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**SPATIAL DISTRIBUTION PATTERNS OF *CORIS JULIS* AND
THALASSOMA PAVO (PISCES, LABRIDAE)
ALONG THE SOUTH-EASTERN APULIAN COAST (SE ITALY)**

SUMMARY

Distribution patterns of two labrid fish, namely *Coris julis* and *Thalassoma pavo*, were assessed by visual census in autumn 2000 at four locations (with three sites per location), and at different depth levels (from 0 to about 30 m depth) in SE Apulia (SE Italy). Total abundance and juvenile density of *T. pavo* tended to be greater in shallow waters to about 10 m depth, in spite of some differences occurred at the scale of sites. Conversely, *C. julis* showed low densities in waters shallower than 5 m, and higher values from 5 down to about 30 m depth. In the case of *C. julis*, differences in the pattern related to depth occurred at both the spatial scales examined (among locations and among sites within location). The patterns observed for the two species concerned both adult and juvenile fishes, which suggests the absence of evident ontogenetic shifts in habitat use during their life history. The results presented here suggest that the two species could segregate according to depth. *T. pavo*, due to its well known thermophily, could thus over-compete *C. julis* at very shallow depths where seawaters are warmer because of the seasonal thermocline (at least during the period of the year when sampling was performed). The patterns observed in this study may also provide useful information about the scenario that could take shape in areas of the NW Mediterranean, such as the Ligurian Sea, where *T. pavo* started increasing in abundance in the recent years.

RIASSUNTO

Le modalità di distribuzione di due specie ittiche appartenenti alla famiglia dei labridi, *Coris julis* e *Thalassoma pavo*, sono state indagate tramite visual census nell'autunno 2000 presso 4 località (con 3 siti presso ogni località) e 4 differenti livelli batimetrici (tra 0 e circa 30 m) nella Puglia sud-orientale. L'abbondanza totale e quella dei giovanili di *T. pavo* è risultata maggiore nelle acque poco profonde

fino a circa 10 m, malgrado una certa variabilità osservata alla scala dei siti. Per contro, *C. julis* ha mostrato densità minori a profondità inferiori ai 5 m e valori più elevati tra i 5 ed i 30 m. Nel caso di *C. julis*, le differenze nella distribuzione in relazione alla profondità sono risultate chiare ad entrambe le scale spaziali indagate (tra località e tra siti presso ogni località). Le modalità osservate per le due specie hanno riguardato sia gli individui adulti sia i giovanili: ciò suggerisce l'assenza di evidenti 'shift' ontogenetici nell'uso degli habitat durante il ciclo vitale. Questi risultati suggeriscono che le due specie potrebbero segregarsi in relazione alla profondità. *T. pavo*, a causa della sua ben nota termofilia, potrebbe così risultare competitivamente superiore a *C. julis* a basse profondità dove le acque sono più calde a causa del termoclino stagionale (almeno durante i periodi dell'anno in cui i campionamenti sono stati eseguiti). Tali risultati possono anche fornire utili indicazioni sul possibile scenario che potrebbe verificarsi nelle aree del mediterraneo nord-occidentale, come il mar Ligure, dove *T. pavo* ha cominciato ad aumentare in abbondanza in anni recenti.

INTRODUCTION

Coris julis and *Thalassoma pavo* are small protogynous labrid fishes widespread in the Mediterranean littoral. *Coris julis* lives in seagrass beds, rocky and sandy habitats down to 50 m depth, although it can also be found in deeper areas. *Thalassoma pavo* chiefly inhabits rocky habitats and seagrass beds from shallow depths down to 25 m (BINI, 1968; TORTONESE, 1975). As far as the geographic distribution in the Mediterranean Sea is concerned, *C. julis* is reported as fairly evenly distributed in the basin, without any evident latitudinal gradient (BINI, 1968; TORTONESE, 1975). *Thalassoma pavo*, instead, is classically reported as more common along the south-eastern coasts of the basin (BINI, 1968; TORTONESE, 1975), which leads to consider this fish as a thermophilic species (see GUIDETTI *et al.*, 2002). In the northernmost areas of the western basin, such as the Ligurian Sea, it was regarded as rare in the past (TORTONESE, 1975). In the recent years, instead, *T. pavo* has progressively expanded northwards, an event which was related to the ongoing water warming in the Mediterranean (GUIDETTI *et al.*, 2002 and references therein).

Most of the previous research on such labrid fishes has focused on sex-inversion and the influence of population density on mating systems (REINBOTH, 1975; BRUSLÉ, 1987; WERNERUS and TESSARI, 1991). In recent years, nevertheless, *T. pavo* received an increasing attention due to its potential role as an indicator of climate changes. A number of studies have thus been carried out on its distribution patterns, ecological requirements, reproductive behaviour, recruitment and early mortality rates (VACCHI *et al.*, 1999; SARA and UGOLINI, 2001; GUIDETTI, 2001, 2002; GUIDETTI *et al.*, 2002).

The fact that the two aforementioned species have the same size and may potentially overlap in habitat and trophic requirements suggests possible competition for resources (e.g., space, food). This involves that some changes could be expected in areas, such as the north-western Mediterranean, where the two species did not coexist in the past and where *T. pavo* is currently increasing in abundance at shallow depths (FRANCOUR *et al.*, 1994; VACCHI *et al.*, 1999; GUIDETTI *et al.*, 2002). To improve understanding of what is happening in the areas recently concerned by increasing density of *T. pavo*, it could be useful to know what happens in areas where the two species live together.

This study, therefore, is aimed at investigating distribution patterns of *Coris julis* and *Thalassoma pavo* in SE Apulia, where the two species coexist.

MATERIALS AND METHODS

Sampling areas

Visual census surveys were carried out in early autumn 2000 at four locations, namely Torre del Serpe (thereafter TS), Torre Minervino (TM), Zinzulusa (ZN), and Ciolo (CL), situated along the south-eastern Apulian coasts (SE Italy; Fig. 1).

The region is characterised by gently-medium sloped calcarenitic plateau and sub-vertical rocky slopes. From the water surface to about 5-6 m depth the rocky substrate is medium-steeply sloped and covered by articulated Corallinaceae and *Cystoseira* spp. From 6-7 m to about 12-15 m depth there is a gentle-medium slope covered by photophilic algae (e.g., Dictyotales) with numerous medium- and large-sized boulders. Deeper, sub-vertical slopes may be found from about 15 m to 22-25 m, where

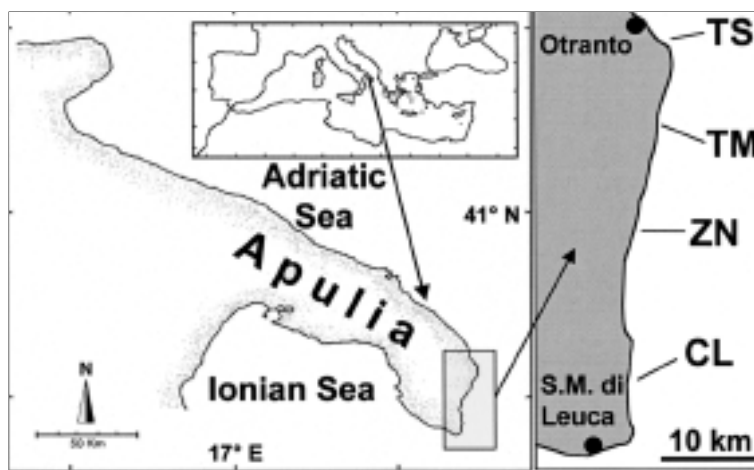


Fig. 1 - Sampling areas with locations (TS: Torre del Serpe; TM: Torre Minervino; CL: Ciolo; ZN: Zinzulusa)

the substrate is mainly constituted by bio-constructions (the so-called “coralligenous formations” in the Mediterranean).

At about 25-30 m depth, the slope decreases and the “coralligenous formations” alternate with sand patches dominating in deeper areas.

Sampling method, experimental design and data analysis

Visual censuses were carried out along transects 25 m long and 5 m wide (see HARMELIN-VIVIEN *et al.*, 1985). Transects were randomly placed at four bathymetric levels: 0-2 m (level A), 5-7 m (B), 12-15 m (C), 25-28 m (D) depth. Three sites were investigated at each of the four locations, with four replicates at each site and depth for a total of 192 visual censuses.

Abundance estimates of *Coris julis* and *Thalassoma pavo* were expressed as number of individuals 125 m⁻². Analysis of variance (three way ANOVA, using GMAV 5 from University of Sydney) was used to assess differences in mean abundances of the two species (of both the entire populations and juveniles). "Location" was considered as a random factor, "Site" as random factor nested in "Location", and "Depth" as fixed and orthogonal. Cochran's test was employed to assess the homogeneity of variances. Whenever transformations did not produce homogeneous variances, ANOVA was used, nevertheless, after setting $\alpha = 0.01$ in order to compensate for the increased likelihood of Type I error. When appropriate, the SNK test was used for *a posteriori* comparisons of the means after an analysis of variance (UNDERWOOD, 1997).

RESULTS

The general structure of ANOVAs performed in this study is shown in Table 1.

Source of variation	d. f.
Location = L	3
Site(Location) = S(L)	8
Depth = D	3
L x D	9
S(L) x D	24
Residual	144
Total	191

Tab. 1 - General structure of ANOVAs performed in the present study. d.f. = degrees of freedom.

The average abundances of the two species at the four locations surveyed in relation to depth (total density and average abundance of juvenile specimens) are reported in Fig. 2 and 3.

Statistical analyses performed on abundances of *Coris julis* revealed that differences among depths were not the same at the spatial scales of locations and sites (interactions 'Location x Depth' and 'Site (Location) x Depth' were significant at $p < 0.001$ level for both total densities and juveniles). As a general rule, nonetheless,

the lowest values were observed in the shallowest transects, with a sudden increase in abundances (for both the entire population and juveniles) at the deeper levels (B, C and D; Fig. 2).

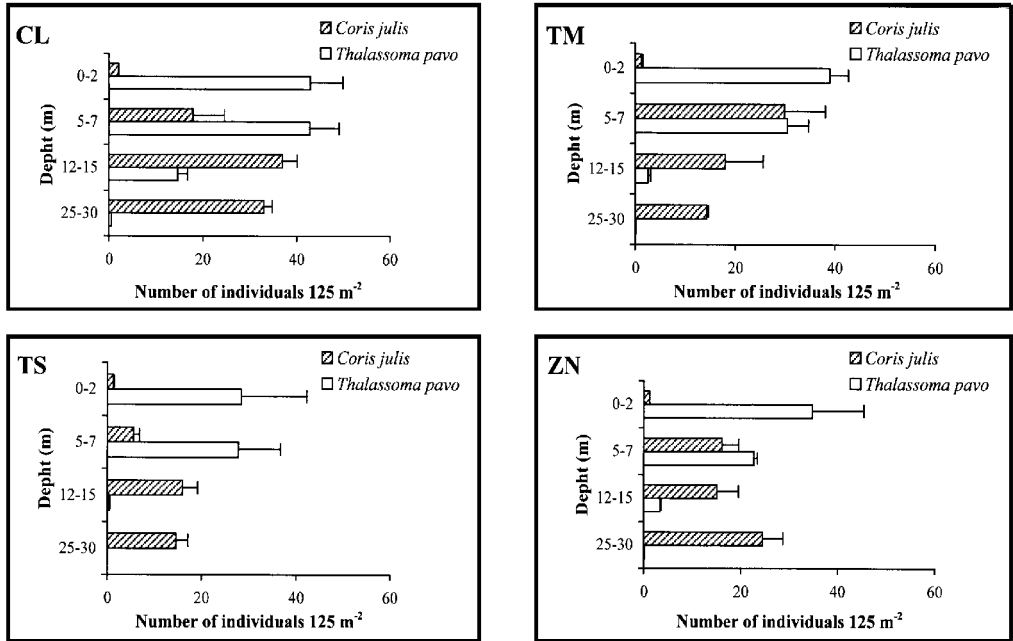


Fig. 2 - Mean abundances of *Thalassoma pavo* and *Coris julis* among depths at the four locations studied.

Analyses of variance carried out on *Thalassoma pavo* also provided evidence of similar distribution patterns for both the entire population and juveniles. The significant interactions ‘Depth x Site (Location)’ (at $p < 0.001$ level for both the whole population and juveniles) revealed that the differences among depth strata were not the same among sites within location. The pattern among depths, instead, was similar at the spatial scale of location. Except for some discrepancy at some sites, *T. pavo* densities at levels A and B were higher than those observed at levels C and D (Fig. 3).

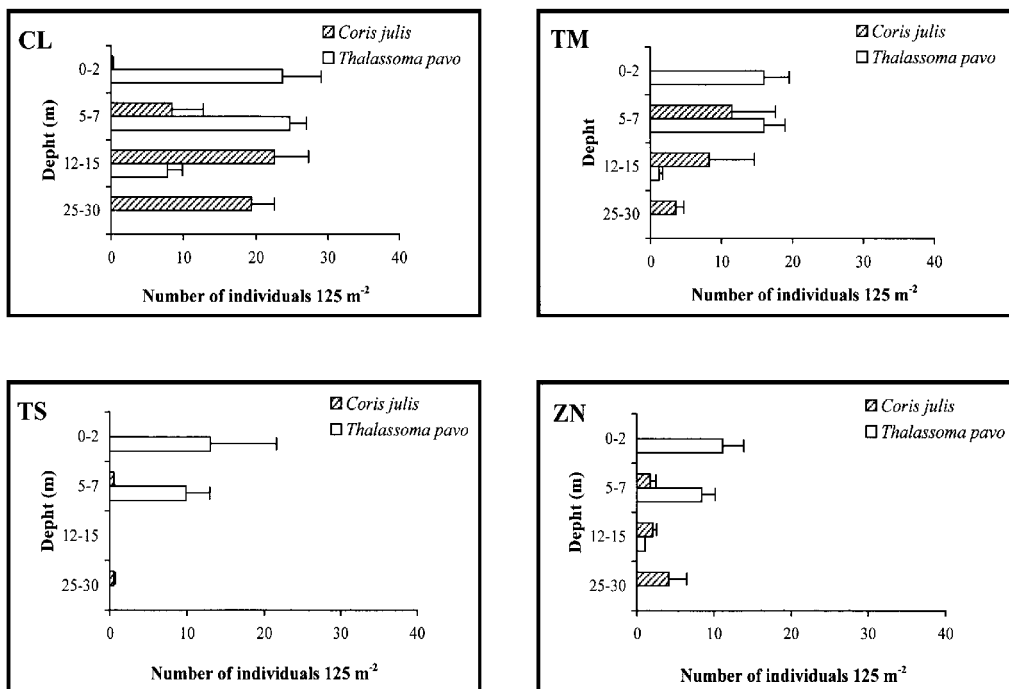


Fig. 3 - Mean abundances of juveniles of *Thalassoma pavo* and *Coris julis* among depths at the four locations studied.

DISCUSSION

The coexistence of similar species within the same ecosystem may occur owing to different use of and/or access to resources (SCHOENER, 1974). From this perspective, resource partitioning in terms of food, habitat, depth, and time partitioning in their use have been extensively documented among fishes in temperate rocky reefs (e.g. LOVE and EBELING, 1978; HIXON, 1980; LARSON, 1980; YOSHIYAMA, 1980; HALLACHER and ROBERTS, 1985; EBELING and LAUR, 1986; HOLBROOK and SCHMITT, 1986). In the Mediterranean Sea, nevertheless, resource partitioning has classically received little attention (see for instance MACPHERSON, 1981, and HARMELIN-VIVIEN *et al.*, 1989; SALA and BALLESTREROS, 1997) and few studies have been carried out on small sedentary fishes (ZANDER, 1982; MACPHERSON, 1994).

The present study provides suggestive evidence of depth segregation between the two labrid fishes *Thalassoma pavo* and *Coris julis* in rocky reefs in SE Apulia. Depth, however, explained only partially the distribution patterns of the two species as differences among depths were not always coherent at the two spatial scales examined (100s metres and 10s kilometres, i.e. among sites within location and among locations, respectively). The decrease/increase in abundance of the two fishes, in addition, were not linearly related to depth. *Thalassoma pavo*, in fact, appeared to live in similar numbers from the surface to approximately 10 m depth, while average abundance suddenly declined in deeper areas. This pattern could be related to the existence of the seasonal thermocline (still present in early autumn) in the Mediterranean waters, and to the fact that *T. pavo* is a thermophilic fish (see GUIDETTI *et al.*, 2002 and references therein). *Coris julis*, conversely, was fairly rare in the shallowest areas (<5 m depth), whereas approximately comparable densities were recorded from 5 m depth to the deepest transects down to about 30 m depth. Another outcome deserving to be considered is that adults and juveniles of both species substantially displayed the same distribution patterns. This result, nevertheless, is consistent with the patterns showed by several labrid species in the Mediterranean and elsewhere, which usually do not show evident ontogenetic shifts in the habitat use during their life histories (GARCIA-RUBIES and MACPHERSON, 1995; GREEN, 1996).

Data about distribution patterns of the two investigated labrids have previously been reported by other authors in the frame of wider studies about fish assemblages in several areas of southern Italy, where *T. pavo* is usually dramatically abundant in shallow rocky-reefs (e.g., MAZZOLDI and DE GIROLAMO, 1998; VACCHI *et al.*, 1998). Only VACCHI *et al.* (1997), nevertheless, suggested the possibility of competition (and consequent depth segregation) between the two species to explain differences in their bathymetric distribution, an issue which became even more important when *T. pavo* started expanding northwards its distribution limits (GUI-

DETTI *et al.*, 2002 and references therein). It has to be taken into account, in fact, that *C. julis* is one of the most common fish even in the shallowest rocky reefs in the Ligurian Sea (see for instance TUNESI and VACCHI, 1992), where *T. pavo* was fairly rare since few years ago (TORTONESE, 1975). As aforementioned, mean abundance of *T. pavo* increased more and more in this area, although densities still remain far lower than those found in the south-western Mediterranean (GUIDETTI *et al.*, 2002). All the above issues suggest that *T. pavo* could competitively exclude *C. julis* from shallow stands. Conversely, at depth levels where the waters are colder (e.g. under the seasonal thermocline) the thermophilous *T. pavo* could not be able to overcompete *C. julis*.

Whether such patterns are actually due to competitive exclusion or not, however, cannot be said only on the basis of the data presented in this study. From this point of view, for example, specific investigations on the diets of the two species would be necessary in order to observe whether there could be an overlap in the use of food resources. Similar observations, in addition, should be repeated in time to observe whether they are temporally coherent or not. It has to be considered, from this perspective, that we sampled the two species in a period of the year corresponding to the end of the reproductive season (usually summer), and distribution patterns of adults may change during spawning periods. Long-term data in regions of recent spreading of *T. pavo* should also be collected for assessing putative changes in time in the distribution patterns of the two studied fish species.

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