



## Stomach fullness index and condition factor of European sardine (*Sardina pilchardus*) in the south Moroccan Atlantic coast

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**Abstract.** The feeding intensity variation of the European sardine *Sardina pilchardus* (Walbaum, 1792) was analyzed from 906 specimens collected from the areas B (Ifni-Cap bojador) from august 2002 to December 2003. Feeding intensity was strongly seasonal, being higher during summer (July/august) and lower during winter (November/February). No significant difference were found between sexes ( $p < 0.05$ ). Stomachal repletion index of *S. pilchardus* decreased with size classes, young specimen (size  $< 14$  cm) fed more intensively than adult fish and the difference in feeding intensity between young and adult sardine was statistically significant ( $p < 0.05$ ). There was similar temporal variation in condition factor and fullness index with generally higher value in summer and lower value in winter, but no significant difference were found between male and female sardines for condition factor parameter.

**Key Words:** spawning, maturity stage, sex ratio, feeding activity, upwelling.

**Introduction.** The European sardine *Sardina pilchardus* is the most important small size pelagic species in Moroccan waters with 704,800 tones landing in 2013 and the most target species by purse seine in the central area (Cap cantin-Cap Bojador) and the south area (Cap Bojador-Cap Blanc) and 50% of captured specimens are originated particularly from the area B (INRH 2014). Despite its economical importance and its main role in the ecosystem, there are scarce published studies concerning the feeding intensity of *S. pilchardus* in Morocco.

The repletion index and condition factor are widely used parameters in fish biology. The value of condition factor is used to measure the condition or well being of a species (Angelescu et al 1958; Rao 1963; Nikolsky 1969; Esper 1990). The condition factor permits the understanding of general condition, growth and reproduction of fish (Le Cren 1951; Wootton 1992; Pauly 1993). For Elliott (1976), Costopoulos & Fonds (1989), the measurements of condition factor enhance the understanding of body composition, growth and reproduction of fish. The fullness index has several applications, in the field of biology, physiology and ecology of fish. Feeding intensity was determined by analyzing the variation of repletion index between sexes, maturity stages, length classes and seasons. The condition of fish was examined by analyzing the condition factor between sexes and season.

The main objective of this study was to investigate the feeding intensity and condition factor of *S. pilchardus* from the area B. Theses data contribute to better knowledge of biology of sardine in this area.

**Material and Method.** *S. pilchardus* specimens (N = 906) were collected monthly from commercial purse seine from the area B (Ifni-Cap bojador) (figure 1) from august 2002 to December 2003. In the laboratory, *S. pilchardus* were measured (nearest mm in total

length) weighed (nearest g in fish weight) and dissected for sex determination (male/female), sexual maturity (I, II, III, IV and V), gonad weight (g), immediately after landing. The maturity scales used were based on the Belvèze (1984) classification of *S. pilchardus* gonads: stage I - immature; stage II - immature or recovery; stage III - maturing; stage IV – mature, and stage V - spent. The fish size range was between 117 and 267 mm. The number of young *S. pilchardus* whose size was strictly less than 140 mm was 74 individuals while the number of adult fish was 832 specimens.

The usual method of expressing the condition of the fish is the equation proposed by Fulton (1911):  $K = W / L^3 \times 100$ . Where: W - weight of sardine (g); L - Length of sardine (cm). Concerning the measurement of fullness index (FI): The whole stomach was detached from the alimentary system by removing the posterior part of the esophagus and intestine. The stomach weights including its contents (TSW) were measured. The stomachs were dissected and their contents were poured into a Petri dish. The weight of the empty stomach (ES) was then recorded. The difference of the two weights gives the weight of food (FW) (Kagwade 1964):  $WF (g) = TSW (g) - ES (g)$ . The measurement of ingested food weight (FW) is expressed as a percentage of total fish weight (W) according to the formula defined by Hureau (1969):  $FI = FW / W \times 100$ , where FI is the index of fullness (fullness index). Only contents of the stomach (cardiac, cecum and pyloric part) were analyzed. Contents of the intestine were discarded to reduce bias caused by different rates of digestion and gut passage times (Hyslop 1980). Feeding intensity is also evaluated via the vacuity index (VI) of sampled stomach which corresponds to the percentage of empty stomachs (ES) with respect to all analyzed stomachs (TS):  $VI = ES / TS \times 100$ .

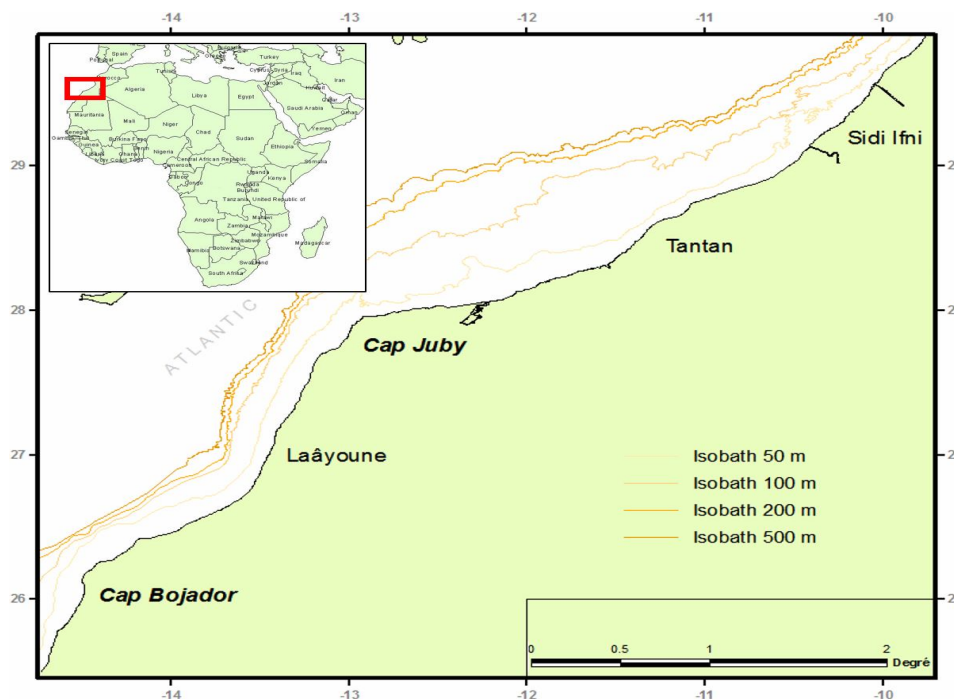


Figure 1. Map showing the study area.

## Results

**Fullness index (FI).** The inter-annual fluctuation of FI of *S. pilchardus* showed the maximum values in July and August and the minimum from December until February (Figure 2). The fullness index and condition factor had almost similar fluctuation and the FI peaked one month earlier than K. The feeding intensity of *S. pilchardus* was seasonal and confined to a specific period of the year (summer) ( $0.59 \pm 0.42$ ). The winter was the season of the year with low feeding intensity ( $0.38 \pm 0.16$ ).

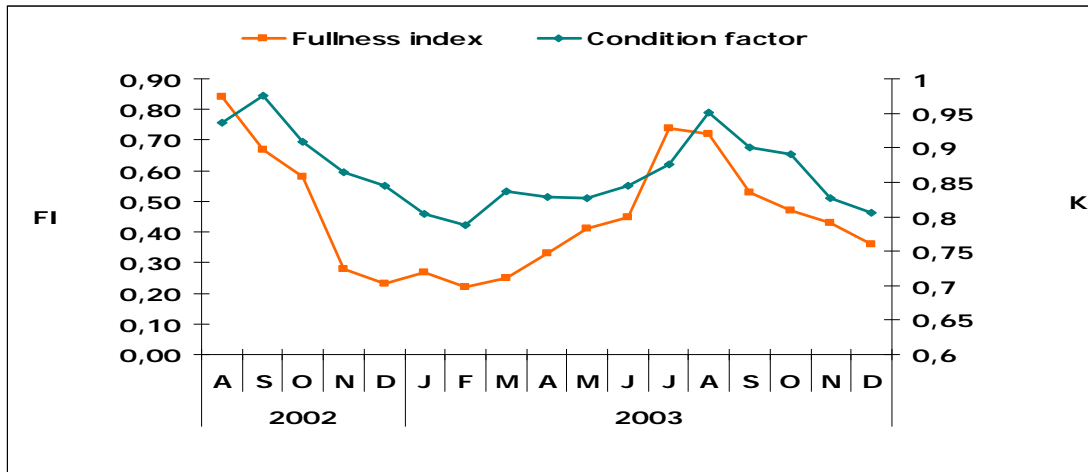


Figure 2. Monthly variation of condition factor and fullness index of *Sardina pilchardus*.

The ANOVA test showed that the season gave a significant effect on FI ( $p < 0.05$ ). Similar results were observed in the vacuity index of sampled specimens with maximum values recorded in winter (January) and lowest in summer (July) (Figure 3).

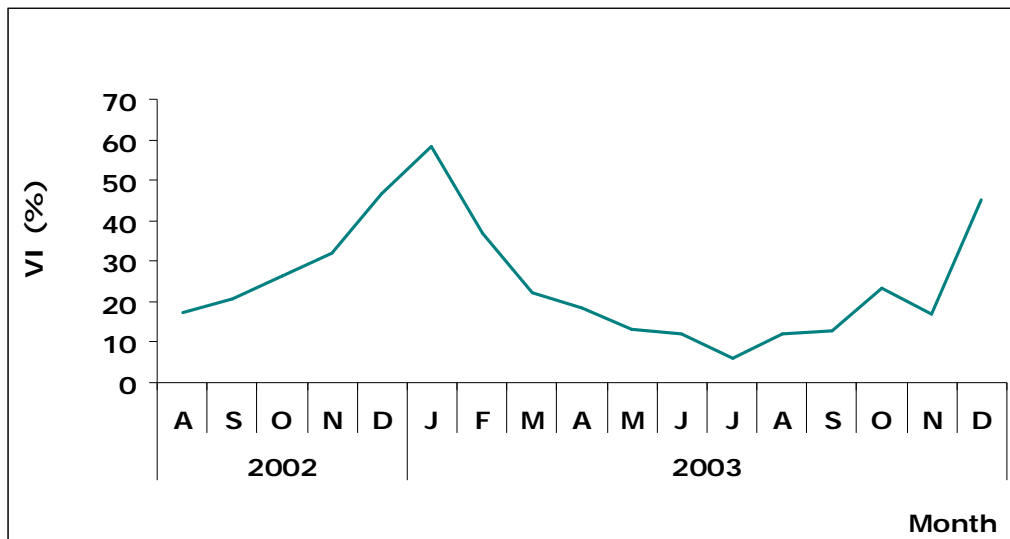


Figure 3. Monthly variation of vacuity index of *Sardina pilchardus*.

The monthly evolution of FI for males and females of *S. pilchardus* showed very similar trend (Figure 4). The mean of fullness index was  $0.54 \pm 0.49$  for female and  $0.49 \pm 0.27$  for male. The differences between sexes were not significant ( $p > 0.05$ ). The repletion index decrease with specimens size (Figure 5). The young *S. pilchardus* with length of  $< 14$  cm presented higher values of FI ( $0.93 \pm 0.34$ ) than adult specimens ( $0.54 \pm 0.39$ ). The differences in feeding intensity between small and large individuals was statistically significant ( $p < 0.05$ ). Concerning the maturity stage of sardine, analysis of variance showed that there was statistically significant differences among FI of spawning specimens ( $0.48 \pm 0.41$ ) and immature and maturing fish specimens ( $0.58 \pm 0.31$ ) ( $p < 0.05$ ).

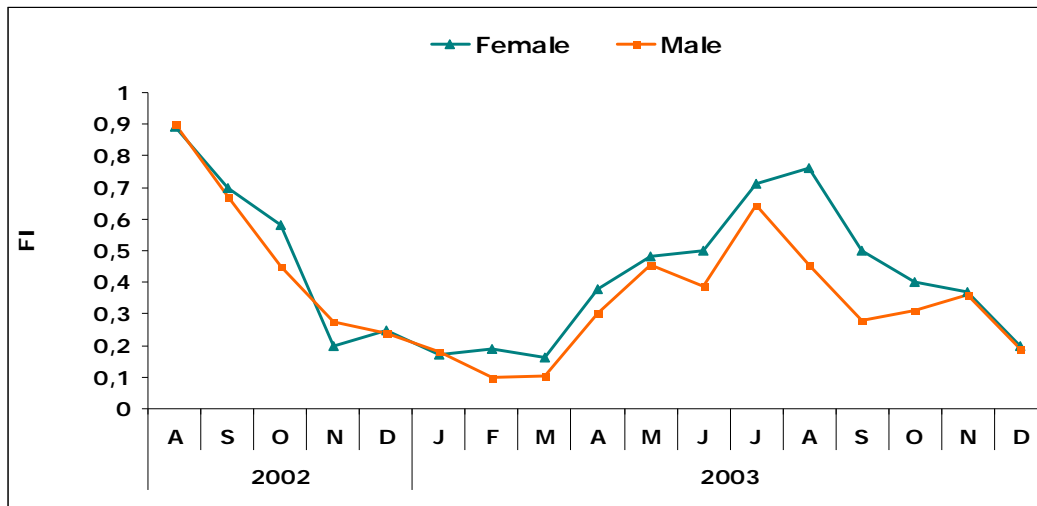


Figure 4. Monthly variation of fullness index of *Sardina pilchardus* for male and female specimens.

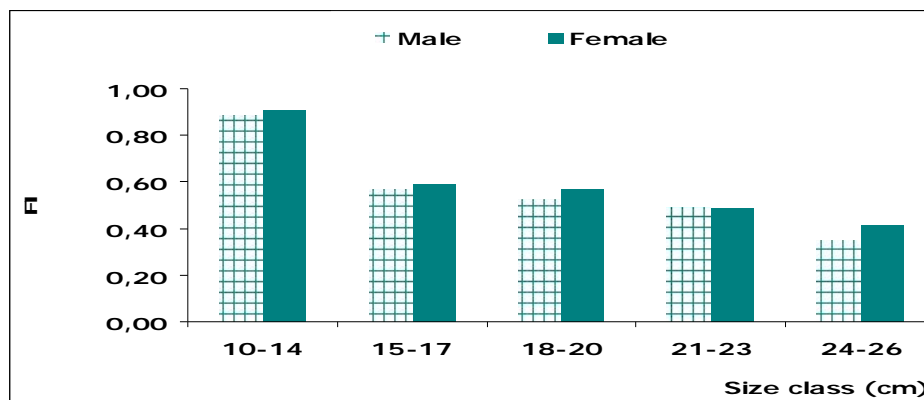


Figure 5. Fullness index variation of *Sardina pilchardus* by size class.

**Condition factor (K).** Inter-annual fluctuation in the mean values of K for males and females were similar (Figure 6). The peak was in summer particularly in September 2002 and August 2003. The differences between female ( $0.84 \pm 1.01$ ) and male ( $0.85 \pm 0.98$ ) were significant ( $p < 0.05$ ).

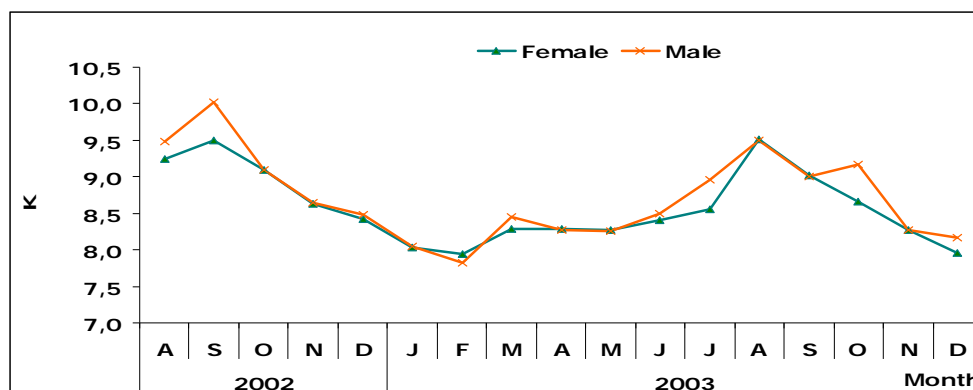


Figure 6. Inter-annual variation of condition factor of *Sardina pilchardus* male and female.

The variation of mean values of fullness index of *S. pilchardus* with season, sexes, size groups and maturity stage is shown in Figure 7.

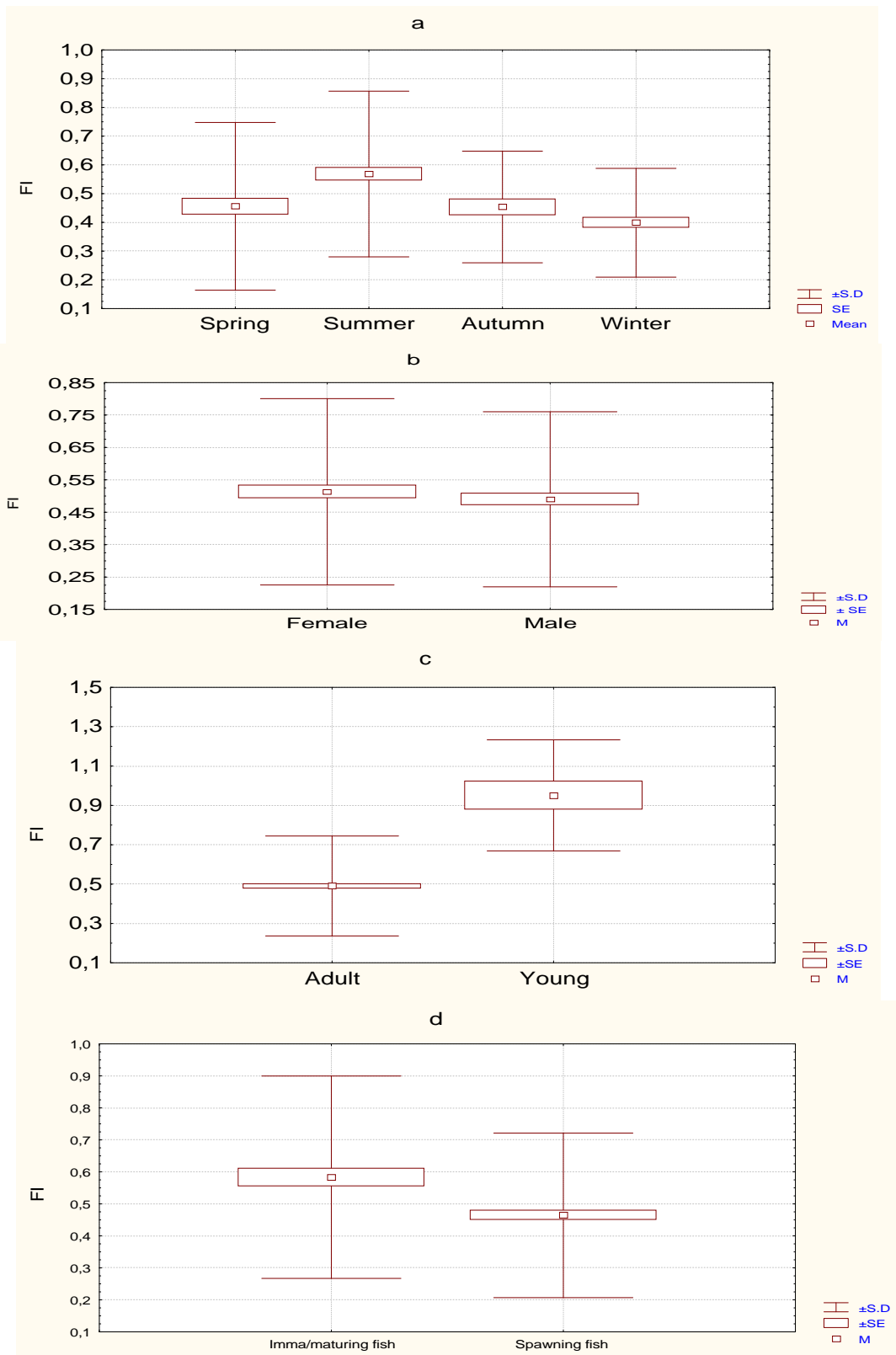


Figure 7. Box plots of fullness index of *Sardina pilchardus* according to, a- season, b- sexes, c- size, and d- maturity stage.

## Discussions

The analyzed results revealed that the feeding intensity varied with the season, maturity stage and the size of *S. pilchardus*. Feeding intensity was strongly seasonal. In fact, *S. pilchardus* feed actively in summer which indicates the favorable trophic conditions during this season. The food availability may have a great influence on the amount of food in *S. pilchardus* stomach, this concord the supposition of Ikusemiju & Olaniyan (1977) and Sarker et al (1980) that the degree of stomach repletion may be an indication of trophic environmental conditions.

Also, the feeding intensity was lower in winter and moderate in spring and autumn. According to Nikolsky (1963), the food supply changes during the year and the seasonal rhythm of food is closely linked to these changes to a degree very significant.

The immature and maturing *S. pilchardus* fed more intensively than spawning fish. This can be attributed that the spawning *S. pilchardus* spent the entire accumulated energy for reproductive activity and the immature or maturing fish spent the energy used for feeding activity for growth.

With the increased size of *S. pilchardus*, there is a gradual reduction in food intake. Odum & Odum (1959) attributed these results to reduced metabolism rate for older specimens; it means that there is an inverse relationship between fish size and metabolism. According to (Zeuthen 1953) when the metabolic activity decreases with the size, it becomes more beneficial for large fish to get more mass with minimal expenditure of energy.

Repletion stomach is closely linked to the development period of the *S. pilchardus*. Indeed young specimens are characterized by intense repletion of stomach compared to adults which would be attributed to increased physiological requirements for growth of fish.

In October 2003, there was a second peak of the proportion of empty stomachs, which could be explained by Pillay (1952) that the level of stomach repletion may be biased by the sampling method because the fish may regurgitate or ingest food during capture.

The available data concerning the condition factor indicated the mean changes of the condition factor showed the highest values in summer mainly in August and progressive decrease from autumn until winter particularly in February, may be explained by reserves used for sexual products in winter period of spawning peak of *S. pilchardus*.

The increase of feeding activity and the condition factor in summer may be attributed to the improving food availability in this season. The study area is directly influenced by upwelling which occurs mainly during summer (Makaoui et al 2005; Benazzouz et al 2014) and enhances an important coastal planktonic production and abundance prey and diversified species composition. This situation may explain the high feeding activity and the best condition of *S. pilchardus* in this season. The energy accumulated in summer will be spent for reproductive activity through winter.

**Conclusions.** The influence of the season, the maturity stage and the size of *S. pilchardus* on the feeding intensity has been highlighted in the present study. These parameters were of great importance in governing the feeding intensity of *S. pilchardus*. The investigation of the feeding intensity and condition of *S. pilchardus* revealed that these two parameters were strongly seasonal. They were lower in winter but higher in summer when upwelling is active.

Furthermore, young, immature and maturing *S. pilchardus* fed more intensively than adults and spawning fish due to the increased physiological requirements for growth of fish. Also, spawning *S. pilchardus* minimize the feeding activity during reproduction period and allocate the energy for sexual activity and production of egg batches.

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