Nest-mediated parental care in a marine fish: Are large-scale nesting habitats selected and do these habitats respond to small-scale requirements?

SINOPOLI MAURO
ISPRA - Institute for Environmental Protection and Research, S.T.S. Palermo, Lungomare Cristoforo Colombo n. 4521 (Ex Complesso Roosevelt) Località Addaura, 90149 Palermo

CATTANO CARLO
Department of Earth and Marine Sciences, University of Palermo, Co.N.I.S.Ma.,via Archirafi 20, 90123 Palermo

CHEMELLO RENATO
Department of Earth and Marine Sciences, University of Palermo, Co.N.I.S.Ma.,via Archirafi 20, 90123 Palermo

TIPMANARO ANGELA
Department of Environmental Science, University of Parma, Parma, Parco Area delle Scienze 11/A, 43124 Parma

MILISENDA GIACOMO
IAMC - Institute for Coastal Marine Environment, CNR - National Research Council, Via Luigi Vaccara 61, 91026 Mazara del Vallo (TP)

GRISTINA MICHELE
IAMC - Institute for Coastal Marine Environment, CNR - National Research Council, Via Luigi Vaccara 61, 91026 Mazara del Vallo (TP)

http://dx.doi.org/10.12681/mms.14993
Nest-mediated parental care in a marine fish: Are large-scale nesting habitats selected and do these habitats respond to small-scale requirements?

MAURO SINOPOLI1, CARLO CATTANO1, RENATO CHEMELLO1, ANGELA TIMPANARO4, GIACOMO MILISENDA2 and MICHELE GRISTINA2

1 Stazione Zoologica "Anton Dohrn", Napoli, Villa Comunale, 80121, Napoli, Italy
2 IAMC - Institute for Coastal Marine Environment, CNR - National Research Council, Via Luigi Vaccara 61, 91026 Mazara del Vallo (TP), Italy
3 Department of Earth and Marine Sciences, University of Palermo, Co.N.I.S.Ma., via Archirafi 20, 90123 Palermo, Italy
4 Department of Environmental Science, University of Parma, Parma, Parco Area delle Scienze 11/A, 43124, Parma, Italy

Corresponding author: mauro.sinopoli@snz.it
Handling Editor: Konstantinos Tsagarakis

Received: 21 November 2017; Accepted: 20 February 2018; Published on line: 8 June 2018

Abstract

Fishes have evolved various reproductive strategies including mechanisms that involve parental care and demersal eggs laid into nests. *Symphodus ocellatus* has a seasonal reproduction period during which large, dominant males become territorial and build nests with fragments of algae, where they attract females to spawn and provide care to the developing eggs. Based on the hypothesis that the *S. ocellatus* males choose the reproductive habitat based on some characteristics of the substrate, here we assessed whether, on a coastal area scale, the distribution of this species changes during the reproductive period because of the selection of some suitable sites or substrates, and whether the nesting microhabitat used by this species responding to certain requirements in relation to different characteristics. From April to September 2010, at four locations and on three substrate types, the fish were counted in three periods related to different stages of reproduction. Furthermore, several physical and biological variables have been recorded around numerous nests to select those with more recurrence. We found that *S. ocellatus* prefers to live on rocky substrates populated by photophilic algae, regardless of the phases of the reproductive cycle. We identified depth (1.7–3.2 m), the presence of a hole, a 10–20 cm algal canopy, and high algal coverage of Dactiotales as nest requirements. *S. ocellatus* is mostly distributed in coastal sites sheltered from the action of waves. This allows the construction and maintenance of nests and the possibility to remain in a water temperature range similar to the reproductive physiological constraints.

Keywords: Nest-building; Labridae; habitat selection; habitat requirement; *Symphodus ocellatus*.

Introduction

Many marine fish species inhabit shallow coastal areas, where anthropogenic disturbances tend to be most frequent and severe, representing the main threat to their survival. Because life history strategies of coastal fish are in association with high habitat specialization, these animals are particularly vulnerable both to habitat loss/deg- rradation and to exploitation (Reynolds et al., 2005). Fish species have evolved various strategies to increase their reproductive success, including simple processes (e.g., reproduction of pelagic species in the water column) and complex mechanisms that involve parental care as demersal eggs laid within nests (Andersson, 1994; Balon, 1975; Taborsky et al., 1987). *Symphodus ocellatus* (Linnaeus, 1758) is a nesting wrasse that is widespread in shallow rocky and vegetated areas of the Mediterranean Sea, Black Sea, and Sea of Azov (Quignard & Pras, 1986). This species has a seasonal reproduction period (from May to early August) during which large, dominant males become strictly territorial and build nests with fragments of algae, to which they attract females to spawn and provide care to the developing eggs (Lejeune, 1985; Warner & Lejeune, 1985; Taborsky et al., 1987; Sinopoli et al., 2015). Dominant building males are often helped by satellites males (with a slightly different color pattern) to defend the nests from other opportunist males (sneakers) (Taborsky et al., 1987; Taborsky, 1994, Alonzo et al., 2000). Females visit multiple nests before selecting one for spawning (Taborsky et al., 1987) and seem to

http://epublishing.ekt.gr | e-Publisher: EKT | Downloaded at 18/06/2019 01:22:00 |
prefer those where other females have already spawned (i.e., mate-choice copying) (Alonzo, 2008) and with fewer sneaker males present (Alonzo & Warner, 2000). Embryonic development lasts about 80 h and, after hatching, swimming larvae have a pelagic phase (PLD) of 8–11 days, after which they settle on shallow habitats amongst branching algae (Raventos & McPherson, 2001).

A study by Garcia-Rubies & Macpherson (1995) reports that the larval recruitment of S. ocellatus occurs both on rocky bottoms with a high algal cover and, to a lesser extent, on P. oceanica from July to September. Some studies report that adults are more abundant in rocky substrates with algal coverage (Letourneur et al., 2003; Lipej et al., 2009). Other studies, however, show higher density on P. oceania and other seagrass meadows (Guidetti, 2000; Moretti et al., 2002). Mouillot et al. (1999) reported that larger fish are more abundant on rocky substrates, whereas smaller sized fish were more abundant on P. oceanica meadows.

Beyond this information, there are no studies indicating that, during the reproductive phase, S. ocellatus individuals choose to populate hard substrates more than soft substrates. Sinopoli et al. (2015) found that nesting males of S. ocellatus actively selected some algal species for nest building, particularly the coralline Jania rubens and the brown alga Dictyota linearis. The choice of these species was justified by their mechanical strength, their capacity to accommodate eggs, and their resistance to biochemical decomposition and wave action. Despite the evidence that S. ocellatus specifically chooses components to build the nest, it is still unclear if the choice of the nest site in S. ocellatus is influenced by specific characteristics of the microhabitat. Several studies regarding different nesting fishes highlighted difference in nests and nest sites, even if this difference led to variation in mating success (Werners et al., 1989; Alonzo & Heckman, 2010). For species in which egg predation is common, many authors have suggested that the quality of the nest depends on some characteristic of the nesting site, such as camouflage (Sargent & Gebler, 1980; Kraak et al., 2000; Candolin & Salesto, 2006).

However, since the structure of the habitats and the algal coverage determine the extent of the territory where courtship activities take place (Candolin & Voigt, 2001), sites that are overly hidden can be disadvantageous, making the nests poorly visible to potential partners (Mori, 1995).

The construction of the white coral reef habitat is significantly influenced by the characteristics of the substrate, the physical, structural, or biological requirements/characteristics of the substrate, we tried to answer two questions. (1) On a coastal area scale, is the habitat occupancy of this species along several sites and substrates constant or does it change during the reproductive period because of a selection of suitable sites or substrates? If these hypotheses are true, we would expect to detect significant differences in the abundances of S. ocellatus when comparing the pre- and post-reproduction periods. (2) If nesting sites are selected based on certain physical, structural, or biological requirements/characteristics, we would expect to see a significant recurrence of specific variables near the nests.

Material and Methods

Study area

The study was conducted in 2010 along the Tyrrhenian coasts of Sicily between Capo Gallo and Isola delle Femmine MPA (Fig.1). This coastal stretch of about 8 km is characterized by a high substrate heterogeneity with a mosaic of rocky substrates, Posidonia oceanica meadows, and wide patches of sandy bottoms. The algal community associated with the rocky substrate in the upper subtidal zone is dominated by photophilous Fucophyceae Cystoseira brachycarpa and C. compressa (Riggio & Raimondo, 1991). Furthermore, substrates at the base of the erect algae and in the dark microhabitat, algal communities are dominated by scaphylous species, such as Corallina elongata and Jania rubens (Giaccone et al., 1985; Mannino et al., 2011).

Large scale site selection

To test the hypothesis that the habitat occupancy of individuals of S. ocellatus varies among the factors characteristic of substratum (CS), reproductive cycle phase (RP), and locations (LC), the following experimental design was developed: a) For CS factor three levels were chosen: sandy (SND), rocky (RCK) and Posidonia oceanica meadows. The study area in northern Sicily (Tyrrhenian Sea); H1 = Barcarello, H2 = Cala Isola, L1 = Isolotto, L2 = Capo Gallo.
anica (POS); b) For the RP factor, we chose three levels: pre-reproductive (PRE, April), reproductive (REP, July), and post-reproductive (POST, September); and c) The choice of levels for the LC factor was based on preliminary observations made during the reproduction period. Indeed, at several locations along the coast, the density of nests varied greatly among locations with the same environmental characteristics. Two high (about 2 nests/10 m², H1; Barcarello and H2; Cala Isola) and two low-density sites (about 0.2 nests/10 m², L1; Isolotto and L2 Capo Gallo) were chosen. We hypothesized that *S. ocellatus* actively chooses high density sites. If true, in periods away from the nest building, *S. ocellatus* individuals should have comparable abundances in high and low-density of nests. This preliminary observation was confirmed that, at all locations, most *S. ocellatus* were found at depths of between 2 and 8 m, as has been reported in other studies (Mouillot *et al.*, 1999; Ruitton *et al.*, 2000; Letourneur *et al.*, 2003). The fish were counted by underwater visual census (UVC). In this case, a modified version of the fixed point technique (D’Anna *et al.*, 1999) was adopted. Scuba divers, using metric references, defined a circle with a diameter of 5 m (19.6 m²). Inside the circle, individuals of *S. ocellatus* were counted for 5 min. Each sample was replicated three times for each of the factors considered in the experimental design, for a total of 108 censuses. To avoid multiple fish counting, a minimum distance of 20 m was set between samples. The choice of this distance was justified by preliminary observations in which *S. ocellatus* showed high residence times and minimum displacement (Sinopoli *et al.*, 2015).

Data were expressed as the mean ± standard deviation (s.d.). To test the significance of the observed differences, an analysis of variance (ANOVA) was performed (Underwood 1997).

**Habitat requirements**

With the aim of finding the highest number of nests possible, we designed a standardized protocol. In this protocol, the SCUBA diver explored a large extent of about 500 m², making routes aimed at covering most of the area. During sampling, the following biotic and abiotic variables were recorded for each nest: the depth of each nest; nest height (i.e. the depth in centimeters of the concavity formed by the nest); average height (in centimeters) of the algal canopy surrounding the nest; type of cavities used for nest building; crevice type (fracture or fissure) in rocks with irregular margin, shape, and variable size; the presence of a hole (a hollow place or cavity with regular margin and circular shape and size constantly, around 10–15 cm in diameter); slope of the substrate in degree (°) being 0° the sea surface; slope Macro (the slope exclusively related to the nest); and the presence [as a percentage cover of the most abundant algal taxa (*Dictyotales*, *Cystoseira* spp. and *Jania rubens*)] or sandy substrate in a circular area of 9 m²]. This surface corresponds to the range of activity during nesting estimated by Sinopoli *et al.* (2015).

To investigate the presence of high suitability zone for the presence of a nest, a count data matrix has been constructed, using the number of nests as the response variable, and three categorical covariates as independent variables. These were: 1) “Deep range”, with three levels (low, 0–1.6 m; medium, 1.7–3.2 m; and high, 3.3–5 m); 2) “type of cavities”, with two levels (hole and crevice); and “canopy height” (tall, 2–10 cm; medium, 10.1–20 cm; high, 20.1–30 cm). As our response variable was a count data, we implemented a generalized linear model (GLM) with Poisson family distribution. Moreover, a GAM model with (10–20 cm) has been used to investigate the relation between the number of the nest and the coverage percentage algal composition. For both models, we started with a full model using the complete interaction among covariates, and use the function step AIC to select the final model, which had the lowest AIC value and the largest explained variance. The complete check of residual’s model and an over-dispersion value below the limit value of 2 have been used to validate our analysis (Zuur *et al.*, 2009).

**Results**

**Large scale site selection**

During the entire period of the study, 162 specimens of *S. ocellatus* were surveyed. The distribution of these fish along locations and habitats was not influenced by their reproductive phase (Fig. 2; Table 1). The density of *S. ocellatus* was significantly higher in the RCK habitat than in the SND and POS habitats. The distribution of *S. ocellatus* was higher at H1 and H2 localities than at L1 and L2, confirming the preliminary observation, but for all the phases of the life cycle (Fig. 2; Table 1).

**Habitat requirements**

The characteristics of 84 nesting sites were recorded. The mean depth where nests were found was 2.6 ± 0.9 m, the mean canopy was 11.6 ± 5.9 cm, and the mean substrate slope was 56 ± 22° (Table 2). *Dicyotiales* resulted the most abundant algal group in the microhabitat with a mean presence of 46.5 ± 22.5% (Table 2).

Our GLM model indicated that depth 2 (1.7–3.2 m), hole and canopy 2 (10–20 cm) were the abiotic nest features that represent nest requirements (Fig. 3, Table 3). Our GAM model highlighted a significant effect of the seaweed coverage (for all three seaweeds) on the number of nests encountered. The nests were composed of 40–50% of *Dicyotiales*, 20–30% of *Cystoseira*, and 10–15% of *Jania* (Fig. 4, Table 4).
Discussion

We found that the overall density of *S. ocellatus* is comparable with that observed in other studies carried out in other areas of the Mediterranean sea using the visual census technique (Francour, 1997; Mazzoldi & De Girolamo, 1998; Guidetti, 2000; De Girolamo & Mazzoldi, 2001; Guidetti & Bussotti, 2002; Letourneur *et al.*, 2003).

The higher density of the ocellated wrasse found associated with rocky substrate than with other substrates was also reported in a one-year study in the Lavezzi Islands (north-western Mediterranean Sea; Mouillot *et al.*, 1999) but only for larger size specimens. A higher number of *S. ocellatus* was also found in the Lavezzi Islands when compared to the Capo Gallo site, which was in agreement with previous studies in other areas of the Mediterranean Sea. These differences in density could be due to differences in the physical characteristics of the substrate, such as the presence of cracks and crevices, which provide shelter for the wrasses. Further studies are needed to better understand the factors that influence the distribution of *S. ocellatus* in the Mediterranean Sea.

**Table 1.** Results of the ANOVA. RP = reproduction phases; LC = location; CS = characteristic of substratum; SND = sandy substrate; POS = *Posidonia oceanica* substrate; RCK = rocky substrate; H1 = Barcarello; H2 = Cala Isola; L1 = Isolotto; L2 = Capo Gallo; SNK = Student-Newman-Keuls test.

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>RP</td>
<td>2</td>
<td>0.5</td>
<td>0.2 *</td>
</tr>
<tr>
<td>LC</td>
<td>3</td>
<td>69.7</td>
<td>34.6**</td>
</tr>
<tr>
<td>CS</td>
<td>2</td>
<td>219.0</td>
<td>109**</td>
</tr>
<tr>
<td>RP x LC</td>
<td>6</td>
<td>0.4</td>
<td>0.2 *</td>
</tr>
<tr>
<td>RP x CS</td>
<td>4</td>
<td>0.6</td>
<td>0.3 *</td>
</tr>
<tr>
<td>LC x CS</td>
<td>6</td>
<td>71.0</td>
<td>35.3**</td>
</tr>
<tr>
<td>RP x LC x CS</td>
<td>12</td>
<td>0.4</td>
<td>0.2 *</td>
</tr>
<tr>
<td>RES</td>
<td>72</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td>TOT</td>
<td>107</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source</th>
<th>SNK</th>
<th>SND</th>
<th>POS</th>
<th>RCK</th>
</tr>
</thead>
<tbody>
<tr>
<td>RP</td>
<td>L1</td>
<td>=L2=H1=H2</td>
<td>L1 =L2=H1=H2</td>
<td>H1 = H2 &gt; L1 = L2</td>
</tr>
<tr>
<td>LC</td>
<td>L1</td>
<td>=L2=H1=H2</td>
<td>L1 =L2=H1=H2</td>
<td>H1 = H2 &gt; L1 = L2</td>
</tr>
<tr>
<td>CS</td>
<td>L1</td>
<td>=L2=H1=H2</td>
<td>L1 =L2=H1=H2</td>
<td>H1 = H2 &gt; L1 = L2</td>
</tr>
</tbody>
</table>

**Table 2.** Mean value (± standard deviation) of all the variable sin the 84 nest sampled for habitat requirements.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean</th>
<th>S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth (m)</td>
<td>2.7</td>
<td>0.9</td>
</tr>
<tr>
<td>Hole/Crevise</td>
<td>1.3</td>
<td>0.5</td>
</tr>
<tr>
<td>Nest height (cm)</td>
<td>7.2</td>
<td>2.9</td>
</tr>
<tr>
<td>Canopy mean</td>
<td>11.7</td>
<td>5.8</td>
</tr>
<tr>
<td>Slope (°)</td>
<td>56.4</td>
<td>22.7</td>
</tr>
<tr>
<td>Slope macro (°)</td>
<td>2.0</td>
<td>0.8</td>
</tr>
<tr>
<td>% Dictyotales</td>
<td>46.5</td>
<td>22.5</td>
</tr>
<tr>
<td>% Cystoseira</td>
<td>24.6</td>
<td>20.1</td>
</tr>
<tr>
<td>% Jania</td>
<td>18.4</td>
<td>19.5</td>
</tr>
<tr>
<td>% Sand</td>
<td>1.5</td>
<td>6.3</td>
</tr>
</tbody>
</table>

**Fig. 2:** Mean (± standard deviation) number of *Symphodus ocellatus* individuals in the three reproductive phase (PRE = before reproduction, REP = during reproduction, POST = after reproduction) on the three substrates (SND = sandy substrate, POS = *P. oceanica* substrate, RCK = rocky substrate) and in the four locations (H1 = Barcarello; H2 = Cala Isola; L1 = Isolotto; L2 = Capo Gallo).
ocellatus on rocky substrate was also found in the summer in the Frioul Archipelago (north-western Mediterranean Sea; Letourneur et al., 2003), while Lipej et al. (2009), in the North Adriatic Sea, found that the density of S. ocellatus individuals was higher in rocky vegetated substrates during the reproductive period (June to August). By contrast, Guidetti (2000) found that S. ocellatus was more abundant in Posidonia oceanica substrate than on rocky substrate, whereas the species was not observed on sandy substrate. The high density of small sized specimens of the ocellated wrasse on seagrass meadows was also found by Mouillot et al., (1999). Guidetti & Bussotti (2002) found high densities of this fish associated with two other seagrasses (Cymodocea nodosa and Zostera noltii) in the coasts of Sardinia (Northern Tyrrhenian Sea). However, they did not include rocky bottoms in their experimental design.

Our results show that the reproductive phase did not influence the distribution nor the density of S. ocellatus along different substrates. No studies have compared the density of this species along different substrate strictly tied to reproductive phases. The higher presence of ocellated wrasse associated with rocky substrate was observed over all seasons in the north-western Mediterranean (Mouillot et al., 1999). The habit of fish to not change the used substrate during the season was already recorded by Guidetti (2000), even if in this case fishes remain associated with P. oceanica. This contrasts with the needs of the reproductive male of building a nest in the hole of a hard substrate using algal fragment (Sinopoli et al., 2015). The evidence that a part of the population does not live closely associated with rocky substrates could be justified by the fact that not all individuals are involved in reproduction during the nest building period. In fact, based on several factors (e.g., sexual maturity stage or energy reserves accumulated by sexually mature specimens), a portion of the population sometimes skips the reproduction season (Taborsky et al., 1987). This part of the population shows a different pattern of schooling behavior and a different use of substrate (Budaev, 1997).

Despite the comparability of substrate features in terms of presence of patches of rocky, sandy and P. oceanica dominance, depths and slope, the high-density zone remains the most populated by the ocellated wrasses over all of the season, including the non-reproductive periods. Other factors can influence the choice of these areas. Francour (1997), sampling on seagrass meadows of different sites, recorded a higher density of S. ocellatus

<table>
<thead>
<tr>
<th>Variable</th>
<th>Df</th>
<th>R²</th>
<th>Chi²</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth Range</td>
<td>2</td>
<td>8.82</td>
<td>0.012</td>
<td>*</td>
</tr>
<tr>
<td>Type Of Cavities</td>
<td>1</td>
<td>10.28</td>
<td>0.001</td>
<td>**</td>
</tr>
<tr>
<td>Canopy’s Height</td>
<td>2</td>
<td>25.78</td>
<td>2.5*10⁻⁶</td>
<td>***</td>
</tr>
</tbody>
</table>

**Fig. 3:** Mean (+ standard deviation) depth and size of the hole/crevice and canopy of the 84 studied nests.

**Table 3.** GLM (General Linear Model) results performed on three categorical independent variables. Significance value is given as ***p value < 0.001, **p value < 0.01, *p value < 0.05.

<table>
<thead>
<tr>
<th>Variable</th>
<th>eDf</th>
<th>Chi²</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cystoseira</td>
<td>2.97</td>
<td>53.2</td>
<td>***</td>
</tr>
<tr>
<td>Dictyotales</td>
<td>2.67</td>
<td>20.86</td>
<td>***</td>
</tr>
<tr>
<td>Jania</td>
<td>5.01</td>
<td>93.78</td>
<td>***</td>
</tr>
</tbody>
</table>

**Table 4.** GLM (General Linear Model) results performed on three principal independent algal variables. Significance value is given as ***p value < 0.001, **p value < 0.01, *p value < 0.05.

**Fig. 4:** The abundance of nests and the percentage cover of the three principal algal species around the nests.
in small gulfs and sites protected from exposure to open water than in sites exposed to wave action. Mazzoldi & De Girolamo (1998) reported a greater abundance of this species in the rocky habitats less exposed to the currents and the wave action compared to open sea sites. Even our high-density sites are located in more sheltered areas. Therefore, it seems that S. ocellatus prefers sheltered than wave-exposed sites, independent of the reproductive period. This choice is in agreement with the findings of Raventos (2004), who reported a higher risk of nest destruction in areas with high exposure to waves.

Nest site characteristics were specifically investigated for Simphodus roissali in the northwest Mediterranean Sea (Raventos, 2006) and for S. roissali, S. ocellatus, and S. cinerus in North Adriatic Sea (Lipej et al., 2009). In that study, it was noted that these holes are the approach similar to the one used in our research. Indeed, to determine the main microhabitat requirements of the nests, they have focused on those features that often recur near nests.

Nesting males of S. roissali select nest sites mainly on flat substrata and close to the rocky littoral strip (Raventos, 2006). A preference for flat substrates was also found by Lipej et al. (2009) together with a significant presence of Cystoseira barbata. Both authors justified this by suggesting that nesting males actively select sites that are more visible to females. Some similarity was found between the microhabitat characteristics of S. ocellatus nesting reported by Lipej et al. (2009) and our results. Indeed, in this study, we showed that the choice of site for nest building is related to the presence of brown algae of the order Dicotiales brown algae and algal canopy in the microhabitat. It is difficult to give a functional meaning to this feature of the nesting sites.

The reproductive success in nesting fish species might depend on the trade-off between nest concealment (that ensures protection by predators and opportunistic males) and nest visibility (that is crucial for attracting the highest possible number of females) (Lejeune, 1985; Wernerus et al., 1989; Alonzo & Warner, 2000; Uglem & Rosenqvist, 2002). Algal canopy height increases nest camouflage. For S. roissali, this effect was compensated because nests were near the margins of the rocky littoral strip. This made nests more visible to S. roissali (Raventos, 2006).

The presence of a circular hole in the substrate was identified as an important feature of the nest microhabitat and as preferable to crevices. Circular holes are present in the hard substrates and are the result of the corrosive actions of water movements (Alexander, 1932; Wentworth, 1944). From previous studies (Sinopoli et al., 2015) it was noted that these holes are the ideal initial nucleus for nest construction. This is because the holes help to keep algae together by counteracting the forces of water motion. Although crevices can be used to build the nest, they do not have the same qualities in retaining the algae.

Our study suggests that a depth between 2.7 and 3.2 m is most suitable for S. ocellatus nesting. Lipej et al. (2009) reported 5.5 m as the mean depth of the nest presence; however they did not give any functional justifica-

**References**


Alonzo, S.H., Taborsky, M., Wirtz, P., 2000. Male alternative re-
productive behaviours in a Mediterranean wrasse, Sympho-
dus ocellatus: Evidence from otoliths for multiple life-history
Balon, E.K., 1975. Reproductive guilds of fishes, a proposal
and definition. Journal of the Fisheries Board of Canada,
32, 821-864.
Bentivegna, F., Benedetto, F., 1989. Gonochorism and seasonal-
al variations in the gonads of the labrid Symphodus (Cren-
ilabrus) ocellatus (Forsskål). Journal of Fish Biology, 34
(3), 343-348.
Boudouresque, C.F., 1984. Groupes ecologiques d’algues ma-
rines et phytoenoses benthiques en Mediterranee nord occi-
dentale: une revue. Giornale Botanico Italiano, 118
(2), 7-42.
Budaev, S.V., 1997. Alternative styles in the European wrasse,
Symphodus ocellatus: boldness-related schooling tendency.
Environmental Biology of Fishes, 49 (1), 71-78.
and territory quality: consequence of male competition or
predation susceptibility? Okos, 95 (2), 225-230.
Candolin, U., Salesto, S., 2006. Effects of increased vegetation
cover on nesting behavior of sticklebacks (Gasterosteus acu-
Questions arising from the use of visual census in natural and
De Girolamo, M., Mazzoldi, C., 2001. The application of visual
census on Mediterranean rocky habitats. Marine Environ-
mental Research, 51 (1), 1-16.
Francour, P., 1997. Fish assemblages of Posidonia oceanica
beds at Port-Cros (France, NW Mediterranean): assessment of
composition and long-term fluctuations by visual census.
Marine Ecology, 18 (2), 157-175.
García-Rubies, A., Macpherson, E., 1995. Substrate use and
temporal pattern of recruitment in juvenile fishes of the
Giaccone, G., Colonna, P., Graziano, C., Mannino, A.M., Su-
riano, C., et al., 1985. Evoluzione e distribuzione della ve-
nutazione marina nei tre golfi della provincia di Palermo
(Sicilia). Bollettino dell’Accademia Gioenia di Scienze
delle Femmine e di Monte Gallo (Palermo).
and definition. Oikos, 91, 1115-1120.
Raventos, N., 2006. Nest site characteristics and nesting suc-
cess of the fivespotted wrasse, Symphodus roissali in the
north-western Mediterranean Sea. Journal of Fish Biology,
68, 305-309.
and settlement marks on the otoliths of Mediterranean litter-
Reynolds, J. D., Dulvy, N. K., Goodwin, N. B., Hutchings, J.
A., 2005. Biology of extinction risk in marine fishes. Pro-
ceeding of the Royal Society B, 272, 2337-2344.
Riggi, S., Raimondo, F., 1991. Proposta di una riserva co-
siera per la tutela e la valorizzazione dei biotopi di Isola
delle Femmine e di Monte Gallo (Palermo). Quaderni di
Botanica Ambientale Applicata, 2, 59-96.
Ruitton, S., Francour, P., Boudouresque, C.F., 2000. Relation-
ships between algae, benthic herbivorous invertebrates and
fishes in rocky sublittoral communities of a temperate sea
(Mediterranean). Estuarine, Coastal and Shelf Science,
50 (2), 217-230.
Sargent, R.C., Gebler, J.B., 1980. Effects of nest site conceal-
ment on hatching success, reproductive success and paternal
behavior of the Three-spine Stickleback, Gasterosteus acu-
Sinopoli, M., Cattano, C., Chemello, R., Timpanaro, A., Timpa-
naro, V. et al., 2015. Nest building in a Mediterranean wrasse
(Symphodus ocellatus): are the algae used randomly chosen or


