Spawning Cycle, Recruitment Patterns, and Maturity Length of Indian Oil Sardine at Al-Azaiba, in the Gulf of Oman, . The Third Asian Fisheries Forum, Singapore: 484–487
Wang S.P., Sun C.L., and Yeh S.Z., 2003, Sex ratios and sexual maturity of swordfish (Xiphias gladius L.) in the waters of Taiwan, Zoological Studies, 42: 529–539
Wei-Chuan Chiang, Chi-Lu Sun, Su-Zan Yeh, Wei-Cheng Su, Don-Chung Liu and Wen-Yie Chen, 2006, Sex ratio, size at sexual maturity and spawning seasonality of sailfish Istiophorus platypterus from Eastern Taiwan, Bulletin of Marine Sciences, 79(3): 727–737
Victor R.N., and Araújo F.G., 2003, Sex ratio and size structure of Micropogonias furnieri (Desmarest, 1823) (Perciformes, Sciaenidae) in Sepetiba Bay, Rio de Janeiro, Brazil. Brazilian Journal of Biology, São Carlos, 63(4): 559-566
Zar J.H., 1984. Biostatistical Analysis, 2nd. Ed., Prentice-Hall, Englewood Cliffs, NJ, USA: pp. 718