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# Growth and reproduction of brown comber (*Serranus hepatus* Linnaeus, 1758) in the central Aegean Sea, Turkey

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**Abstract:** The growth and reproduction of brown comber (*Serranus hepatus* Linnaeus, 1758) were studied using specimens collected from the central Aegean Sea between July 2004 and June 2007. A total of 2410 specimens were analyzed, and of those, 2290 individuals were mature and 120 individuals were juvenile. Analyses covered all individuals because the species is a simultaneous hermaphrodite. The length–weight relationship was determined as $W = 0.013L^{3.11}$, indicating a positive allometric growth for all samples. The estimated von Bertalanffy growth parameters were $L_\infty = 13.19$ cm, $k = 0.252$ y$^{-1}$, and $t_o = -0.630$ y, and the infinite weight ($W_\infty$) was calculated as 39.38 g. The growth performance index (φ′) of the stock was calculated as 1.642. The first reproduction length was found to be 7.76 cm, corresponding to 3 years of age. The spawning period of the species was determined between May and October.

**Key words:** Brown comber, *Serranus hepatus*, age, growth, reproduction, first reproduction length, central Aegean Sea

## 1. Introduction

*Serranus hepatus* (Linnaeus, 1758), known as brown comber, is a member of the family Serranidae. The brown comber is categorized as a demersal, subtropical species, which occurs along the coasts of the eastern Atlantic Ocean from Portugal to the Canary Islands and southwards along the African coast to Senegal, as well as throughout the Mediterranean Sea (Smith, 1990) excluding the Black Sea (Mater et al., 2003). It is commonly distributed over sea grass, sand, mud, and rocks to depths of 100 m (Jardas, 1996). Jardas (1996) also added that, according to observation, the brown comber has a relatively high density over the Adriatic continental shelf and is considered to be among the most abundant fish species in the zone mentioned above. Furthermore, the feeding habits of the species were stated by Labropoulou et al. (1998). They reported 62 species belonging to 3 major groups, decapods, amphipods, and fish, by analyzing stomach contents, and they added that decapods dominated the diet composition. Dulčić et al. (2007) also stated that brown comber has been found in the stomachs of some commercial species such as *Merluccius merluccius*, *Epinephelus marginatus*, and *Phycis phycis*. In addition, according to Bilecenoğlu (2009), the brown comber is a carnivorous species, mostly consuming benthic decapod crustaceans, especially natantians and brachyurans. Although it has a widespread occurrence, brown comber is of low commercial value, probably because of its small size (Dulčić et al., 2007).

Regarding reproduction strategies, gonadal differentiation can be observed in many teleost fish species. Furthermore, the family Serranidae is well known for its diverse expressions of sexual pattern in the wild, which range from gonochorism (separate sexes) to simultaneous hermaphroditism and various forms of protogyny (female to male sex change) (Sadovy and Domeier, 2005). Nelson (2006) stated that the 2 sexes generally do not develop concurrently and added the case of functional hermaphroditism in most *Serranus* species and their relatives, as well. This sexual pattern allows the possibility of self-fertilization (Atz, 1965), which can be either internal or external. Furthermore, Bruslé (1983) reported the hermaphroditism status of the species as synchronous and added that differentiation of the ovary was earlier than that of the testis.

The brown comber is generally captured by bottom trawling as a by-catch species throughout the year in the Aegean Sea. The annual total catch or total number of landings of the species is unknown for Turkey. Despite poor studies on this species, some researchers have conducted biological investigations on brown comber. Merella et al. (1997), Gonçalves et al. (1997), Valle et al. (2003), Abdallah (2002), Stergiou and Moutopoulos (2001), and Dulčić et al. (2007) studied the length–weight relationship of the species in or around the Balearic Islands, the southwest coasts of Portugal, the western

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Mediterranean, Egypt, the Aegean Sea, and the eastern Adriatic, respectively. In addition, studies on growth, age, and mortality are available from Tunisia (Bouain, 1983), the Cretan continental shelf (Labropoulou et al., 1998), Greece (Wagué and Papaconstantinou, 1997) and the Adriatic (Dulčić et al., 2007). Furthermore, Düzbastılar et al. (2010) studied the survival of the species escaping from the cod-end of a bottom trawl and Bilecenoğlu (2009) reported the growth and feeding habits of brown comber in İzmir Bay in the Aegean Sea. Age, growth, and reproduction are topics that have crucial importance for stock assessment of brown comber, and these subjects were investigated in the central Aegean Sea in this study.

The aim of this research was to provide information on age, growth, and reproduction of brown comber (*S. hepatus*) in the central Aegean Sea.

**2. Materials and methods**

The brown comber samples were obtained by R/V EGESÜF with trawl hauls from İzmir Bay (Figure 1) from July 2004 to June 2007. The depths of the trawl operations varied between 30 and 70 m. The cod-end used in the trawl net had knotless diamond shaped meshes made of polyamide material with 22-mm stretched mesh size netting.

Total lengths of specimens (*TL*) were measured in the natural body position to the nearest millimeter in the laboratory. Total weight (*W*) and gonad weight ($W_g$) of each individual was measured to the nearest 0.01 g, and the sexes were recorded. The lengths of the fish were categorized in group intervals of 0.5 cm and pooled data were used to draw yearly length–frequency diagrams. Pairs of sagittal otoliths were removed from the individuals covering each length group, their excess tissues were cleaned, and they were stored inside microplates.

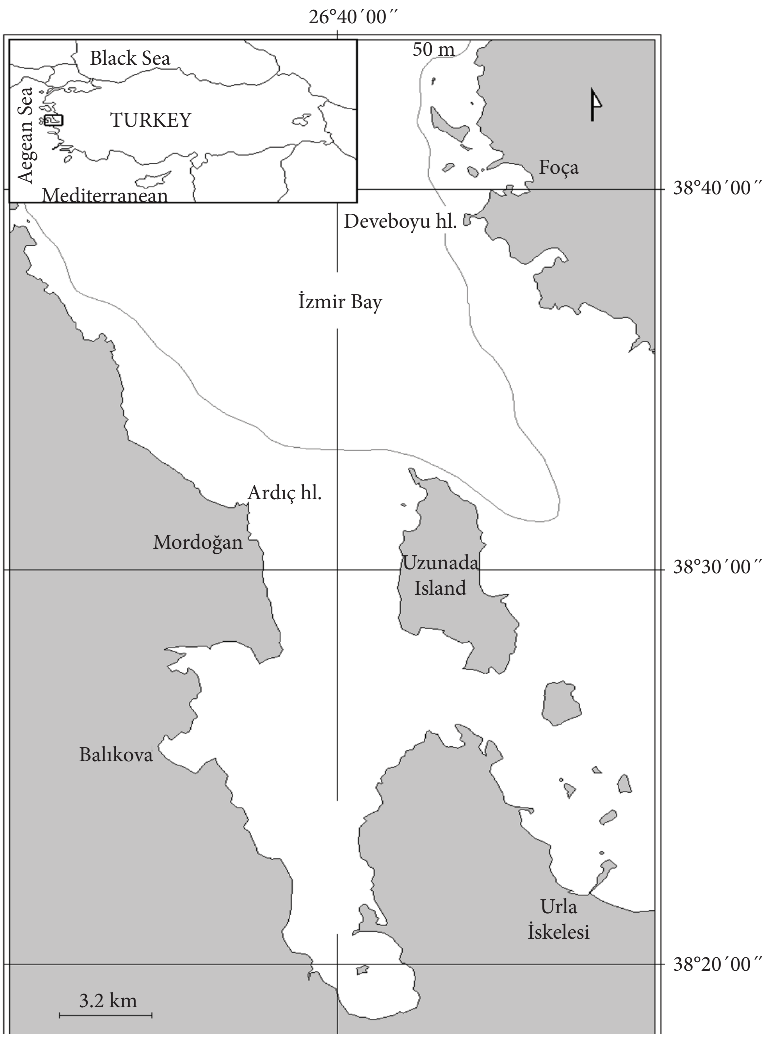


**Figure 1.** The study area.

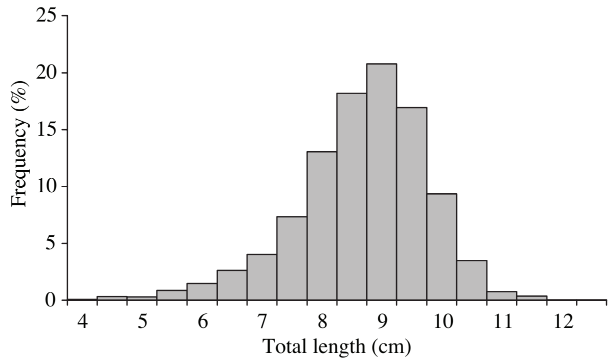


**Figure 2.** Total length–frequency distribution of the brown comber (*Serranus hepatus*) in the central Aegean sea.

For the determining of sex and maturity stages, macroscopic analyses were used. The maturity stages reported by Gunderson (1993) were used in the study as follows: stage I, immature; stage II, resting; stage III, developing; stage IV, ripe; and stage V, spent. All analysis was carried out independently of sex because the species is a simultaneous hermaphrodite.

The length–weight relationship was based on the equation $W = aL^b$, where $W$ is total body weight (g), $L$ is total length (cm), and $a$ and $b$ are coefficients (Ricker, 1973). The $a$ and $b$ parameters of the equation given above were calculated by linear regression analysis on log-transformed data. The coefficient of determination ($R^2$) was used to obtain the association degree between variables.

The otoliths belonging to all sampled size classes were taken for age determination using a stereoscopic zoom microscope under reflected light against a black background. Age determination was performed using opaque and transparent rings. The occurrence of these 2 zones together in the same otolith was considered to be the annual growth indicator. Furthermore, 2 independent readers carried out the age estimations.

Growth was analyzed by fitting the von Bertalanffy growth function to size-at-age data using standard nonlinear optimization methods (Sparre and Venema, 1998). Data were evaluated by the function $L_t = L_\infty\,[1 - e^{-k(t-to)}]$ where $L_t$ is the fish length (cm) at time $t$ (years), $L_\infty$ is the asymptotic length (cm), $k$ is the growth coefficient (years$^{-1}$), and $t_o$ (years) is the hypothetical time at which the length is equal to zero. Munro's growth performance index ($\varphi' = \log(k) + 2\log(L_\infty)$) and t-test (Pauly and Munro, 1984) were used to test the accuracy of the growth parameters.

The spawning period was obtained with monthly variations of the gonadosomatic index (GSI). The equation given by Ricker (1975), GSI = $[W_g / (W - W_g)] \times 100$, was used to determine the GSI (%), where $W_g$ is the gonad weight (g) and $W$ is the total weight (g) of fish.

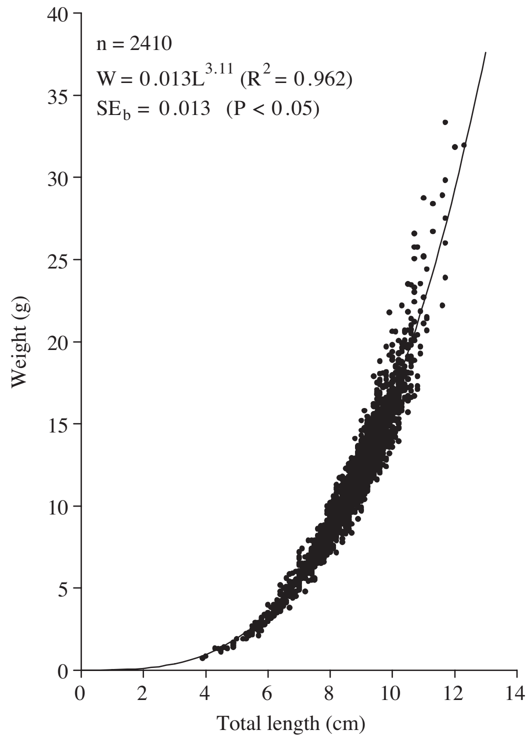


**Figure 3.** Length–weight relationship of the brown comber (*Serranus hepatus*) in the central Aegean Sea.

Length at first maturity ($L_m$) was calculated according to the method of King (1996). It was described as the length at which 50% of the population investigated was near spawning (King, 1996). An L50 computer program, performed with the LogLog function, was used to determine the length at 50% maturity (İlkyaz et al., 1998). The equations $r(l) = \exp(-\exp(-(a + bl)))$ and $L_m = (-\ln(-\ln(0.5)) - a)/b$ were applied, where $r(l)$ is the proportion of mature individuals in each length class (%), $l$ is the total length of fish (cm), $L_m$ is the mean length at sexual maturity (50%, cm), $a$ is the intercept, and $b$ is the slope.

## 3. Results

A total of 2410 brown combers (*Serranus hepatus* Linnaeus, 1758) were sampled during the study. Of those, 2290 (95%) were mature and 120 (5%) were juvenile. A length–frequency graphic is shown in Figure 2. The smallest individual was sampled in November, at 3.9 cm, while the longest was obtained in June, at 12.3 cm. The mean length of all samples was determined as 8.68 ± 0.02 cm.

The length–weight relationship was calculated as $W = 0.013L^{3.11}$ ($R^2 = 0.96$) (Figure 3) and positive allometric growth was determined for all individuals (t-test, $P < 0.05$, $SE_b = 0.013$).

The gonadosomatic index graphic is presented in Figure 4. It was observed that the gonadosomatic index

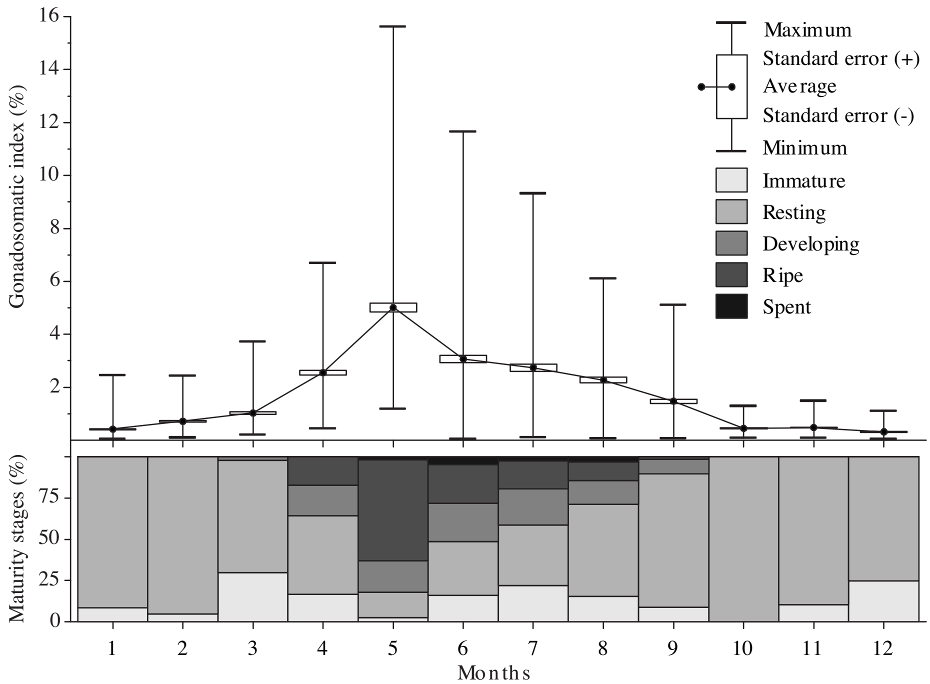


**Figure 4.** Monthly average gonadosomatic index (GSI) values (%) of the brown comber (*Serranus hepatus*) in the central Aegean Sea.

of the species reached the maximum value in May and gradually decreased until October. Similarly, the number of individuals within gonad stages III and IV were at a maximum in May and gradually declined to August.

Individuals of the stock ranged between 1 to 8 years of ages. Length at infinity ($L_\infty$) was calculated as 13.19 cm while weight at infinity ($W_\infty$) was 39.38 g, growth coefficient ($k$) was 0.252 $y^{-1}$, and the hypothetical time at which the length is equal to 0 ($t_o$) was –0.630 y ($a$ = 2.937, $b$ = 0.777, $R^2$ = 0.997) (Figure 5). The growth performance index (φ′) of the samples was determined as 1.642. This parameter of the previous studies is between 1.45 and 1.92 with mean 1.736 (Table). The t-test results showed that there was no significant difference between the growth performance indexes of the other studies (t-test = 0.034, P > 0.05).

The first gonad formation was observed at 4.0 cm for the species. The first reproduction length ($L_m$) was determined as 7.76 cm, corresponding to 3 years of age ($a$ = –25.896, $b$ = 3.337, $R^2$ = 0.893) (Figure 6).

## 4. Discussion

Despite its widespread occurrence, little information is available on the biology and ecology of the species. Brown comber is generally categorized as a species of low commercial value in the Mediterranean and a noncommercial species in Turkey, probably because of its small size. In this study, the total length of the species varied between 3.9 and 12.3 cm, with an average length of 8.68 ± 0.02 cm. Dulčić et al. (2007) determined the mean total length as 9.7 ± 1.29 cm, with a minimum of 5.8 cm and maximum of 13.0 cm. Labropoulou et al. (1998) found 3.1 and 14.0 cm total length for the smallest and largest specimen, respectively. Furthermore, Gürkan and Bayhan (2010) reported the minimum total length as 6.0 cm and the maximum as 11.1 cm in the Aegean Sea. The length range of the samples indicates a good sampling of the stock, including all length groups, and this situation can be observed in the length–frequency distribution diagram.

However, in this research, the length–weight relationship was $W = 0.013L^{3.11}$ ($R^2$ = 0.962) for all individuals, indicating a positive allometry. Our results

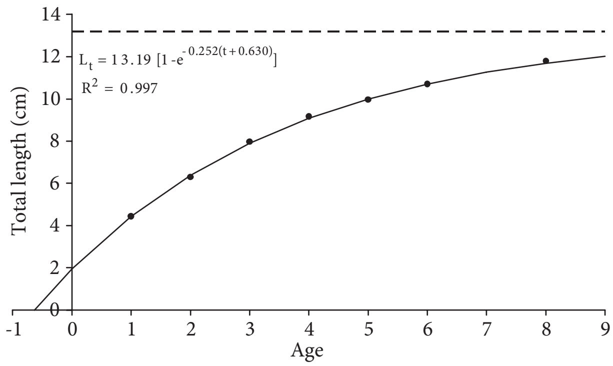


**Figure 5.** Growth curve of the brown comber (*Serranus hepatus*) in the central Aegean Sea.

**Table.** The length–weight relationships and growth data of the present and previous studies for brown comber (*Serranus hepatus*).

| LR | LT | n | *a* | *b* | GT | AR | $L_\infty$ | *k* | $t_o$ | φ′ | Author |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.9–12.3 | TL | 2410 | 0.013 | 3.11 | + | 1–8 | 13.19 | 0.252 | −0.630 | 1.642 | Present study |
| 5.2–11.7 | TL | 603 | 0.0157 | 2.998 | – | 0–4 | 11.9 | 0.56 | −1.14 | 1.90 | Bilecenoğlu (2009) |
| 5.8–13.0 | TL | 1218 | 0.010 | 3.19 | + | 2–7 | 14.82 | 0.217 | −1.672 | 1.68* | Dulčić et al. (2007) |
| | | | | | | | 10.6 | 0.248 | −0.44 | 1.45 | Bouain (1983) |
| 3.1–14.0 | TL | 1268 | | | | 0–5 | 15.2 | 0.36 | −0.57 | 1.92* | Labropoulou et al. (1998) |
| 8.5–13.8 | TL | 69 | 0.00006 | 2.720 | – | | | | | | Gonçalves et al. (1997) |
| 3.1–12.5 | TL | 153 | 0.025 | 2.840 | – | | | | | | Abdallah (2002) |
| 6.7–13.1 | TL | 123 | 0.0177 | 2.977 | – | | | | | | Borges et al. (2003) |
| 2.4–10.5 | TL | 584 | 0.0161 | 3.029 | + | | | | | | Çiçek et al. (2006) |
| 4.1–10.5 | TL | 64 | 0.0142 | 3.110 | + | | | | | | Veiga et al. (2009) |
| 3.4–7.9 | SL | 87 | 0.0111 | 3.123 | + | | | | | | Valle et al. (2003) |
| 6.0–11.1 | TL | 204 | 0.0096 | 3.223 | + | | | | | | Gürkan and Bayhan (2010) |
| 5.4–18.9 | TL | 87 | 0.0112 | 3.123 | + | | | | | | Dulčić and Glamuzina (2006) |

LR: length range (cm). LT: length type (TL: total length, SL: standard length). n: number of samples. *a* and *b*: intercept and slope of the length–weight relationships. GT: growth type (+/–: positive or negative allometric growth ($b \neq 3$)). AR: age range (years). $L_\infty$: the asymptotic length (cm). *k*: the growth coefficient (years$^{-1}$). $t_o$ : hypothetical time at which the length is equal to 0 (years). φ′: Munro's growth performance index. *: calculated (not reported by the author).

on length–weight relationship are similar to the studies conducted by Dulčić et al. (2007), Çiçek et al. (2006), Veiga et al. (2009), Valle et al. (2003), Gürkan and Bayhan (2010), and Dulčić and Glamuzina (2006), all having a positive allometry. However, Bilecenoğlu (2009), Gonçalves et al. (1997), Abdallah (2002), and Borges et al. (2003) reported negative allometry for the species. The probable reasons for these differences are considered to be the capture period, growth rate, stomach conditions, discrepancies regarding the maturity stages and age, disease, and parasite loads (Shepherd and Grimes, 1983; Weatherly and Gill, 1987). Nevertheless, findings regarding the length–weight relationships of previous studies are given in the Table.

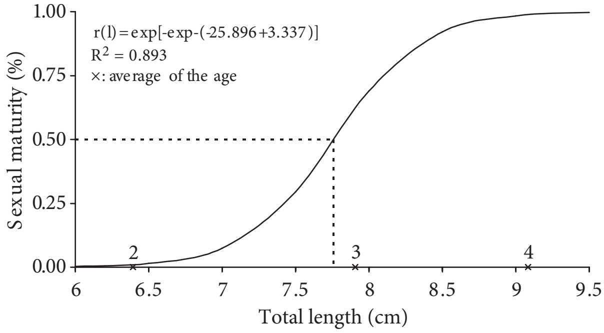


**Figure 6.** Estimation of the length at maturity of the brown comber (*Serranus hepatus*) in the central Aegean Sea.

Dulčić et al. (2007) reported on individuals between 2 and 7 years old. Furthermore, Labropoulou et al. (1998) determined the ages to be between 0 and 5 years and Bilecenoğlu (2009) reported the maximum age as 4 years. In our study, the age of the individuals varied from 1 to 8 years old. Regarding the growth parameters, the findings of other researchers are similar to those of the present work. However, the *k* value given by Bilecenoğlu (2009) differed remarkably from those of our study (n = 603, length range = 5.2–11.7, *k* = 0.56). Although the 2 studies were carried out in the same area, this difference is thought to result from the number of specimens observed, length and age range differences, and the sampling period. The growth performance index (φ') value (1.642) of our study fell within the values of previous studies, which varied between 1.45 (Bouain, 1983) and 1.92 (Labropoulou et al., 1998). Despite some small differences with the findings of other researchers on growth parameters, our results were similar and can be observed in the Table.

The spawning period of brown comber was determined to be between May and October. It was observed that the gonadosomatic index of the species reached the maximum value in May and gradually decreased until October. Furthermore, García-Díaz et al. (2006) reported the spawning season of another serranid species, the blacktail comber (*Serranus atricauda*), as being throughout the year in the Canary Islands. Tortonese (1986) reported the spawning season of brown comber as being between March and August. On the other hand, Truslé (1983) reported synchronous hermaphroditism and added that differentiation of the ovary was earlier than that of the testis. Dulčić et al. (2007) examined the gonads macroscopically during the maturity and spawning season, confirming that all observed specimens were simultaneous hermaphrodites. In the present work, brown comber gonads were examined macroscopically and, as a result of this, all observed specimens were determined as simultaneous hermaphrodites.

Poor findings on the reproduction of this species prevent comprehensive discussions. It has been reported that the spawning of the genus *Serranus* occurs as one fish in each pair of roles as a male and the other as a female, which results in cross-fertilization (García-Díaz et al., 2006). The authors also added that the histological description of gonad structure is fundamental for understanding reproduction. Furthermore, histological techniques are omitted in most reproduction studies because of the high costs and time consumption involved (García-Díaz et al., 2006). Sadovy and Domeier (2005) reported the difficulty of sexual pattern determination in the family Serranidae for 3 reasons. First, all individuals having a developmental phase including oocytes and an ovarian-like lumen makes the gonad impossible to distinguish by testicular morphology alone. Second, testicular tissue among the serranines arises in discrete islets, only visible in some areas of the gonad with careful observation. Finally, the last reason stated by the authors is considerable phenotypic plasticity of sexual expression in this family, with functional sexual patterns differing over time or across space.

In conclusion, brown comber, being the prey of many highly commercial species such as European hake (*Merluccius merluccius*), dusky grouper (*Epinephelus marginatus*), and forkbeard (*Phycis phycis*), is an important species for trophic relations and the ecosystem. Therefore, information on the stock status of the species becomes important when it directly affects the situations mentioned above. Thus, age, growth, and reproduction are topics that have crucial importance for stock assessment of brown comber, and these subjects were investigated in the central Aegean Sea.

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