

Complementary distribution of two sympatric serranids in a NATURA 2000 site in the Northern Aegean Sea (Eastern Mediterranean)

IOANNIS GIOVOS¹, KONSTANTINOS GANIAS¹ AND GEORGIOS SKOUFAS²

¹Ichthyology Lab, School of Biology, Aristotle University of Thessaloniki, Thessaloniki, Greece, ²Department of Fisheries Technology and Aquaculture, Alexander Technological and Educational Institute of Thessaloniki, Thessaloniki, Greece

*The present work aimed to investigate possible spatial and seasonal patterns in the distribution of two sympatric serranids, the painted comber, *Serranus scriba* and the comber, *Serranus cabrilla*. The research took place at a NATURA 2000 site located at Sithonia peninsula, N. Greece. Underwater visual census was used for data collection; specifically, individuals from each species were recorded along four isobathic transects of 200 m² each, placed every 5 m and ranging from 5 to 20 m depth. A total of 27 samplings were conducted between September 2010 and August 2011. The results clearly demonstrated complementary bathymetric distributions for *S. scriba* and *S. cabrilla*, the former mostly occurring until 10 m depth, and the latter in deeper layers. This pattern was maintained during the whole season. In addition the two species exhibited differences in their preferred substrate type and their pattern of association to the sea bottom. Our results were viewed under the light of resource partitioning between the two sympatric species.*

Keywords: Serranids, bathymetric distribution, Mediterranean, resource partitioning, *Serranus cabrilla*, *Serranus scriba*

Submitted 29 May 2014; accepted 19 September 2014; first published online 16 October 2014

INTRODUCTION

The painted comber, *Serranus scriba* (Linnaeus, 1758), and the comber, *Serranus cabrilla* (Linnaeus, 1758), are two of the most common and widespread littoral species in the Mediterranean Sea. While both species are reef associated, *S. scriba* shows higher preference for rocky substrates, mostly dwelling in rocky cavities, while *S. cabrilla* spends more time moving in the water column (Fasola *et al.*, 1997). In addition, *S. scriba* is often found in seagrass beds (*Posidonia oceanica*) while *S. cabrilla* is found both in seagrass beds (*P. oceanica* and *Cymodocea nodosa*) and in muddy and sandy bottoms (Tortonese, 1986; Guidetti & Cattaneo-Vietti, 2002; Giakoumi & Kokkoris, 2013). The two species are simultaneously hermaphroditic (Fisher & Petersen, 1987) and exhibit similar body size and shape with quite different colouration patterns (Table 1). Moreover minor differences have been reported in their feeding habits with the trophic level of *S. scriba* in the Mediterranean ranging from 3.70–3.87 and that of *S. cabrilla* from 3.30–4.37 (Stergiou & Karpouzi, 2002). Given that the two species usually occur in the littoral zone of the same broader areas, resource partitioning should be of major importance for the maintenance of their populations (Schoener, 1974; Sphigel & Fishelson, 1989).

Fasola *et al.* (1997) studied potential resource partitioning in a Mediterranean rocky slope fish assemblage and showed that *S. cabrilla* mostly occurs in deeper zones (maximum abundance: 36–42 m) than *S. scriba* (maximum abundance: 16–20 m). Vacchi *et al.* (1998) also worked at the fish-assemblage level and suggested a similar pattern, with *S. scriba* being mostly concentrated between 10–15 m and *S. cabrilla* between 25–30 m. The study of Guidetti & Cattaneo-Vietti (2002) was focused exclusively on the two species and assessed their distribution patterns in relation to the mineralogical features of their substrate; the authors provided evidence that *S. scriba* and *S. cabrilla* preferred granite and carbonate bottoms, respectively. Pais *et al.* (2004) investigated the distribution patterns in a fish assemblage, including *S. scriba* and *S. cabrilla* in relation to the substrate type (granite *vs* schist) and depth. However, the authors did not detect any patterns in the distribution of the two species either with depth or rock type, while similar results are also reported by Tunesi *et al.* (2006).

According to the previously mentioned literature the bathymetric distribution of *S. scriba* and *S. cabrilla* and the factors determining it still remain unclear. In addition, none of these studies has assessed possible seasonal patterns in the bathymetric distribution of the two species. The main objective of the present study was to assess seasonality in the bathymetric distribution of *S. scriba* and *S. cabrilla* in a Mediterranean littoral area. The association of individuals to the bottom and the physical characteristics of their habitat including the nature of the substrate were also examined.

Corresponding author:
K. Ganias
Email: kganias@bio.auth.gr

Table 1. Summary of habitat and life history characteristics for *Serranus scriba* and *Serranus cabrilla*.

Characteristic	<i>Serranus scriba</i>	<i>Serranus cabrilla</i>
Habitat	Rocky cavities, <i>Posidonia oceanica</i> , <i>Cymodocea</i> sp. beds ^{1,2}	Sandy, muddy bottoms ^{1,2}
Maximum size (TL)	~36 cm ¹	~40 cm ¹
Colouration	Versatile yellowish colouration with 5–7 vertical brownish stripes and a violet spot in the ventral area above the anal fin ³	Grey-reddish body covered with 7–9 grey vertical stripes disrupted by a pale ribbon along the middle body ³
Breeding season	Spring–Summer ⁴	Spring–early Summer ⁵
Food items	Small crustaceans (mainly decapods such as brachyurans) and small fish ⁶	Small crustaceans (mainly decapods) and small fish ⁷

¹ Tortonese (1986).

² Bussotti & Guidetti (2009).

³ Guidetti & Cattaneo-Vietti (2002).

⁴ Tuset *et al.* (1996).

⁵ Sabates (1990).

⁶ Arculeo *et al.* (1993).

⁷ Labropoulou & Eleftheriou (1997).

MATERIALS AND METHODS

Sampling

The spatial patterns of *Serranus scriba* and *Serranus cabrilla* were explored in two different surveys. The first survey assessed seasonality in bathymetric positioning of the two species while the second survey assessed their vertical positioning in relation to substrate type. The first survey took place at 'Akti Kalogrias' (AK) which is situated in Sithonia peninsula, Toronaïos Bay, N. Greece (Figure 1). According to NATURA 2000 Network, AK is placed inside a broader marine protected area which is also a site of community importance with the code name GR1270007. Although the study site belongs to NATURA 2000 Network, limited scientific data have been published about its marine communities and currently it has no established management structure. The survey took place over a small rocky reef, characterized by steep slope and a large amount of cavities and sandy patches. AK is highly touristic, especially during summer, while activities such as sport fishing or amateur fishing take place throughout the year. However, neither *S. scriba* or *S. cabrilla* are targeted in this region commercially or recreationally.

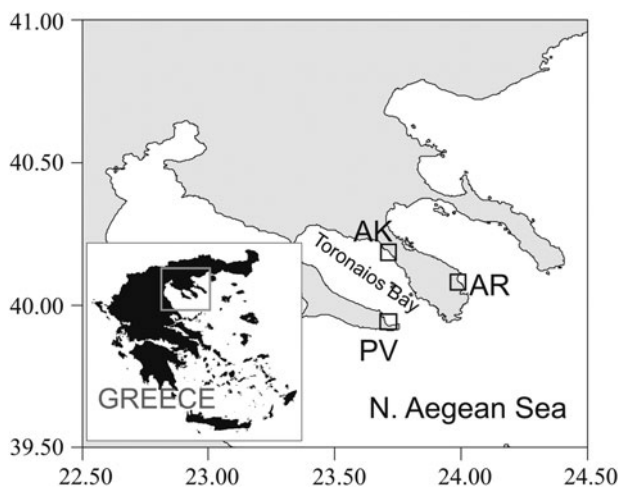


Fig. 1. Study area indicating the three sampling sites. AK, Akti Kalogrias; AR, Akti Armenistis; PV, Porto Valitsa.

Data collection in the first survey was based on a variation of the visual census method of Harmelin-Vivien *et al.* (1985). Specifically, instead of using ropes or strings that could disturb or attract individuals (Fasola *et al.*, 1997) distance measurements were based on the number of fin-kicks with 1 kick corresponding to 1 m. Application of such non-destructive methods is critical, especially for protected areas, because the acquisition of quantitative data has minimum impact on the marine environment. For both species, individuals were recorded along 4 isobaths of 100 m each placed every 5 m, ranging between 5–20 m depth. Depth was monitored using an Oceanic Veo 180Nx personal dive computer. Transects were not fixed but taken at random in each sampling. Given that the mean width of the visual field along each transect was 2 m the area covered in each isobathic transect (our sampling unit) was 200 m². Samplings were conducted once every 1–4 weeks between September 2010 and August 2011 making a total of 27 samplings.

The second survey took place immediately after analysing data from the first survey. Because the analysis showed that the two species exhibit seasonal consistency in their depth of occurrence (see Results section) all samplings were carried out during the same week in October 2011, at the preferred depth range of each species (*S. scriba*: 5–10 m; *S. cabrilla*: 15–20 m). Sampling was carried out at AK while two additional samplings were carried out at two neighbouring sites, 'Akti Armenistis' (AR) and 'Porto Valitsa' (PV) (Figure 1), in order to enhance the spatial resolution of our samples. Data collection followed a similar protocol to the one previously described for the first survey with the exception that stationary targets (small anchored buoys) were placed over the exact points at the bottom where individuals of *S. scriba* and *S. cabrilla* were initially spotted at 5–10 m and at 15–20 m transects respectively. The distance of each individual from the bottom, DIS [bottom dweller (BD), <25 and >25 cm] was also recorded. After completing the transects, the stationary targets were revisited in order to visually assess the dominant substrate type, ST (rocky patches vs sandy patches) at the 25 × 25 cm quadrat around each target.

Statistical analysis

Fish abundance, N (the number of fish per sampling unit), in the first survey was analysed pertinent to sampling depth and

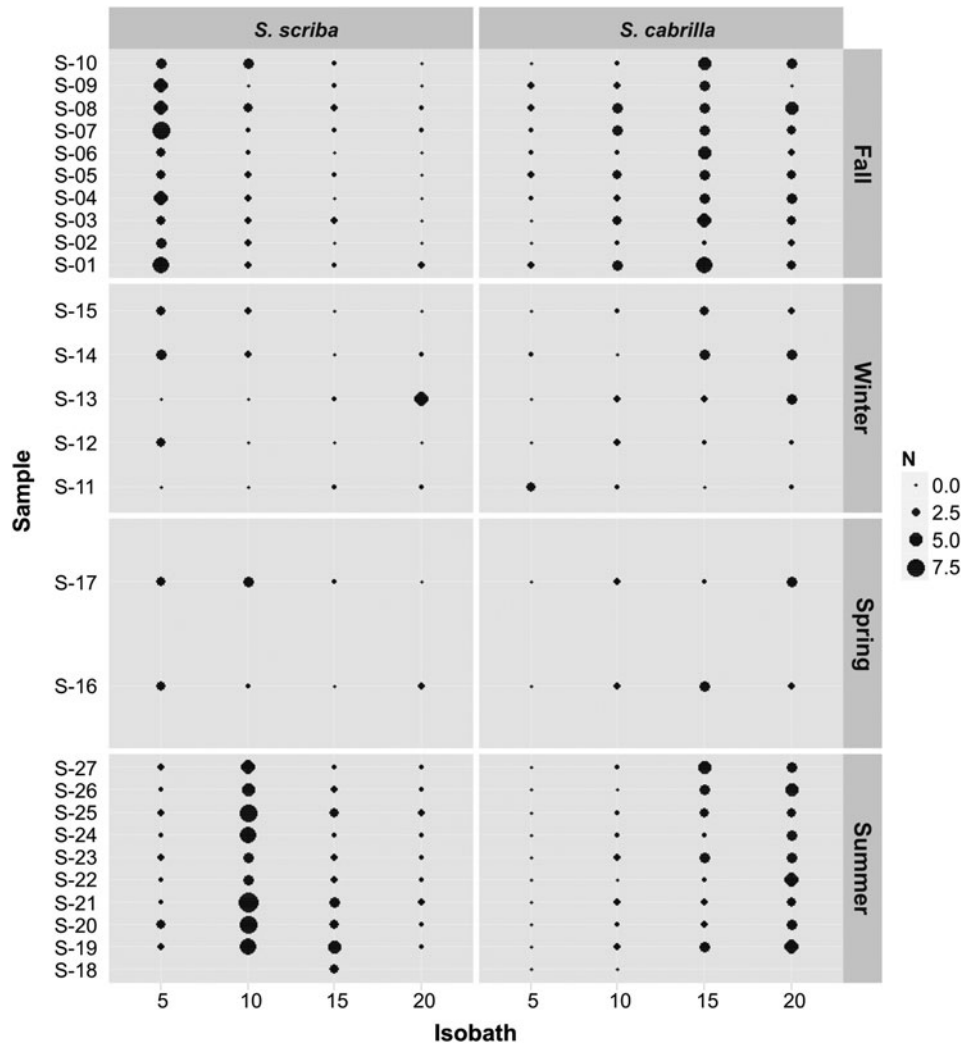


Fig. 2. Fish densities (N: number of individuals/200 m²) per species, sampling unit, season and isobath.

season. Given that N theoretically conforms to a Poisson distribution (integer-valued count data), it was primarily tested for over-dispersion through calculating the ratio of the residual deviance of the null model (i.e. only the intercept) to the residual degrees of freedom. The ratio was quite high ($1853/802 = 2.3$) suggesting that N data were over-dispersed, i.e. there was 2.3 more variation in the residuals than expected. Consequently, N data were modelled as a function of species (*S. scriba* or *S. cabrilla*), season (autumn, winter, spring, summer) and isobath (5, 10, 15, 20 m) using a generalized mixed effects model (GLMM) with an over-dispersed Poisson distribution and a logarithmic link function. All effects were treated as random variables, having isobath nested inside season, and season nested inside species. In order to account for over-dispersion a random effect was also included in the GLMM for the sampling unit. The variance components, i.e. the proportion of the random effect variance that is attributable to each random effect was estimated by dividing their variance to the total variance of random effects. We used the conditional modes (CM) of the random effects of the GLMM to describe the bathymetric trends for the two species. Data were analysed using R v.2.14.1 (R Development Core Team, 2012). GLMM analysis was performed using the package lme4

while graph plots were constructed using the package ggplot2.

The proportions of *S. scriba* and *S. cabrilla* in each DIS × ST category from the second survey were analysed using analysis of means (ANOM) while the interaction between DIS and ST was tested through contingency tables analysis. ANOM and contingency tables were performed using STATGRAPHICS v. 15.12.11.

RESULTS

Figure 2 shows the abundance of the two studied species per sampling unit, isobath and season. Simple visual examination of the plot suggests that *S. scriba* and *S. cabrilla* exhibit opposing bathymetric distribution trends, the former mainly occurring at the 5 and 10 m isobaths whilst the latter at the 15 and 20 m isobaths. GLMM analysis showed that almost 100% of the total variance of the random effects (species, season, isobath, sampling unit) was attributed to the nested effect of isobath (Table 2). The conditional modes (CM) of the random effects of the GLMM are showed in Figure 3. For all seasons, CM values in *S. cabrilla* tended to increase with depth (except between the 15–20 m isobaths in autumn)

Table 2. Variance components of the random effects used in the GLMM.

Random effect	Variance	SD	% Variance
Sampling unit	0.01	0.08	0.01
Species	0.00	0.00	0.00
Species : Season	0.00	0.00	0.00
Species : Season:Isobath	0.54	0.73	0.99

while the opposite pattern was generally observed for CM values in *S. scriba* (Figure 3). The most important deviation from this general pattern was observed for *S. scriba* in summer, when the highest CM score was found at the 10 m isobath.

In addition, the two species displayed differences both in the pattern of association to the bottom and in their preferred substrate type. Specifically, almost 58% of *S. scriba* were bottom dwellers while no individuals were recorded above 25 cm from the sea bottom. On the contrary, ~73% of *S. cabrilla* occurred above 25 cm from the bottom while none of them was bottom dwelling. Concerning the preferred

substrate type, most *S. scriba* were recorded over rocky bottoms (88%) while *S. cabrilla* were mostly recorded over sandy patches (54%). ANOM showed that the significantly higher proportion of *S. scriba* (48%) occurred >25 cm over sandy patches while the significantly higher proportion of *S. cabrilla* (46%) was dwelling over rocky bottoms (Figure 4). For both species contingency tables analysis showed that the pattern of association to the sea bottom was not related to the substrate type (*S. scriba*: $\chi^2 = 2.077$, d.f. = 2, $P > 0.1$; *S. cabrilla*: $\chi^2 = 3.203$, d.f. = 2, $P > 0.1$).

DISCUSSION

Our study showed that *S. scriba* and *S. cabrilla* exhibit complementary bathymetric distributions, the former mainly occurring at the 5 m isobath and the latter at the 20 m isobath, as already suggested in some studies (Fasola *et al.*, 1997; Vacchi *et al.*, 1998). However, our work is the first to assess bathymetric patterns on a seasonal basis showing that this complementary spatial pattern is maintained during the

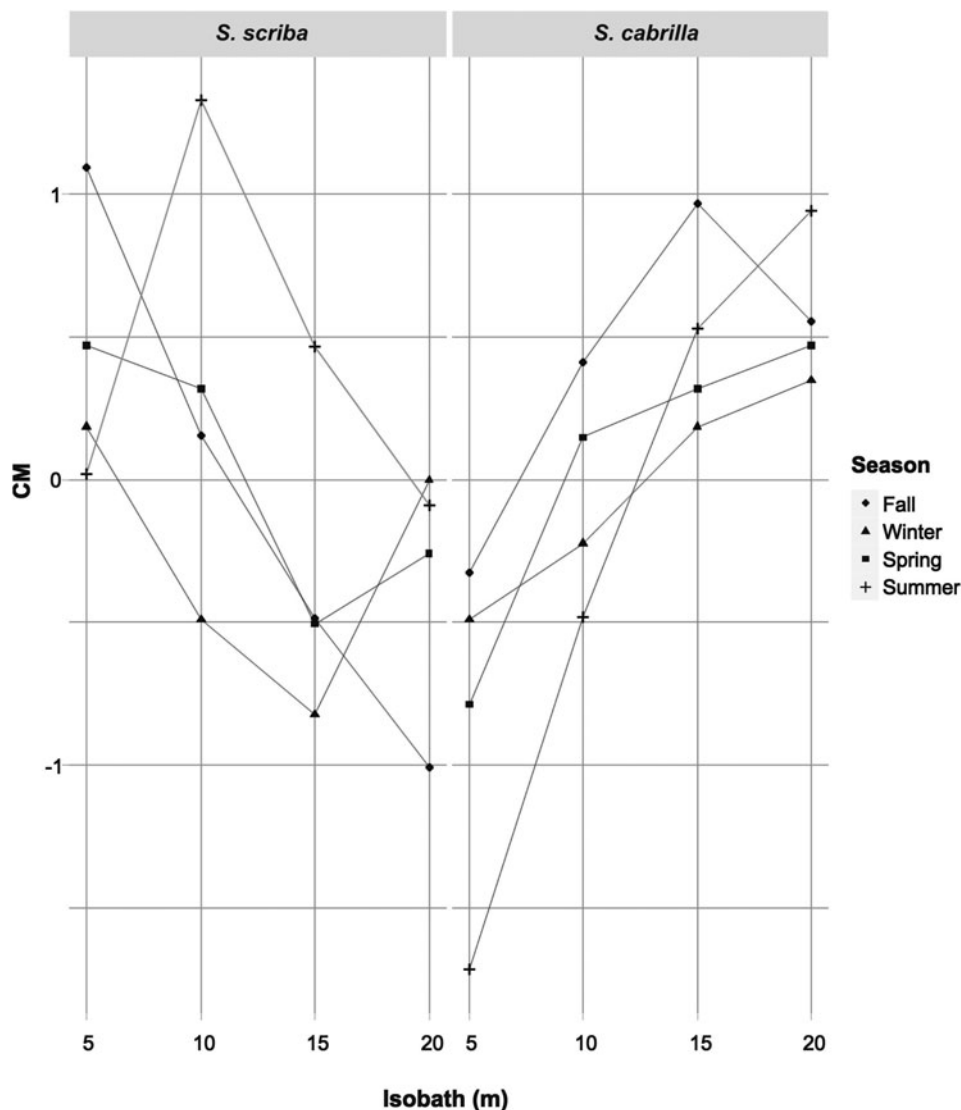


Fig. 3. Change of the conditional modes of the GLMM in each of the four isobaths per season for *S. scriba* and *S. cabrilla*.

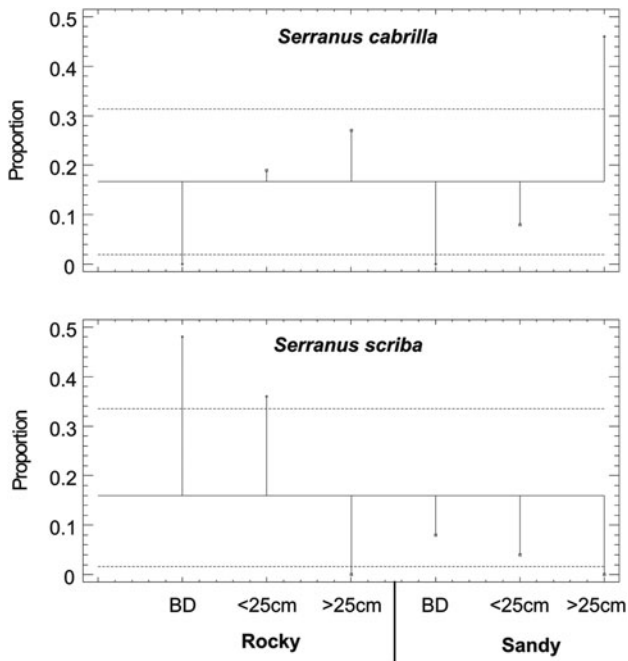


Fig. 4. Analysis of means (ANOM) plot for comparing the proportions of *Serranus cabrilla* and *Serranus scriba* in each substrate type (rocky vs sandy patches) and vertical positioning (BD: bottom dwelling, <25–14;cm >25 cm) class. Vertical bars represent the difference between the proportions and the grand mean (horizontal solid line). Dotted horizontal lines in plots represent 95% confidence limits.

whole season. This suggests that in both *S. scriba* and *S. cabrilla* bathymetric pattern is a well-established ecoethological adaptation regulated by endogenous and/or environmental drivers. A slight deviation from this general pattern was shown for *S. scriba* during the summer when highest densities occurred slightly deeper, at 10 m isobath (Figure 2). This can be attributed to depth repositioning of *S. scriba* due to changes of the physical parameters such as water temperature, light level, etc. (Rowe, 1994). On the other hand the possibility of human disturbance from touristic activities should not be ignored (Tuya *et al.*, 2006).

Differences in the bathymetric distribution between these two sympatric serranids could be linked to differences in their pattern of association to the seabed. Depth-related changes in reef gradient should be excluded as a possible cause since individuals of the two species occurred at locations of similar slope. On the other hand, *S. scriba* were almost always observed over rocky substrates and were mostly bottom dwellers whilst *S. cabrilla* were mostly observed over sandy substrates at distances more than 25 cm from the bottom. In that respect, populations of *S. scriba* would be more sensitive to hard substrate-related changes in the epibenthic biota.

Cerrano *et al.* (1999) and Bavestrello *et al.* (2000) showed for sandy and rocky bottoms respectively that increasing carbonate/quartz ratios are accompanied by steep declines in the population densities of both meiobenthic and macrobenthic organisms as a result of the top-down, bottom-up mechanism described by Menge (2000). Cattaneo-Vietti *et al.* (2002) and Guidetti *et al.* (2004) provided evidence that variation in the structure of epibenthic communities and fish assemblages resulted from differences in the mineralogical composition

of the substrate. In that respect the observed decrease of *S. scriba* with depth could be due to sediment-related decline in epibenthic preying fields. The increasing abundance of *S. cabrilla* with depth could thus be attributed to habitat partitioning given that the two species are sympatric; they display similar life histories and feeding habits (Arculeo *et al.*, 1993; Labropoulou & Eleftheriou, 1997) and should therefore partition their resources for maintenance of their populations.

The observed differences in the bathymetric distribution of the two species might further be related to differences in their colouration patterns. As already reported (Table 1), the colouration of *S. cabrilla* is disruptive along its sagittal plane, exhibiting a pale ribbon along the middle of its body. Such areas of contrasting colouration in disruptively coloured fish break up their outline, making them appear unfishlike and consequently more difficult to discern at lower light levels and at more homogeneous environments (Helfman *et al.*, 2009), which is the case with *S. cabrilla*. On the other hand, *S. scriba* lives at lower depths and on rocky bottoms of versatile colouration where water is more transparent and light is more abundant. Therefore conspicuous colouration and other visual cues such as the violet spot above the anal fin would be more important for interspecific visual communication, camouflage and so forth.

ACKNOWLEDGEMENTS

G. Orfanidis, M. Zoupas and A. Adamidis are thanked for helping IG during samplings.

REFERENCES

- Arculeo M., Froggia C. and Riggio S. (1993) Food partitioning between *Serranus scriba* and *Scorpaena porcus* (Perciformes) on the infralittoral ground of the South Tyrrhenian Sea. *Cybium* 17, 251–258.
- Bavestrello G., Bianchi C.N., Calcinaï B., Cattaneo-Vietti R., Cerrano C., Morri M., Puse S. and Sara M. (2000) Bio-mineralogy as a structuring factor for marine epibenthic communities. *Marine Ecology Progress Series* 193, 241–249.
- Bussotti S. and Guidetti P. (2009) Do Mediterranean fish assemblages associated with marine caves and rocky cliffs differ? *Estuarine, Coastal and Shelf Science* 81, 65–73.
- Cattaneo-Vietti R., Albertelli G., Bavestrello G., Bianchi C.N., Cerrano C., Chiantore M., Gaggero L., Morri C. and Schiaparelli S. (2002) Can rock composition affect sublittoral epibenthic communities? *Marine Ecology* 21, 65–77.
- Cerrano C., Arillo A., Bavestrello G., Benatti U., Calcinaï B., Cattaneo-Vietti R., Cortesogno L., Gaggero L., Giovine M. and Puse S. (1999) Organism-quartz interaction in structuring benthic communities: towards a marine bio-mineralogy. *Ecology Letters* 2, 1–3.
- Fasola M., Canova L., Foschie F., Novelli O. and Bressan M. (1997) Resource use by Mediterranean rocky slope fish assemblages. *Marine Ecology* 18, 51–66.
- Fisher E.A. and Petersen C.W. (1987) The evolution of sexual patterns in the seabasses. *Bioscience* 37, 482–489.
- Giakoumi S. and Kokkoris G.D. (2013) Effects of habitat and substrate complexity on shallow sublittoral fish assemblages in the Cyclades

- Archipelago, North-eastern Mediterranean Sea. *Mediterranean Marine Science* 14, 58–68.
- Guidetti P., Bianchi C.N., Chiantore M., Schiaparelli S., Morri C. and Cattaneo-Vietti R.** (2004) Living on the rocks: substrate mineralogy and the structure of subtidal rocky substrate communities in the Mediterranean Sea. *Marine Ecology Progress Series* 274, 57–68.
- Guidetti P. and Cattaneo-Vietti R.** (2002) Can mineralogical features influence distribution patterns of fish? A case study in shallow Mediterranean rocky reefs. *Journal of the Marine Biological Association of the United Kingdom* 82, 1043–1044.
- Harmelin-Vivien M.L., Harmelin J.G., Chauvet C., Duval C., Galzin R., Lejeune P., Barnabe G., Blanc F. and Chevalier R.** (1985) The underwater observation of fish communities and fish populations: methods and problem. *Revue d'Ecologie* 40, 467–540.
- Helfman G., Collette B.B., Facey D.E. and Bowen B.W.** (2009) *The diversity of fishes: biology, evolution, and ecology*. Chichester: John Wiley & Sons.
- Labropoulou M. and Eleftheriou A.** (1997) The foraging ecology of the two pairs of congeneric demersal fish species: importance of morphological characteristics in prey selection. *Journal of Fish Biology* 50, 324–340.
- Menge B.A.** (2000) Top-down and bottom-up community regulation in marine rocky intertidal habitats. *Journal of Experimental Marine Biology and Ecology* 250, 257–289.
- Pais A., Azzurro E. and Chessa L.A.** (2004) Distribution patterns of coastal fish assemblages associated with different rocky substrates in Asinara Island National Park (Sardinia, Italy). *Italian Journal of Zoology* 71, 309–316.
- R Development Core Team** (2012). *R: A Language and Environment for Statistical Computing*. Vienna: R Foundation for Statistical Computing. www.R-project.org.
- Rowe D.K.** (1994) Vertical segregation and seasonal changes in fish depth distributions between lakes of contrasting trophic status. *Journal of Fish Biology* 45, 787–800.
- Sabates A.** (1990) Distribution patterns of larval fish populations in the Northwestern Mediterranean. *Marine Ecology Progress Series* 59, 75–82.
- Schoener T.W.** (1974) Resource partitioning in ecological communities. *Science* 185, 27–39.
- Sphigel M. and Fishelson L.** (1989) Food habits and prey selection of three species of groupers from the genus of *Cephalopis* (Serranidae: Teleostei). *Environmental Biology of Fishes* 24, 67–73.
- Stergiou K.I. and Karpouzi V.S.** (2002) Feeding habits and trophic levels of Mediterranean fish. *Reviews in Fish Biology and Fisheries* 11, 217–254.
- Tortonese E.** (1986) Serranidae. In Whitehead P.J.P., Blauhot M.L., Hureau C., Nielsen J. and Tortonese E. (eds) *Fishes of the north-eastern Atlantic and the Mediterranean*. Volume 2. Paris: UNESCO.
- Tunesi L., Molinari A., Salvati E. and Mori M.** (2006) Depth and substrate type driven patterns in infralittoral fish assemblage of the NW Mediterranean Sea. *Cybium* 30, 151–159.
- Tuset V.M., Gonzalez J.A., Garcia-Diaz M.M. and Santana J.I.** (1996) Feeding habits of *Serranus cabrilla* (Serranidae) in the Canary Islands. *Cybium* 20, 161–167.
- Tuya F., Sanchez-Jerez P. and Haroun R.J.** (2006) Populations of inshore serranids across the Canarian Archipelago: relationships with human pressure and implications for conservation. *Biological Conservation* 128, 13–24.
- and
- Vacchi M., Bussotti S., Guidetti P. and La Mesa G.** (1998) Study of the coastal fish assemblage in the marine reserve of the Ustica Island (southern Tyrrhenian Sea). *Italian Journal of Zoology* 65, 281–286.

Correspondence should be addressed to:

K. Ganas
 Ichthyology Lab, School of Biology, Aristotle University of
 Thessaloniki, Thessaloniki, Greece
 email: kganas@bio.auth.gr