Research Article *http://dx.doi.org/10.4314/mejs.v16i1.3*

Defining the reproductive period of the European pilchard (*Sardina pilchardus* Walbaum, 1792) in Saros Bay (North Aegean Sea, Turkey)

Özgür Cengiz[1*], Uğur Özekinci[2] and Alkan Öztakın[2]
[1]Van Yüzüncü Yıl University, Fisheries Faculty, Van, Turkey ([*]ozgurcengiz17@gmail.com).
[2]Çanakkale Onsekiz Mart University, Marine Science and Technology Faculty, Çanakkale, Turkey.

ABSTRACT

The European pilchard (*Sardina pilchardus* Walbaum, 1792) is one of the main target species of commercial fishery along the Aegean coasts. This work was carried out between July 2014 and June 2015 off Saros Bay (North Aegean Sea, Turkey). The study focuses on determining the reproductive period of the species. The elevated GSI values suggested the spawning period occurred mainly between September and May with a peak in February.

Keywords: Spawning period, Fisheries management, *Sardina pilchardus*, Saros Bay, Turkey.

1. INTRODUCTION

Species-specific life history data (age, growth, maturity, sex ratio, time of spawning, fecundity, feeding, and mortality) are very important in the context of fisheries management, as they constitute the supporting material for the technical management regulations (Winemiller, 2005). Long-term availability of life history data may also detect evolutionary adaptations of a population to exogenous disturbance, such as fishing pressure (Olsen et al., 2004). Fish reproductive modes are extremely diverse, which includes variations concerning partner choice, spawning grounds and periods, and distinct schemes for parental care (Wootton and Smith, 2015). To understand those reproductive strategies in relation to the size at maturity, reproductive period and spawning grounds is essential to management of both fisheries and aquatic ecosystems (Fontoura et al., 2018).

Small pelagic species comprise about one quarter of the global catch of fishes, such that they are both economically and ecologically considerable (Lleonart and Maynou, 2003; Ganias, 2014). Among these species, the European sardine (*Sardina pilchardus* Walbaum, 1792), plays a key role in maintaining ecological processes in marine systems, occupying an essential intermediate trophic level in pelagic ecosystems (Bakun, 2006; Rumolo et al., 2016). This species belongs to the Clupeidae family, inhabiting from the North Sea to Senegal in the Atlantic waters, as well as in the Mediterranean Sea (Parrish et al., 1989) and is a schooling fish, usually inhabiting the continental shelf (Iglesias et al., 2003), whose landings account for 15% (more than 185.000 tons) of the total production of the Mediterranean Sea between 2016

Submitted on: 8th August 2022 ***Revised and Accepted on: 2nd February 2024***

and 2018 (FAO, 2020). The European sardine (*Sardina pilchardus* Walbaum, 1792) is a multiple batch spawner with continuous development of gametes, showing a protracted spawning period with early maturation and high fecundity across most of the distribution range (Zwolinski et al., 2001; Somarakis et al., 2004; Silva et al., 2006; Ganias, 2009), also displaying a high variability in terms of its recruitment, biomass, and distribution, mostly dependent on environmental and climatic conditions (Katara et al., 2011; Basilone et al., 2021).

All over the world, the information on the reproductive period of *Sardina pilchardus* were given in the Portugal (Ré et al., 1990; Zwolonski et al., 2001), in the Izmir Bay (Hoşsucu, 1992; Karakayış and Toğulga, 2000), in the Iberian Peninsula (Sola et al., 1992; Guisande et al., 2001), in the Aegean Sea (Cihangir, 1996), in the Dardanelles (Tekinay et al., 2002), in the Northern Atlantic (Ettahiri et al., 2003; Stratoudakis et al., 2004; Silva et al., 2006), in the Thermaikos Gulf (Voulgaridou and Stergiou, 2003), in the Biscay Bay (Bellier et al., 2007), in the Morocco (Amenzoui et al., 2005), as a summary. The aims of the present study were to provide first information on the spawning period of the european pilchard in the Saros Bay (North Aegean Sea, Turkey) and to compare these results with those of the previous studies.

2. METHODOLOGY

The Mediterranean Basin has an oligotrophic feature, whereas the eastern Mediterranean exists its highest oligotrophic part (Psarra et al., 2000). There is a trend parallel to the decreasing primary production values along the North-South line of the Aegean Sea (Antoine et al., 1995; Gönülal and Dalyan, 2017). The northern Aegean territories are qualified by an extended continental shelf, smooth muddy/sandy grounds and top nutrient concentrations (Maravelias and Papaconstantinou, 2006) and when compared with the southern Aegean territories, these areas are higher for zooplankton and phytoplankton abundance (Theocharis et al., 1999).

The northern Aegean coasts of Turkey are divided to sub-regions as the Saros Bay, the Gallipoli Peninsula, the Gökceada and Bozcaada Islands and the Edremit Bay (Cengiz and Paruğ, 2020; Cengiz, 2021a; Cengiz, 2021b). The length of Saros Bay is about 61 km and the width at the opening to the Aegean Sea is about 36 km (Eronat and Sayın, 2014). As the bay had been closed to bottom trawl fishing since 2000 (Cengiz et al., 2014) and no industrial activity was prevalent in the area (Sarı and Çağatay, 2001), it can be considered as a pristine environment (Cengiz et al., 2015) (Fig 1).

Samples were obtained monthly between July 2014 and June 2015 in random stratified sampling from commercial fishermen off Saros Bay. The individuals were measured to the weighed to the nearest 0.01 g in total weight. The sex was determined by examining the gonads

macroscopically. Gonads of all specimens were dissected and weighed to the nearest 0.001 g to calculate the spawning period. The spawning period was estimated by analysing, monthly, the changes of the gonadosomatic index (*GSI*) using the equation: $GSI = [Wg/(W - Wg)] * 100$ where, *Wg* is the gonad weight (g) and *W* is the total weight (g) of fish (Avsar, 2005).

Figure 1. Northern Aegean coasts of Turkey (1: Saros Bay; 2: Gallipoli Peninsula; 3: Gökçeada Isl.; 4: Bozcaada Isl.; 5: Edremit Bay.

3. RESULTS

In present study, the reproductive cycles of female and male individuals was synchronized. All year around the GSI values for females were higher than the male values. GSI reached the highest values with 5.32 and 5.00 for females and males, respectively, in February. The elevated GSI values suggested the spawning period occurred mainly between September and May with a peak in February (Fig 2).

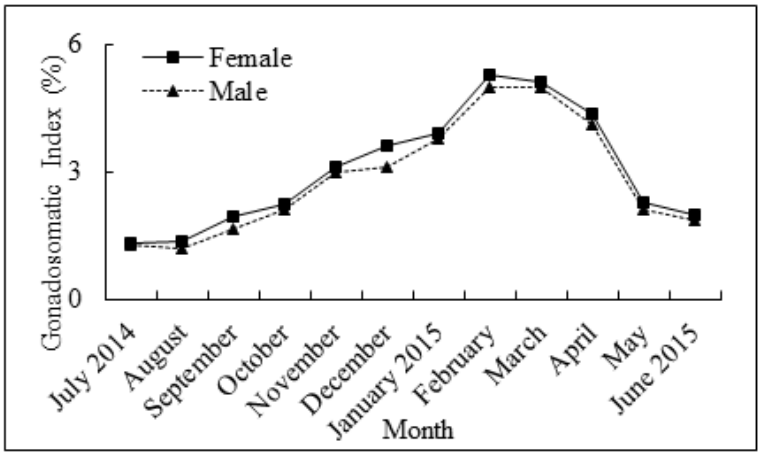

Figure 2. GSI values for females and males of *Sardina pilchardus* from Saros Bay (North Aegean Sea, Turkey).

4. DISCUSSION

Comparison the spawning periods of *Sardina pilchardus* from Saros Bay with those reported by other authors in different areas is shown in table 1. The spawning period has a close relationship to the ecological characteristics of the water system in which the species live (İlkyaz et al., 2010; Cengiz et al., 2019) and apparently varies from area to area because of the differences in hydrographic and climatic conditions (İlhan et al., 2010).

Table 1. Comparison the spawning periods of *Sardina pilchardus* from Saros Bay with those reported by other authors in different areas.

References	Area	Month											
		Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Ré et al. (1990)	Portugal	x	x	x							x	x	x
Hoşsucu (1992)*	İzmir Bay	x	x	x	x	x						x	x
Sola et al. (1992)*	Iberian Peninsula	x	x	x	x	x	x	x			x	x	x
Cihangir (1996)*	Aegean Sea	x	x	x	x	x				x	x	x	x
Karakayış and Toğulga (2000)*	İzmir Bay	x	x	x	x						x	x	x
Guisande et al. (2001)*	Iberian Peninsula			x	x								
Zwolonski et al. (2001)*	Portugal	x	x	x	x					x	x	x	x
Tekinay et al. (2002)*	Dardanelles	x	x	x	x					x	x	x	x
Ettahiri et al. (2003)*	Northern Atlantic	x	x	x							x	x	x
Voulgaridou and Stergiou (2003)*	Thermaikos Gulf	x	x	x	x						x	x	x
Stratoudakis et al. (2004)*	Northern Atlantic	x	x	x							x	x	x
Amenzoui et al. (2005)*	Morocco	x	x	x	x	x	x	x			x	x	x
Silva et al. (2006)*	Northern Atlantic	x	x	x	x	x						x	x
Bellier et al. (2007)*	Biscay Bay		x	x	x	x	x	x	x	x	x	x	
Erdoğan et al. (2010)	Edremit Bay	x	x	x	x	x				x	x	x	x
This study	Saros Bay	x	x	x	x	x				x	x	x	x

Note: *from Erdoğan et al. (2010).

5. CONCLUSION

As a result, the data presented here may be used to compare similar parameters in ongoing fishery studies for different areas of world. The results of present study will increase the life history data available for *Sardina pilchardus* by providing the scientific support required in

order to identify the current stock state and will help conservation and management of the species.

6. ACKNOWLEDGEMENTS

The present study was carried out with the financial support of COMU BAP (Project No: FBA-2015-375). The authors are grateful to commercial fishermen for their valuable contributions.

7. CONFLICT OF INTEREST

No conflict of interest.

8. REFERENCE

Amenzoui, K., FerhanTachinante, F., Yahyaoui, A., Mesfioui, A. H & Kifani, S. 2005. Etude de quelques aspects de la reproduction de *Sardina pilchardus* (Walbaum, 1792) de la région de Laâyoune (Maroc). *Bulletin de l'Institut Scientifique, Rabat, Section Sciences de la Vie, 2004–2005*. **26–27**: 43–50.

Antoine, D., Morel, A & André, J. M. 1995. Algal pigment distribution and primary production in the eastern Mediterranean as derived from coastal zone color scanner observations. *Journal of Geophysical Research: Oceans*, **100**: 16193–16209.

Avsar, D. 2005. *Fisheries biology and population dynamics*, Adana, 332 p.

Bakun, A. 2006. Fronts and eddies as key structures in the habitat of marine fish larvae: opportunity, adaptive response and competitive advantage. *Scientia Marina*, **70(S2)**: 105–122.

Basilone, G., Ferreri, R., Aronica, S., Mazzola, S., Bonanno, A., Gargano, A., Pulizzi, M., Fontana, I., Giacalone, G., Calandrino, P., Genovese, S & Barra, M. 2021. Reproduction and Sexual Maturity of European Sardine (*Sardina pilchardus*) in the Central Mediterranean Sea. *Frontiers in Marine Science*, **8**: 715846.

Bellier, E., Planque, B & Petitgas, P. 2007. Historical fluctuations in spawning location of anchovy (*Engraulis encrasicolus*) and sardine (*Sardina pilchardus*) in the Bay of Biscayduring 1967–1973 and 2000–2004. *Fisheries Oceanography*, **16(1)**: 1–15.

Cengiz Ö. 2021a. Opercular girth, maximum girth and total length relationships for eight fish species from the Saros Bay (northern Aegean Sea, Turkey). *The Palawan Scientist*, **13(2)**: 25–36.

Cengiz Ö. 2021b. Length-weight relationships of four *Symphodus* species (Perciformes: Labridae) off Gökçeada Island (Northern Aegean Sea, Turkey). *Acta Natura et Scientia*, **2(2)**: 159–165.

Cengiz, Ö., İşmen, A & Özekinci, U. 2014. Reproductive biology of the spotted flounder, *Citharus linguatula* (Actinopterygii: Pleuronectiformes: Citharidae), from Saros Bay (northern Aegean Sea, Turkey). *Acta Ichthyologica et Piscatoria*, **44(2)**: 123–129.

Cengiz, Ö., İşmen, A., Özekinci, U & Öztekin, A. 2015. Some reproductive characteristics of four-spotted megrim (*Lepidorhombus boscii* Risso, 1810) from Saros Bay (Northern Aegean Sea, Turkey). *Journal of Agricultural Sciences*, **21(2)**: 270–278.

Cengiz, Ö & Paruğ, Ş. Ş. 2020. A new record of the rarely reported grey triggerfish (*Balistes capriscus* Gmelin, 1789) from Northern Aegean Sea (Turkey). *Marine and Life Sciences*, **2**: 1–4.

Cengiz, Ö., Paruğ, Ş. Ş & Kızılkaya, B. 2019. Weight-length relationship and reproduction of bogue (*Boops* Linnaeus, 1758) in Saros Bay (Northern Aegean Sea, Turkey). *KSU Journal of Agriculture and Nature*, **22(4)**: 577–582.

Cihangir, B. 1996. Reproduction of European pilchard, *Sardina pilchardus* (Walbaum, 1792) in the Aegean Sea. *Turkish Journal of Zoology*, **20**: 33–50.

Erdoğan, Z., Torçu-Koç, H., Gıcılı, S & Ulunehir, G. 2010. Age, growth and mortality of European pilchard, *Sardina pilchardus* in Edremit Bay (northern Aegean Sea, Turkey). *Cybium*, **34**: 185–193.

Eronat, C & Sayın, E. 2014. Temporal evolution of the water characteristics in the bays along the eastern coast of the Aegean Sea: Saros, İzmir, and Gökova bays. *Turkish Journal of Earth Sciences*, **23(1)**: 53–66.

Ettahiri, O., Berraho, A., Vidy, G., Ramdani, M & Do Chi, T. 2003. Observation on the spawning of *Sardina* and *Sardinella* off the south Moroccan Atlantic coast (21–26°N). *Fisheries Research*, **60**: 207–222.

FAO. 2020. *The State of Mediterranean and Black Sea Fisheries*. Rome: General Fisheries Commission for the Mediterranean.

Fontoura, N. F., Ceni, G., Braun, A. S & Marques, C. S. 2018. Defining the reproductive period of freshwater fish species using the gonadosomatic index: a proposed protocol applied to ten species of the Patos Lagoon basin. *Neotropical Ichthyology*, **16(2)**: e170006.

Ganias, K. 2009. Linking sardine spawning dynamics to environmental variability. *Estuarine, Coastal and Shelf Science*, **84**: 402–408.

Ganias, K. 2014. Biology and Ecology of Sardines and Anchovies. CRC Press.

Gönülal, O & Dalyan, C. 2017. *Deep-Sea Biodiversity in the Aegean Sea.* In: Mediterranean Identities - Environment, Society, Culture, Bjelovar: IntechOpen, pp.149-178.

Guisande, C., Cabanas, J. M., Vergara, A. R & Riveiro, I. 2001. Effect of climate on recruitment success of Atlantic Iberian sardine *Sardina pilchardus*. *Marine Ecology Progress Series*, **123**: 243–250.

Hoşsucu, B. 1992. Researches on bio-ecology of eggs and larvae of pilchard (*Sardina pilchardus*, Walb.) in İzmir Bay. *İstanbul University Journal of Aquatic Products*, **2**: 5–12 (In Turkish).

Iglesias, M., Carrera, P & Muiño, R. 2003. Spatio-temporal patterns and morphological characterisation of multispecies pelagic fish schools in the North-Western Mediterranean Sea. *Aquatic Living Resources*, **16(6)**: 541–548.

İlhan, D., Akalın, S., Tosunoğlu, Z & Özaydın, O. 2010. Growth characteristics and reproduction of comber, *Serranus cabrilla* (Actinopterygii, Perciformes, Serranidae), in the Aegean Sea. *Acta Ichthyologica et Piscatoria*, **40**: 55–60.

İlkyaz, A. T., Metin, G., Soykan, O & Kınacıgil, H. T. 2010. Age, growth and sexual development of solenette, *Buglossidium luteum* (Risso, 1810), in the central Aegean Sea. *Journal of Applied Ichthyology*, **26**: 436–440.

Karakayış, M & Toğulga, M. 2000. Study on the biology of the sardine (*Sardina pilchardus* Walbaum, 1792) in the İzmir Bay (Aegean Sea). *Ege Univ. Journal of Fisheries and Aquatic Sciences*, **17(3-4)**: 59–69.

Katara, I., Pierce, G.J., Illian, J & Scott, B. E. 2011. Environmental drivers of the anchovy/sardine complex in the Eastern Mediterranean. *Hydrobiologia*, **670**: 49–65.

Lleonart, J & Maynou, F. 2003. Fish stock assessments in the Mediterranean: State of the art. *Scientia Marina*, **67(1)**: 37–49.

Maravelias, C. D & Papaconstantinou, C. 2006. Geographic, seasonal and bathymetric distribution of demersal fish species in the eastern Mediterranean. *Journal of Applied Ichthyology*, **22**: 35–42.

Olsen, E. M., Heino, M., Lilly, G. R., Morgan, M. J., Brattey, J., Ernande, B & Dieckmann, U. 2004. Maturation trends indicative of rapid evolution preceded the collapse of northern cod. *Nature*, **428**: 932–935.

Parrish, R. H., Serra, R & Grant, W. S. 1989. The monotypic sardines, *Sardina* and *Sardinops*: their taxonomy, distribution, stock structure, and zoogeography. *Canadian Journal of Fisheries and Aquatic Sciences*, **46(11)**: 2019–2036.

Psarra, S., Tselepides, A & Ignatıades, L. 2000. Primary productivity in the oligotrophic Cretan Sea (NE Mediterranean): Seasonal and interannual variability. *Progress in Oceanography*, **46(2-4)**: 187–204.

Ré, P., Cabral, E., Silva, R., Cunha, E., Farinha, A., Meneses, I & Moita, T., 1990. Sardine spawning off Portugal. *Boletim do Instituto Nacional de Investigação das Pescas*, **15**: 31–34.

Rumolo, P., Bonanno, A., Barra, M., Fanelli, E., Calabrò, M., Genovese, S., Ferreri, R., Mazzola, S & Basilone, G. 2016. Spatial variations in feeding habits and trophic levels of two small pelagic fish species in the central Mediterranean Sea. *Marine Environmental Research*, **115**: 65–77.

Sarı, E & Çağatay, M. N. 2001. Distributions of heavy metals in the surface sediments of the Gulf of Saros, NE Aegean Sea. *Environment International*, **26(3)**: 169–173.

Silva, A., Santos, M. B., Caneco, B., Pestana, G., Porteiro, C., Carrera, P & Stratoudakis, Y. 2006. Temporal and geographic variability of sardine maturity at length in the northeastern Atlantic and the western Mediterranean. *ICES Journal of Marine Science*, **63**: 663–676.

Sola, A., Franco, C., Lago De Lanzos, A & Motos, L. 1992. Temporal evolution of *Sardina pilchardus* (Walb.) spawning on the N-NW coast of the Iberian Peninsula. *Boletin del Instituto Espanol de Oceanografia*, **8(1)**: 97–114.

Somarakis, S., Ganias, K., Tserpes, G & Koutsikopoulos, C. 2004. Ovarian allometry and the use of the gonosomatic index: a case study in the Mediterranean sardine, *Sardina pilchardus*. *Marine Biology*, **146**: 181–189.

Stratoudakis, Y., Coombs, S.H., Halliday, N., Conway, D., Smyth, T., Costas, G., Franco, C., Lago De Lanzós, A., Bernal, M., Silva, A., Santos, M. B., Alvarez, P & Santos, M. 2004. Sardine (*Sardina pilchardus*) spawning season in the North East Atlantic and relationships with sea surface temperature. ICES CM2004/Q:19:19.

Tekinay, A. A., Akyüz, P., Güroy, D., Kahyaoğlu E. G & Alparslan M. 2002. An investigation on some population parameters of European pilchard (*Sardina pilchardus* Walbaum, 1792) in the Dardanelles. *Turkish Journal of Marine Science*, **8**: 131–139.

Theocharis, A., Balopoulos, E., Kioroglou, S., Kontoyiannis, H & Iona, A. 1999. A synthesis of the circulation and hydrography of the South Aegean Sea and the Straits of the Cretan Arc (March 1994–January 1995). *Progress In Oceanography*, **44**: 469–509.

Voulgaridou, P & Stergiou, K.I. 2003. Trends in various parameters of sardine. *Scientia Marina*, **67(Suppl. 1)**: 269–280.

Winemiller, K. O. 2005. Life history strategies, population regulation, and implications for fisheries management. *Canadian Journal of Fisheries and Aquatic Sciences*, **62**: 872–885.

Wootton, R. J & Smith, C. 2015. Reproductive biology of teleost fishes. Oxford: John Wiley & Sons.

Zwolinski J., Stratoudakis Y & Soares, E. 2001. Intra-annual variation in the batch fecundity of sardine off Portugal. *Journal of Fish Biology*, **58**: 1633–1645.