HABITAT PREFERENCES, DISTRIBUTION, AND ABUNDANCE OF GOBIUS VITTATUS (GOBIIDAE) IN THE KVARNER AREA (NORTHERN ADRIATIC SEA)

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GOBIUS VITTATUS
HABITAT
DISTRIBUTION
ABUNDANCE

ABSTRACT. – Habitat data for many Mediterranean gobies are absent or scarce and mostly restricted to very limited qualitative descriptions. The striped goby, *Gobius vittatus* was considered to be rare or very rare, and many aspects of its ecology are still unknown. In the present work we aimed at collecting data on distribution, abundance and microhabitat preferences of *G. vittatus* in the Kvarner area (northern Adriatic Sea). *G. vittatus* was one of the most common epibenthic fish in the investigated area, being recorded at 66 % of SCUBA dives. *G. vittatus* was most frequently found at a mixed rock and sand bottom, characterised by steep or medium slope from 5 to 34 m depth. The most frequently co-occurring epibenthic fish species with *G. vittatus* was *Parablennius rouxi*. The abundance of *G. vittatus* varied significantly across months and was positively correlated with temperature.

INTRODUCTION

With 59 species, Gobiidae is the most specious fish family in the Mediterranean (Kovačić 2005). Habitat data for many Mediterranean gobies have been absent or scarce and mostly restricted to very short qualitative descriptions (Miller 1986). During the last twenty years, knowledge on habitat data for part of these species has been improved in the studies focused on habitat utilization and distribution pattern of Mediterranean gobiid species (Ahnelt & Kovačić 1997, Kovačić 1997, Herler *et al*. 1999, Patzner 1999a, 1999b, Bussotti & Guidetti 2005, Herler & Patzner 2005) and in the new first records of some Mediterranean gobies that provided more detailed descriptions of habitat preferences (Ahnelt *et al*. 1994, Kovačić 1999, 2001, Stefanni & Mazzoldi 1999, Kovačić & Miller 2000, Herler & Kovačić 2002, Herler & Patzner 2002). The striped goby, *Gobius vittatus* Vinciguerra, 1883 was considered to be rare or very rare (Tortonese 1975, Jardas 1985) due to the lack of data, and many aspects of its ecology are still unknown. Later, the species was reported to be more common by Patzner & Moosleitner (1998). The morphological description of this species is reported in only a few publications and it is generally based on one or two specimens (Vinciguerra 1883, Kolombatović 1886, 1891, Fage 1918, De Buen 1923, Tortonese 1975). Before the present research, the only detailed information on morphology, diet and habitat preferences of *G. vittatus* was collected at Banyuls-sur-Mer (France) by Heymer & Zander (1978). Habitat data were restricted to bathymetric distribution and bottom characterisation (Vinciguerra 1883, Tortonese 1975, Heymer & Zander 1978). *Gobius vittatus* was also recorded at several localities in the Adriatic Sea (Jardas *et al*. 1996, Novosel *et al*. 2002, Kovačić 2002) and in the Western Mediterranean (Harmelin-Vivien & Francour 1992, La Mesa & Vacchi 1999, Tunesi *et al*. 2006) by visual census surveys. The research of this species in the Kvarner area provided the first data on several aspects of the ecology of *G. vittatus* (Kovačić 2004, 2006, 2007, present paper). The aim of this work is to present results on distribution, abundance and habitat preferences of *G. vittatus* in the Kvarner area (northern Adriatic Sea). These first data on abundance and habitat preferences of this species contribute to a better understanding of the ecology of small epibenthic fishes of deeper infralittoral in the Mediterranean.

MATERIAL AND METHODS

A total of 175 SCUBA dives at 77 locations in the Kvarner area (northern Adriatic Sea) from 1993 to 2002 were used as a data source for the present research on *Gobius vittatus* (Fig. 1). The SCUBA dives were performed perpendicularly to the shoreline, ended at various depths (5-42 m, usually 20-30 m), and they were of various lengths, depending on the bottom inclination. The qualitative composition of fish assemblage (i.e. species occurrence), depth, slope and structure of the bottom were recorded at points. Distances between points were 2 or 5 m depth, depending on the bottom inclination. Water depth was grouped into zones for the presentation of the data: < 5 m, 5-9 m, 10-14 m, 15-19 m, 20-24 m, 25-29 m, 30-34 m, 35-39 m, > 39 m. The bottom was classified in four estimated types: soft sediment bottom (< 2 mm, without or with rarely present cobbles and boulders), mixed bottom type (cobbles, boulders and bedrock mixed with surfaces of sand), gravel and cobbles (2 mm-20 cm), and bedrock and boulders (> 20 cm). The slope was categorized in three estimated classes: gentle (< 20º), medium (20º-60º) and steep (> 60º). The frequency of occurrence of

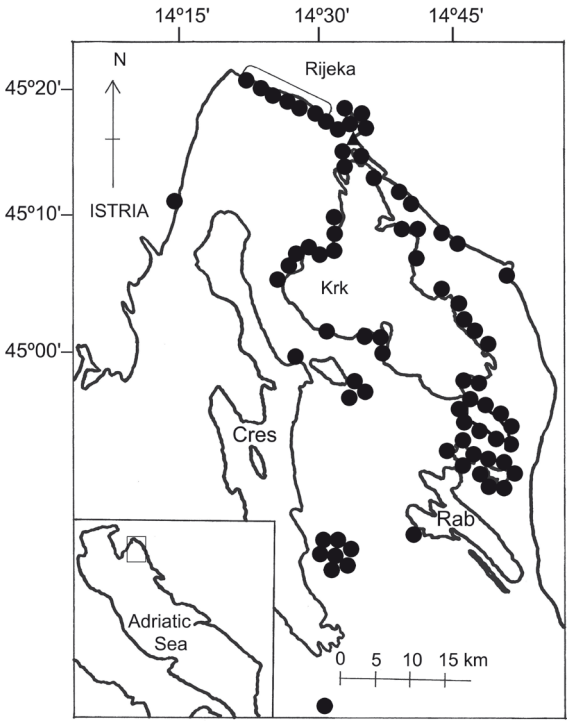

Fig. 1 – Location of sampling sites in the Kvarner area, Croatia. The triangle indicates the locality of Oštro.

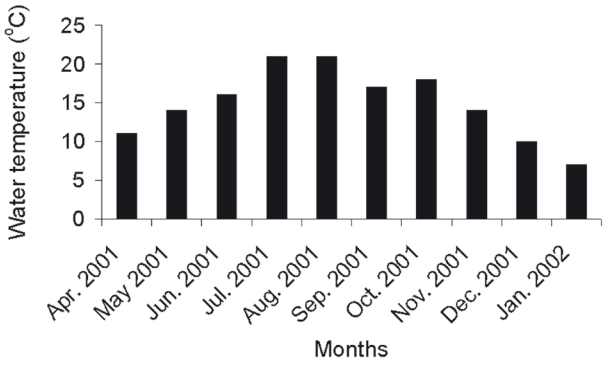

Fig. 2 – Monthly variation of sea-water temperature at the locality of Oštro.

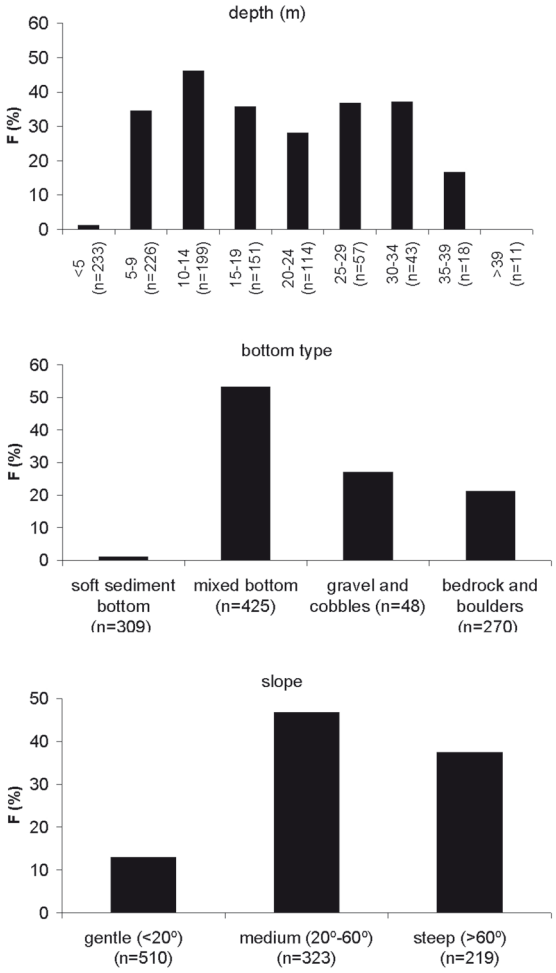

Fig. 3 – Frequency of occurrence (F) of *Gobius vittatus* in the Kvarner area. The occurrence frequency at different depth ranges, bottom types and slopes (n = total number of observed points for each depth range, bottom type or slope).

G. vittatus at different depth zones, bottom types and slopes was calculated, as well as the frequency of co-occurrence of syntopic fishes with *G. vittatus*. Categories of fish in relation to the bottom followed Wilkins & Myers (1992).

Additional surveys, addressed specifically to study abundance and seasonal variation in abundance of *G. vittatus* and other epibenthic fishes at characteristic habitat of *G. vittatus* were performed at Cape Lipica, near the locality of Oštro (Fig. 1). The bottom from 5 to 20 m at Cape Lipica matched well with preferred habitat of this species recognized by the previous SCUBA dives at 77 locations in the Kvarner area (see Results). At this site, the bottom was rocky and moderately sloping from the shoreline to 5 m depth. Medium to steep bedrock from 5 to 20 m depth was rarely covered with individual stones and boulders of different size and partially grooved with sandy channels and pools. The bedrock ends at 20 m depth where the gently sloping sandy bottom enriched with silt at greater depths begins. At Cape Lipica, the abundance of *G. vittatus* and of other epibenthic fishes was monitored monthly, from April 2001 to January 2002. Fish counts were performed along 10 transects at 8-16 m depth (10 x 2 m) each month. At each transect, a ballasted rope, marked every 1 m, was laid on the bottom parallel to the shoreline. Two counts were made on each transect and the mean count for each transect was used in all subsequent calculations. Water temperature was measured at the bottom during visual counts (Fig. 2). Visual estimates of the benthic biocoenosis at Cape Lipica were carried out at characteristic habitat of *G. vittatus* once per season (in April, July and October 2001 and in January 2002). Benthic communities were classified according to Pérès & Picard (1964), as applied by Bellan-Santini *et al.* (1994). The abundance of fishes at Cape Lipica was compared across months using the non-parametric Kruskal-Wallis test, since the assumptions of normality and homogeneity for ANOVA were not met after transformations. Correlation between fish abundance and water temperature was evaluated

using the Spearman rank correlation coefficient (rs) (Sokal & Rohlf 1995).

RESULTS

Gobius vittatus was one of the most common inshore fish species in the Kvarner area, recorded at 115 (65.7 %) out of 175 SCUBA dives performed for ichthyological purposes in the Kvarner area and at 299 (28.4 %) out of 1052 recorded points during dives. It was most frequently found on the mixed bottom type, then on the bottom composed of bedrock and boulders and also on the bottom covered with gravel and cobbles, usually on steep and medium sloping substrates (Fig. 3). *Gobius vittatus* dwelled preferentially from 5 to 34 m depth, although it was also recorded at very shallow depth (2.5 m) (Fig. 3).

A total of 57 fish species co-occurred at recorded points with *G. vittatus*, including 29 hyperbenthic and benthopelagic species, 23 epibenthic and 5 cryptobenthic species (Table I). Dominant families in terms of species numbers were Gobiidae (18 species), Labridae (8 spe-

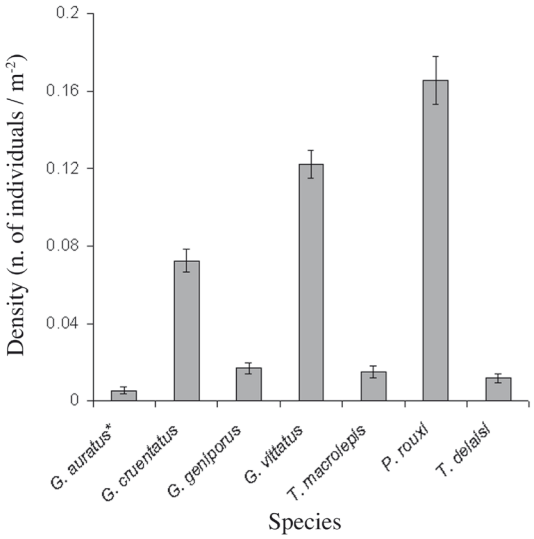

Fig. 4 – Mean abundance (SE) of epibenthic fishes at the locality of Oštro. **Gobius auratus* morph 2 of Herler *et al*. (2005).

Species	%F	Species	%F
Cryptobenthic		Hyperbenthic and benthopelagic	
Zebrus zebrus	4.5	*Coris julis*	69.7
Chromogobis zebratus	3.9	*Serranus hepatus*	42.7
Lepadogaster candollei	2.8	*Chromis chromis*	39.9
Odondebuenia balearica	0.6	*Symphodus ocellatus*	14.6
Corcyrogobius liechtensteini	0.6	*Symphodus mediterraneus*	11.8
Epibenthic		*Diplodus vulgaris*	9.6
Parablennius rouxi	46.1	*Spicara smaris*	9.0
Thorogobius macrolepis	29.2	*Symphodus tinca*	9.0
Tripterygion delaisi	20.8	*Diplodus annularis*	6.7
Gobius cruentatus	19.1	*Oblada melanura*	6.7
*Gobius auratus**	17.4	*Serranus scriba*	6.7
Gobius roulei	16.3	*Symphodus cinereus*	5.6
Gobius geniporus	14.6	*Boops boops*	5.1
Gobius bucchichi	11.2	*Spicara maena*	5.1
Parablennius tentacularis	5.6	*Serranus cabrilla*	3.9
Scorpaena porcus	5.1	*Symphodus melanocercus*	3.4
Gobius kolombatovici	4.5	*Diplodus puntazzo*	2.2
Thorogobius ephippiatus	4.5	*Diplodus sargus*	1.7
Speleogobius trigloides	3.9	*Spondyliosoma cantharus*	1.7
Gobius niger	3.4	*Labrus bimaculatus*	1.1
Tripterygion tripteronotus	2.8	*Pomatoschistus quagga*	1.1
Buenia affinis	2.2	*Symphodus rostratus*	1.1
Gobius fallax	1.7	*Atherina* sp.	0.6
Parablennius zvonimiri	1.7	*Belone belone*	0.6
Gobius couchi	1.1	*Mullus surmulletus*	0.6
Lipophrys nigriceps	1.1	*Phycis phycis*	0.6
Parablenius gattorugine	1.1	*Sarpa salpa*	0.6
Parablennius sanguinolentus	0.6	*Symphodus roissali*	0.6
Scorpaena scrofa	0.6	*Zeus faber*	0.6

Table I – Frequency of co-occurrence in percentage (% F) of syntopic fishes with *Gobius vittatus* in the Kvarner area. **Gobius auratus* morph 2 of Herler *et al*. (2005), previously identified for the Kvarner area as *G. xanthocephalus* in Kovačić (2002).

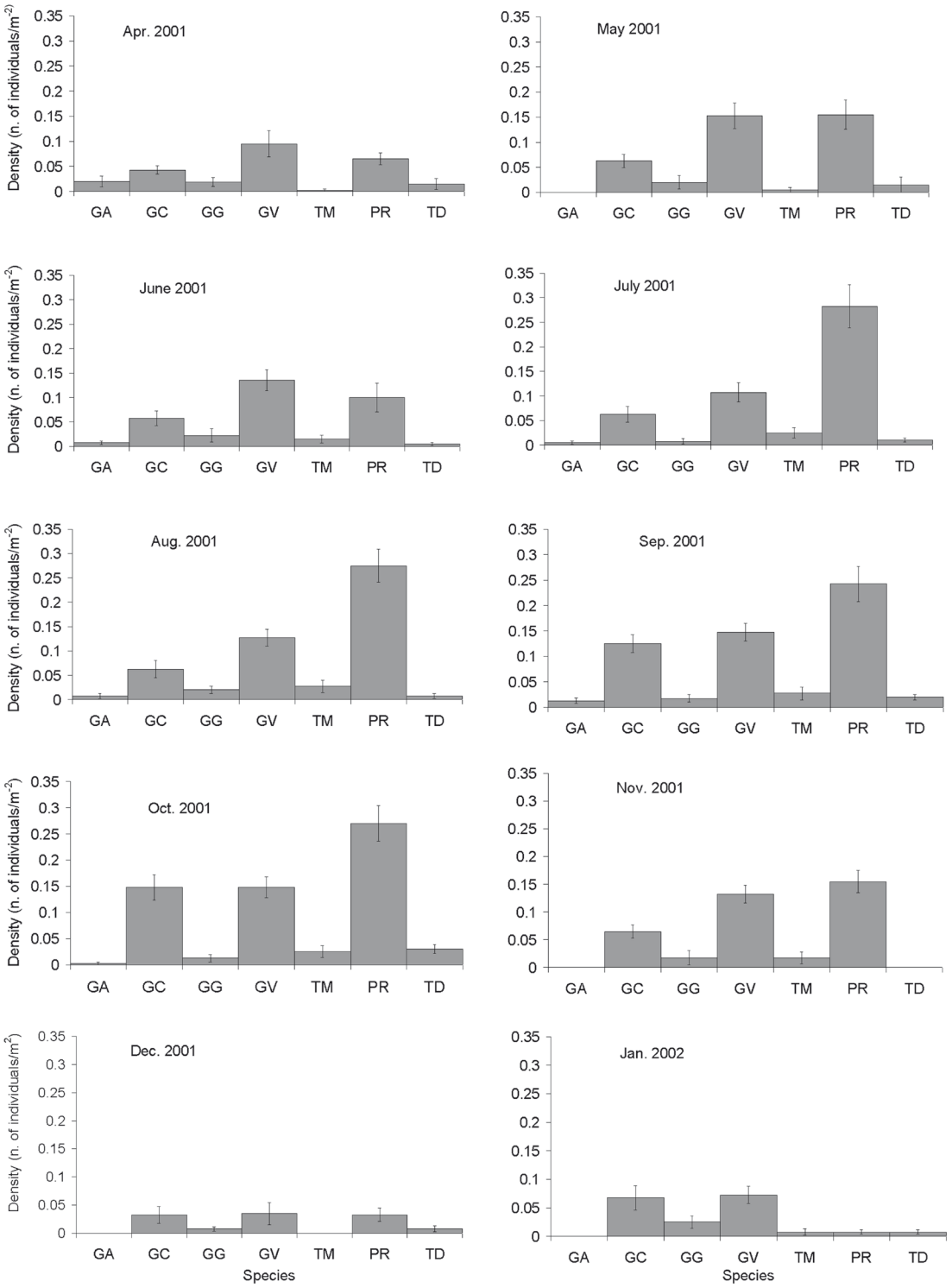

Fig. 5 – Mean monthly abundance (SE) of epibenthic fishes at the locality of Oštro. GA = *Gobius auratus* morph 2 of Herler *et al*. (2005), GC = *Gobius cruentatus*, GG = *Gobius geniporus*, GV = *Gobius vittatus*, TM = *Thorogobius macrolepis*, PR = *Parablennius rouxi*, TD = *Tripterygion delaisi*.

cies), Sparidae (8 species) and Blenniidae (6 species). The most frequently co-occurring species with *G. vittatus* were *Coris julis* (Linnaeus, 1758) (69.7 %), *Parablennius rouxi* (Cocco, 1833) (46.1 %), *Serranus hepatus* (Linnaeus, 1758) (42.7 %), *Chromis chromis* (Linnaeus, 1758) (39.9 %), and *Thorogobius macrolepis* (Kolombatović, 1891) (29.2 %) (Table I).

Seven epibenthic fish species, including *G. vittatus*, were recorded during the visual counts at the locality of Oštro. The epibenthic fish assemblage at this site was quite

similar to those observed at other locations of the Kvarner area (Table I and Fig. 4). At Oštro, *P. rouxi*, *G. vittatus* and *G. cruentatus* Gmelin, 1789 were the most abundant epibenthic fish species (Fig. 4). The abundance of the epibenthic fish assemblage, as well as of the three dominant species varied significantly across months (assemblage: H Kruskal-Wallis = 62.2, $P < 0.001$; *G. cruentatus*: H = 30.6, $P < 0.001$; *G. vittatus*: H = 24.2; $P < 0.01$, *P. rouxi*: H = 66.2, $P < 0.001$) (Fig. 5). The abundance of the three most abundant species were significantly correlated with temperature (*G. cruentatus*: $r_s = 0.216$, $P < 0.05$, $N = 100$; *G. vittatus*: $r_s = 0.251$, $P < 0.05$, $N = 100$; *P. rouxi*: $r_s = 0.768$, $P < 0.01$, $N = 100$).

The bedrock and the boulders within characteristic habitat of *G. vittatus* at the locality of Oštro were covered with algae, while soft sediment was rare. An occasional exception was the occurrence of a mobile algae layer, consisting mainly of *Polysiphonia* ssp., *Womersleyella setacea* (Hollenberg) R.E. Norris, 1968 and *Cladophora* ssp. that covered the bottom in the lower part of the depth range of *G. vittatus* (> 10 m). The biocenosis of infralittoral algae was the most abundant biocoenosis within the depth range of *G. vittatus*. Rocky surface exposed to light was covered by small photophilic macroalgae, while sciaphilic macroalgae dominated shaded or deeper rocky surfaces. Large photophylic *Cystoseira*-macroalgae were rare. The precorraligenous facies of the corralligenous biocoenosis and the biocoenosis of shaded and semi-dark niches occurred in the poor light conditions of very shady parts of the rocky surface. The benthic biocoenoses within the depth range of *G. vittatus* at the locality of Oštro showed seasonal changes. *Cystoseira corniculata* (Turner) Zanardini, 1841 was recorded only in spring. During summer, *Acetabularia acetabulum* (Linnaeus) P.C. Silva, 1952 and *Padina pavonica* (Linnaeus) Thivy, 1960 were dominant on the rocky bottom exposed to light while *Dictyota* spp. became visible during the colder seasons of the year and *Cladophora* ssp. during the period in which the lowest winter temperatures were measured.

Gobius vittatus was usually observed resting on the bottom a few centimetres apart from a shelter (crevices, small caves, space below boulders and rocks). When disturbed, it escaped into a shelter, rather than into open areas.

DISCUSSION

In the present research, the upper limit of depth range for *Gobius vittatus* was much more shallow than it had previously been reported (Vinciguerra 1883: 15 m; Tortonese 1975: 15-65 m; Heymer & Zander 1978: 20-42 m; Miller 1986: 15-85 m; Patzner & Moosleitner 1998: 15-40 m, Vacchi *et al*. 1999: 46 m). *Gobius vittatus* from Banyuls-sur-Mer (France) (Heymer & Zander 1978) and from the Kvarner area (Northern Adriatic Sea) differed in depth distribution and habitat choice. *G. vittatus* occurred in different biological communities in Banyuls-sur-Mer (coralligenous bottom formed of calcareous algae (Lithothamniae and Squamariaceae) and inhabited by species like *Corallium rubrum*) and the Kvarner area. The presence of coloration similarity between *G. vittatus* and *P. rouxi* was already observed by Heymer & Zander (1978), and a mimetic relationship was presumed. High co-occurrence of *G. vittatus* and *P. rouxi* in the Kvarner area supports the presumption of mimetic relationship between the two species based on coloration similarity (Heymer & Zander 1978).

Though frequently claimed as a rare species (Tortonese 1975, Jardas 1985), *G. vittatus* was quite common in the Kvarner area. The abundance of *G. vittatus* at its characteristic habitat in the summer months at the locality of Oštro was within the range of rough estimations for Banyuls-sur-Mer of 1-3 individuals / 10 m^2 (Heymer & Zander 1978). Comparison of the abundance of *G. vittatus* with scarce published data on the abundance of infralittoral epibenthic Gobiidae of similar size in the Mediterranean gave variable results. In their characteristic habitats, *Gobius couchi* Miller & El-Tawil, 1974 and *Gobius auratus* Risso, 1810 (uniformly yellow colour morph 1 of Herler *et al*. 2005) are less abundant than *G. vittatus* (< 0.1 ind. / m^2), while *G. geniporus* and *Thorogobius macrolepis* are of similar abundance as *G. vittatus* (0.1-0.3 ind. / m^2), and *G. roulei* De Buen 1928, *G. fallax* Sarato, 1889 and *G. auratus* (colour morph 2 of Herler *et al*. 2005 with yellow basic coloration and distinct longitudinal lines of red dots) show higher abundances compared to *G. vittatus* (> 0.3 ind. / m^2) (Ahnelt & Kovačić 1997, Kovačić 2001, Bussotti & Guidetti 2005, Herler & Patzner 2005). Recorded seasonal decrease of abundance of small inshore epibenthic fishes based on visual census method in months with low water temperature at the bottom is probably not related to the migration to deeper waters (Kotrschal 1983). Using an anaesthetic, Kotrschal (1983) discovered that the number of inshore blennies, tripterygiids and gobies was similar in summer and winter, but that in winter they were mostly hidden in shelters. Therefore, decrease in movements outside the shelters probably caused the reduction in visible abundance of fishes during winter.

The most frequently co-occurring epibenthic species with *G. vittatus* in the Kvarner area and the most abundant recorded syntopic species at Oštro showed similar species composition. Wilkins & Myers (1992) distinguished five fish guilds within an assemblage of temperate Atlantic gobies on the basis of the preferred microhabitat. No similar work exists for the Mediterranean. Small epibenthic fish species were usually ignored in descriptions of inshore fish assemblages in the Mediterranean, with only a few exceptions (La Mesa & Vacchi 1999, Kovačić 2002, Lipej *et al*. 2003, Guidetti *et al*. 2005). Both gobies and blennies represent the two most species-

rich families of small epibenthic fishes in the Mediterranean, but microhabitat preferences of blennies are much better explored (Illich & Kotrschal 1990, Nieder 2000 and references therein). Below 1.5 m depth, where only a few blenniid species usually live (Nieder 2000), the infralittoral assemblage of small epibenthic fishes is dominated by Gobiidae (Kovačić 2002). Microhabitat guilds of small epibenthic fish species below 1.5 m depth are still not investigated, and they could be the most distinguishable and characteristic part for each fish assemblage of the deeper infralittoral.

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