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

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

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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 Dyctiotales 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/degradation 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
prefer those where other females have already spawned (i.e., mate-choice copying) (Alonzo, 2008) and with fewer sneaker 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 among branched algae (Ravento & 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. oceanica* and other seagrass meadows (Guidetti & Bussotti, 2002). Morelli 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 sites 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, the nest site in *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 oce-

![Fig. 1: Study area in northern Sicily (Tyrrhenian Sea); H1 = Barcarello, H2 = Cala Isola, L1 = Isolotto, L2 = Copo Gallo.](http://epublishing.ekt.gr)
...
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 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).

Table 1. Results of the ANOVA. RP = reproduction phases; LC = location; CS = characteristic of substratum; SND = sandy substrate; POS = *Posidonia oceonica* 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>RPxLC</td>
<td>6</td>
<td>0.4</td>
<td>0.2</td>
</tr>
<tr>
<td>RPxCS</td>
<td>4</td>
<td>0.6</td>
<td>0.3</td>
</tr>
<tr>
<td>LCxCS</td>
<td>6</td>
<td>71.0</td>
<td>35.3 **</td>
</tr>
<tr>
<td>RPxLCxCS</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 2. Mean value (± standard deviation) of all the variable in 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 (cm)</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>

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 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). This hypothesis is partially confirmed by Mouillot et al. (1999), who found larger individuals (probably sexually mature) associated with the rocky substrate and smaller individuals associated with seagrass.

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

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

**Fig. 4:** The abundance of nests and the percentage cover of the three principal algal species around the 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>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 Heigh</td>
<td>2</td>
<td>25.78</td>
<td>2.5*10⁻⁶</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.

<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>
in small gulfs and sites protected from exposure to open water than in sites exposed to wave action. Mazzolli & 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. cinererus in North Adriatic Sea (Lipej et al., 2009). In this study, the authors assessed the characteristics of sites used for reproduction in our research. Indeed, to determine the main microhabitat requirements of the nests, they have focused on those features that occur often near nests.

Nesting males of S. roissali select nest sites mainly on flat substrata and close to the margin in 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 Dactiotaletes 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) (Ljeune, 1985; Werneros 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 countering 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 justification on the depth of the nests. In our opinion this shallow depth could be related to reproductive physiological constraints. In fact, S. ocellatus sexual maturation was optimal when the sea water temperatures were 22–23°C in the Gulf of Naples (Tyrrhenian sea; Bentivegna & Benedetto, 1989). During May and June, in our study areas water temperature begins to increase from the most superficial part directly exposed to solar irradiation. For this reason, the depths between 0 and 4 m reach 20°C first.

Some studies attempted to define the reproductive habitat requirements of nesting fish species, and salient features of the nest sites were highlighted (Raventos, 2006; Lipej et al., 2009). Although a functional role has been attributed to each of these features, no studies have correlated these features with reproductive performance and success. This is because fish are thought to be able to compensate for suboptimal habitats by gains in mating performance (Milazzo et al., 2016).

In conclusion in this study we can reject the first hypothesis since the ocellated wrasse in their pre-reproductive and reproductive periods remain associated with the rocky habitat in which it build nests. We can accept the second hypothesis because of the significant recurrence of four variables (middle sized canopy, around 3 m in depth, circular holes and the availability of Dactiotaletes) near nests. However, the presence of Dactiotaletes deserves further reflection. The presence of this algae could be due to co-occurrence, rather than being a strict microhabitat requirement. Indeed, this order of algae is included in the ecological group that is only present at sites that are less exposed to wave action and open water flows (Boudouro- esque, 1984). This observation confirms that S. ocella- tus prefers the low-hydrodynamic sites, as observed in other studies (Francour, 1997; Mazzolli & De Girolamo, 1998). This choice, in addition to the advantage of nest protection from wave motion (Raventos, 2004), decreases the remixing of the water, allowing the temperature to quickly reach optimal levels for the maturation of the gonads (Bentivegna & Benedetto, 1989).

Acknowledgements

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References


Kraak, S.B.M., Bakker, T.C.M., Hoëvart, S., 2000. Stickleback males, especially large and red ones, are more likely to nest concealed in macrophytes. *Behaviour*, 137, 907-919.


