Study of reproductive aspects of *Trachurus trachurus* (Linnaeus, 1758) from western coast of Algeria

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In the present work, the reproductive study of the fish species *Trachurus trachurus* (Linnaeus, 1758) in Algeria, was investigated which is important for fishery resources and conservation management. 1495 samples were collected from Oran Bay (Western coast of Algeria) between July 2010 and June 2011. This paper provides values of sizes at first sexual maturity (L50) that were estimated for males at 18.42 cm and females 18.28 cm, respectively. The spawning period for the population extends from January to May and the spawning peak occurs from January to March. However, the factor of condition (K) increased in summer during the sexual resting phase. This factor is weak in winter during the period of reproduction. Regarding the sex ratio, there was no significant difference in the number of males and females.

**Keywords**: Western coast of Algeria; *Trachurus trachurus*; Sex ratio; Length at first maturity; Spawning period.

**Introduction**

Horse mackerel, *Tarchurus trachurus* (Linnaeus, 1758), is a major commercial fishery for the waters of the Mediterranean Sea, taxonomically, it belongs to the family of Carangidae. This family is represented by 200 species that are widely distributed in tropical, subtropical, moderate areas of all oceans and adjoining seas 1.

This pelagic fish is very common in western coast of Algeria (Oran bay), however, few studies on reproduction aspect were carried out. Recently, in 2013, Gherram et al6. have studied the fecundity of the horse mackerel (*T. trachurus*) of Algeria2. This species is considered to be an undetermined spawner3,4. The stocks of *T. trachurus* have been defined for management and assessment purposes and it is assumed that these form distinct spawning populations: the southern horse mackerel around the Iberian Peninsula; the western horse mackerel in the Norwegian Sea, northern North Sea, west and south of the British Isles, western and eastern English Channel and west of France. According to Ruckert et al 5, the latter stock is divided into a distinct northern and southern component. Horse mackerel is a fairly long-lived species, reaching a maximum age of well over 30 years 6. Therefore, an occasional strong year class can lead to high abundance of this species. In the case of the western horse mackerel, the extraordinary strong 1982 year-class created a substantial fishery in the northern areas, which continued for more than a decade. As a result, *T. trachurus* became an important commercial species in the 1980s, 90s and is now one of the three most important pelagic species. Another reason for this is the decrease of the availability of resources due to over-fishing and the subsequent increase of value of other species in the case of horse mackerel. Assigning maturity stages by macroscopical analysis has been the most common approach used so far to describe gonadal development 7. However, there has been no agreement on the use of common maturity scale for Lucio and Martin8.

Present study consists an original research of some reproductive characteristics of the Algerian horse mackerel, including maturation process, size at first maturity and timing of spawning during a one-year period (from July 2010 to June 2011).

**Materials and Methods**

The studied specimens were collected from commercial landings carried out between July 2010 and June 2011 at the port of Oran in western of
Algeria (Fig. 1). A total of 1495 horse mackerel was sampled, among which 670 were females, 797 males and 28 undetermined. The sampling rate per month was related to fish availability. Each time, the specimens were sampled per class of size, measured to the nearest one centimeter. For each specimen, measurements included total length (Lt), total weight (W) and the gonads’ weight (G) to the nearest decigram; sex and stage of sexual maturity were also determined using the scale recommended by Fontana 9; it includes sex stages of sexual maturity for both sexes as follows:

Stage I: Immature;
Stage II: Immature or in resting phase;
Stage III: pre-spawning;
Stage IV: Mature and pre-spawning;
Stage V: Post-spawning.

Sex ratio of males and females is monthly calculated according to the following equation:

\[
\text{Sex ratio} = \frac{F}{M}; \quad F: \text{number of females}; \quad M: \text{number of males.}
\]

This parameter was analyzed by 1 cm length class basis and it was calculated at peak spawning. Deviation from 1:1 null hypothesis was statistically tested by \( x^2 \)-test. The laying period is determined by two methods (1) Qualitative method: it is based on monthly changes of the percentage of macroscopic development of gonad stages. (2) Quantitative method: it is based on monthly changes of parameters related to sexual maturity, such as mean gonadosomatic index (GSI) and factor of condition (K).

GSI is defined by J. Lahave10 as follows:

\[
\text{GSI} = \left( \frac{G}{W} \right) \times 100; \quad G: \text{gonad weight}; \quad W: \text{total weight}. \]

However, factor of condition follows F. kartas, J.P, Quignard11:

\[
K = \left( \frac{W}{Lt^3} \right) \times 100; \quad W: \text{total weight}; \quad Lt: \text{total length}. \]

In addition, mean GSI and K were estimated by considering separately two size ranges, which were established in accordance with the length at first sexual maturity.

Size at first sexual maturity was estimated in both sexes and for the species from the percentages of mature individuals (stages III, IV and V) occurring over the reproductive period (previously determined from monthly mean GSI9).

Excel (Microsoft Corporation, USA) and STATISTICA (version 10) were used for statistical analysis. Data are expressed as Mean ± SD. To assess the variation of the variables among samples, a two-way analysis of variance (ANOVA) was performed.

Microscopic examination of gonads

Gonads were fixed in Bouin for 1 week, then they were passed through acetone baths and paraffin blocks were prepared. Tissues were sectioned into 5-7 \( \mu \)m thickness and then stained with Hematoxylin and Eosin for females and trichromatic hot coloration for males.

Results and Discussion

Annual sex ratios were not significantly different from the expected 1:1 ratio, during the period of peak spawning, females outnumber males. Sex ratio by size class shows a dominance of males in sizes ranging between 12 and 14 cm, except for the class of size
25 cm, where males outnumbered females (Fig.2 and Table.1). In mean size ranging between 15 and 20 cm, males outnumbered females, except for size 22 cm, where females outnumbered males.

During our study period (from July 2010 to June 2011), length at first maturity was estimated as 18.42 cm for males and 18.28 cm for females (Figs. 3 and 4). Length at full maturity no significant at differences were found in the L50 between sexes (Table.2). However, they fluctuate according to month in the both sexes.

The evolution of mean RGS and RHS of males and females shows similar patterns. The mean values of gonadosomatic index gives three peaks in January, March, May and then dropped, reaching the lowest values in summer, as shown in fig. 6, the most important peak was observed in January which means the spawning season happens in winter 2011. The analysis of the seasonal patterns of the percentage of mature \textit{T. trachurus} (stage IV and V) (Fig. 5 and Table 3) and mean gonadosomatic index (Fig.6) indicate the existence of a protected spawning season that extends from January to May with a maximal sexual activity between January to June.

The factor of condition K shows similar patterns in both sexes, from 2010 to 2011, temporal trends of K shows a rather apparent seasonal cycle (Fig.7). The horse mackerel reached a higher condition from September to April, whereas the minimal values appeared in October and November.

The percentage of mature individuals of \textit{T. trachurus} per length are estimated during the spawning season. In our study, we notice that the

<table>
<thead>
<tr>
<th>Total</th>
<th>M</th>
<th>F</th>
<th>F/M (%)</th>
<th>M/F (%)</th>
<th>Sex-ratio</th>
<th>$\chi^2$</th>
</tr>
</thead>
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<tr>
<td>1467</td>
<td>797</td>
<td>670</td>
<td>45.67</td>
<td>54.33</td>
<td>1.19</td>
<td>13.63</td>
</tr>
</tbody>
</table>

Fig. 3 — Maturity ogive and length at first maturity L 50 in males of \textit{T. trachurus} over the period July 2010 to June 2011.

Fig. 4 — Maturity ogive and length at first maturity L50 in females of \textit{T. trachurus} over the period July 2010 to June 2011.

Table 2 — Results of the analysis of variance (Test F, ANOVA) of the IGS, IHS and K index of \textit{T. trachurus} Males and Females according to the months of the Oran bay.

<table>
<thead>
<tr>
<th></th>
<th>F (sex)</th>
<th>F (Months)</th>
<th>F (Sexe × months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IGS</td>
<td>3.53 ns</td>
<td>4.33 **</td>
<td>4.77 **</td>
</tr>
<tr>
<td>IHS</td>
<td>2.46 ns</td>
<td>0.83 ns</td>
<td>1.38 ns</td>
</tr>
<tr>
<td>K</td>
<td>20.86 **</td>
<td>15.78 **</td>
<td>15.93 **</td>
</tr>
</tbody>
</table>

Fig. 5 — Monthly percentages of macroscopic stages of maturity in females (a) and males (b) of \textit{T. trachurus} over the period July 2010 to June 2011.
values of the length at first maturity estimated in Oran bay are similar than those observed in other areas (Table 4). At first glance, the inter-annual variability in length at maturity could be attributed to the differential growth of successive annual cohorts when facing different environmental conditions.

As shown in Figs. 8 and 9, ovaries and testis histology and morphology was divided into five and four stages respectively.

Both the macroscopic aspect (Table 3) of gonads and the seasonal variation of the mean GSI indicate that the reproductive period lasts from January to May. Our experimental results disagree with These results, we found that the reproduction period of *T. trachurus* is in winter.

The maximum values of the mean GSI observed in *T. trachurus* (especially in females) were found to be low in relation to another species. Moreover, the mean GSI reached higher values in males than in females, contrary to what is considered the norm Macer and Treasurer.

The *T. trachurus* of the Algerian western coast has a maximal spawning rate in winter, however it is low in summer. In fact, small pelagic adopt a spawning strategy that aims at minimizing the losses by advection, the spawning fraction, which is inversely related to atresia, varies throughout the spawning period in the same year and among years. Spawning fraction reaches its highest values at the peak of spawning. As the GSI generally depends on the length and weight of the fish, the low values of GSI measured in this work probably result from the small size of scads. Furthermore, such low values of GSI, together with the fact that no post-ovulatory follicles were found in the ovaries, tends to confirm the Arneri and
<table>
<thead>
<tr>
<th>Macroscopic observations</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Stage 1: Immature</strong></td>
<td><img src="image1" alt="Image" /></td>
<td><img src="image2" alt="Image" /></td>
</tr>
<tr>
<td>GSI mean is (0.332±0.258) for males, GSI mean is (0.469±0.233) for females.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| **Stage 2: Maturing or in resting phase** | ![Image](image3) | ![Image](image4) |
| GSI mean from 0.462±0.140 for males, GSI mean from 1.155±1.003 for females. |

| **Stage 3: Mature** | ![Image](image5) | ![Image](image6) |
| GSI mean from 1.989±0.929 for males, GSI mean from 1.387±0.419 for females. |

| **Stage 4: Ripe and running** | ![Image](image7) | ![Image](image8) |
| GSI mean from 2.445±1.444 for males, GSI mean from 3.013±1.659 for females. |

| **Stage 5: Spent** | ![Image](image9) | ![Image](image10) |
| GSI mean from 4.029±1.187 for males, GSI mean from 4.205±3.852 for females. |

| **Stage 6: Resting** | ![Image](image11) | ![Image](image12) |
| GSI mean from 1.110±0.715 for males, GSI mean from 2.014±1.297 for females. |

Tangerini\textsuperscript{14} hypothesis that the most northerly part of Upper Adriatic should be excluded from the reproductive area of *T. mediterraneus*. However, the presence of mature specimens suggests that the periodic findings of pelagic eggs of the genus *Trachurus trachurus*, which appear in very small numbers every summer could result from occasional spawners, rather than from passive transport, especially considering the relatively rapid embryonic development (24-26 h) in this species\textsuperscript{16}. 


Our observations about total length at sexual maturity (18 cm) confirm those of Aeneri, Lucio and Martin\textsuperscript{14} which showed the body condition factor of horse mackerel does not appear to change during the spawning season, this is due to the replacement of fat by water.

Fig. 8 — Cross section of ovaries from female horse mackerel \textit{T. trachurus} at different maturity stages of development, N: nucleus, Nu: nucleoli, Ca: cortical alveoli.

Oogonia or small primary oocytes in nest with primary oocyte G x 100

Cortical alveolus (Endogenous vitellogenesis) G x 100

Part of ovary containing early and late vitellogenic oocytes with densely stained (yolk bodies, exogenous vitellogenesis) G x 400

Stage showing a preovulatory follicle
Conclusion

*T. trachurus* of Oran bay is gonochoric species and presents a sex ratio without significant difference (p>0.05). The values of sizes at first sexual maturity (L50) were estimated for males at 18.42 cm and females at 18.28 cm, the evolution of meanRGS and RHS of

<table>
<thead>
<tr>
<th>Author</th>
<th>Sampling years</th>
<th>Area</th>
<th>Length at first maturity (cm)</th>
</tr>
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<tbody>
<tr>
<td>[21]</td>
<td>1943</td>
<td>Bay of Biscay</td>
<td>19–23</td>
</tr>
<tr>
<td>[29]</td>
<td>1989–1991</td>
<td>Catalonia (NW Mediterranean Sea)</td>
<td>22</td>
</tr>
</tbody>
</table>

FL = fork length; SL = standard length.
both sexes shows similar patterns, the macroscopic and microscopic appearance are in agreement with the different indices determined in this study.

The mean values of gonadosomatic index gives three peaks in January, March and May, the spawning season happens in winter, whereas it has a low spawning rate in summer.

Acknowledgements

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References

17. Polonsky, A.S., Growth and age and maturation of the horse mackerel (Trachurus trachurus (Linné) in the north east Atlantic (1969).