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Depth distribution and habitat utilization of blennies (Blenniidae & Tripterygiidae) on two differently exposed coastal areas on the island of Lošinj, Croatia

Tiefenverteilung und Habitatpräferenzen von Schleimfischen (Blenniidae & Tripterygiidae) an zwei unterschiedlich exponierten Habitaten, auf Lošinj, Kroatien

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Summary: Depth distribution and habitat preference of blennies (Blenniidae and Tripterygiidae) around the island of Lošinj in Croatia were investigated using the underwater visual census method. Comparing two fish communities down to a depth of four meters, one in an exposed location and one in a sheltered location, revealed that the mean richness in species was lower by two species at the wave-exposed site. However, the Shannon-Wiener index and thus the diversity measured was higher with 1.7044 at the exposed site, due to the influence of the wave motion. The Shannon-Wiener index at variable depths did not differ significantly between sites and a maximum of diversity was found at a depth of 20 to 25 cm. Fish were most often observed on level and sunny rock covered with algae as well as on steep rock walls. Less frequently they were observed on level rock without algae cover. Counting all surveys at both sites altogether, the two most abundant species were *Parablennius incognitus* with 1374 observations and *Tripterygion tripteronotum* with 1803 observations.

Keywords: Blenniidae, Tripterygiidae, depth distribution, habitat utilization.

Zusammenfassung: Die Tiefenverteilung und die Habitatpräferenzen von Blenniidae und Tripterygiidae wurden auf der Insel Lošinj in Kroatien, mittels visuellen Unterwasserzählungen untersucht. Der Vergleich zweier Fischgemeinschaften bis zu einer Tiefe von vier Metern, an einer exponierten sowie einer geschützten Küste, zeigt, dass der Mittelwert der Artenvielfalt an der wellenexponierten Küste um zwei Arten geringer ist. Der Shannon-Wiener-Index und somit die Diversität ist jedoch mit 1,7044 auf der exponierten Küste höher, aufgrund des Einflusses der Wellenbewegung. Beim Vergleich des Shannon-Wiener-Index auf unterschiedlichen Tiefen beider Ausrichtungen konnten keine signifikanten Unterschiede festgestellt werden, ein Diversitätsmaximum befand sich zwischen 20 und 25 cm. Am häufigsten konnten Individuen auf flachem, sonnigem und mit Algen bewachsenem Fels und auf Steilhängen beobachtet werden. Nur sehr selten wurden die Tiere auf flachem Fels ohne Aufwuchs erfasst. Die mit Abstand höchsten Abundanzen, auf beiden Ausrichtungen und in allen Probenahmen, zeigten *Parablennius incognitus* mit insgesamt 1374 Beobachtungen und *Tripterygion tripteronotum* mit insgesamt 1803 Beobachtungen

Schlüsselwörter: Blenniidae, Tripterygiidae, Tiefenverteilung, Habitatpräferenzen.

1. Introduction

Blenniids and tripterygiids are epi- and cryptobenthic fish, which inhabit the Mediterranean Sea with 28 species (Patzner & Moosleitner 2003, 2009). Most fish of the family Blenniidae in the Adriatic Sea live in the mediolittoral and the shallow upper infralittoral and are often one of the dominant fish in nearshore habitats (Orlando-Bonaca & Lipej 2005). Several species use holes made by *Lithophaga lithophaga* or *Rocellaria dubia* as shelter, egg depots and refuge. These are chosen according to species or size (Koppel 1988; Kotrschal 1988).

Intensive research on blennies in the Mediterranean Sea has already been conducted in the past. Studies on the presence of these fish, their behavior, diet, trophic ecomorphology and microhabitat preferences (e.g. Abel 1962; Zander 1972b, 1980, 1983; Zander & Bartsch 1972; Heymer & Zander 1975; Zander & Heymer 1976; Wirtz 1978; Patzner 1984; Gonçalves & Almada 1998; Nieder 2000; Orlando-Bonaca & Lipej 2007) as well as their habitat utilization and depth distribution (e.g. Zander 1972b; Macpherson 1994; Patzner 1999; Zander et al. 1999; Orlando-Bonaca & Lipej 2005; la Mesa et al. 2006; Velasco et al. 2010; de Raedemaecker et al. 2010; Kovačić et al. 2012) do exist. Data about the occurrence and distribution of these fish were collected in the northern Adriatic Sea in different locations: in Venice (Segantin 1968), in the Gulf of Trieste (Patzner 1985; Orlando-Bonaca & Lipej 2007) and around Rovinj, Istria (Zander & Jelinek 1976; Obrenovic & Stevcic 1977; Goldschmid et al. 1980; Illich & Kotrschal 1990). Observations from the Kvarner area (Gulf of Rijeka) are summarized by Zavodnik & Kovačić (2000).

Due to their epi- and cryptobenthic lifestyle, combtooth and triplefin blennies cannot be caught with drawls, therefore most data have mainly been collected by the use of different visual census methods, either by snorkeling or diving (Lipej & Orlando-Bonaca 2006; Orlando-Bonaca & Lipej 2007, 2010). The underwater visual census method is often used to investigate fish communities in shallow and nearshore habitats with heterogeneous substratum, for example rock, coral and artificial reefs. Furthermore, this method provides data about population dynamics and the ecology of organisms as well as rapid estimations of biomass, length frequency distribution and relative biomass (Samoilys & Carlos 2000; de Girolamo & Mazzoldi 2001).

The aim of this paper is to present quantitative and qualitative data on the families Blenniidae and Tripterygiidae on the island Lošinj and the Kvarner area, because data from areas located further south in the Gulf of Rijeka like the island Lošinj were missing. The habitat utilization and preferences as well as the depth distribution of each species on an exposed site and a sheltered site were analyzed and compared with a focus on the wave motion, since only a handful of records exist regarding the depth distribution of littoral fish directly under the water surface (Nieder 2000). Furthermore, some endemic species of the family Blenniidae, *Microlipophrys adriaticus*, *Microlipophrys dalmatinus* and *Parablennius zvonimiri*, are still not classified in the Global Red List of IUCN (The World Conservation Union) because there is not enough data available yet (Abdul Malak et al. 2011).

2. Material and methods

2.1. Study area

The island Lošinj (fig. 1) is located in the biogeographical sector of the northern Adriatic Sea (Garibaldi & Caddy 1998) or the Central Adriatic (Bianchi & Morri 2000). The northern Adriatic coast is strongly influenced by strong winds that play an important role in climate dynamics and local weather. The winter related bora (= bura) is a cold and gusty downdraft from the northeastern quadrant, which can gain speed up to 130 km/h (UNEP 1992; Hofrichter 2002). The scirocco (= jugo) is a relatively steady and warm wind from the southeast, which generates big waves on the sea and brings weather deterioration. During the period of summer, local thermal circulations are related to days with fine and calm weather (UNEP 1992; Prtenjak & Grisogono 2007). The city of Rijeka about 90 km away from the area of investigation has developed into the largest shipyard and harbor in the northern Adriatic Sea. It also has a high number of pollution sources like petroleum industry, oil refinery, domestic heating, heavy traffic, thermal power plant and local industrial sources. Hence the Kvarner area has become one of the most polluted areas of the Adriatic coast (UNEP 1992). Two areas on the coastline of Lošinj with different orientation in their wind and wave exposure were selected (fig. 1). Both areas consist of limestone rock with a maximum tidal distinction between one to one and a half meters (Hofrichter 2002). The area

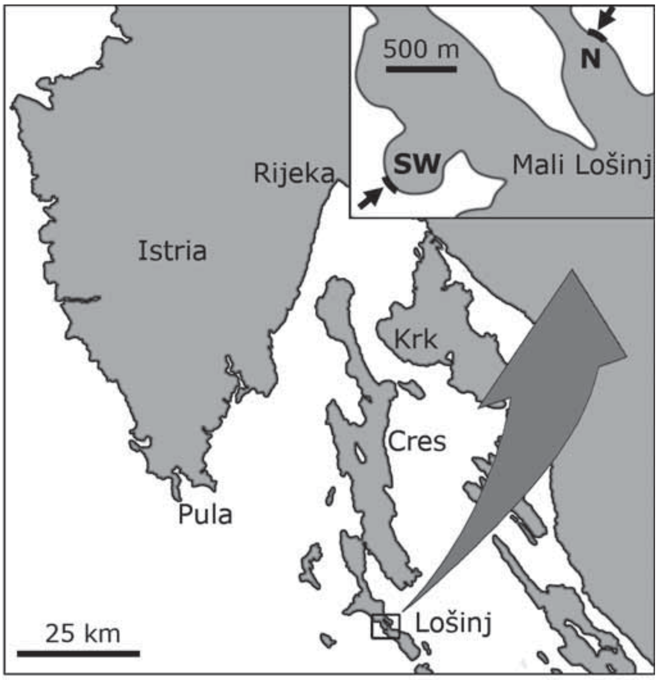

Fig. 1: Location of the study area on the island Lošinj, insert shows the town of Mali Lošinj with both study areas. N = northern site, SW = south-western site.
Abb. 1: Lage des Untersuchungsgebiets auf der Insel Lošinj, Insert zeigt das Ortsgebiet von Mali Lošinj mit den beiden Standorten. N = nach Norden ausgerichtet, SW = nach Südwesten ausgerichtet.

facing southwest (44°31'46.1"N, 14°26'46.6"E), which is exposed to higher waves, is located on the Promenade Šetalište Dr. Alfreda Edlera of Manussija, between the campsite Čikat and the Čikat Bay. The area facing north (44°31'46.1"N, 14°26'46.6"E) is less exposed to wave action and is located on the road Veloselska cesta.

2.2 Data collection

During August and September 2015 individuals of the families Blenniidae and Tripterygiidae were surveyed on two different littoral sections on the island Lošinj. Data were collected by snorkeling with the underwater visual census method (de Girolamo & Mazzoldi 2001; Labrosse et al. 2002). On both locations (fig. 1) an area of 250 m² with similar topology and habitats was defined and partitioned in five stripe transects with 10 x 5 m each (Samoilys & Carlos 2000). The transect vertices were marked underwater. Altogether ten surveys between 7 and 8 am and another ten surveys between 1 and 2 pm were performed on the same transects at each location. The assessment time was chosen deliberately, since there was little boat traffic which could disrupt data collection. The study area was surveyed parallel to the coast in 1.25 and 3.75 m intervals with a constant speed of 2.4 m/min (Sutherland 1996). Each individual was counted and classified on each transect. The habitat that it occupied was documented and depth was determined by a measuring cord.

Types of habitats

Water level (WL): Mean water level with impact of wave action, immediately beneath the water surface of the karstified coast.

Endolithic holes made by *Lithophaga lithophaga* or *Rocellaria dubia* (EH): In rocky walls and overhangs, these bivalves bore holes with a diameter of around 1.5 cm (varying from 0.6 to 2.5 cm) and a length of around 5 cm (varying from

2 to 8 cm) into limestone. After the death of the mussel, the shell disappears and the holes are used by different invertebrates and fish.

Cavities (CA): Cavities of different sizes may be found in rocky slopes, walls, and overhangs. The openings of small cavities are 15 to 50 cm in diameter and cavity depth is 20 to 50 cm. The main characteristics of the cavities are that large areas are covered by the red algae *Peyssonnelia squamaria* and that light levels are low. The walls and the ceilings have secondary holes of 2 to 5 cm in which the fish usually hide.

Rock walls (RW): Steep rock walls which usually drop 90°, partially with low light levels depending on the orientation.

Flat bedrock with aufwuchs (FB), sunny (+) or shady (-): Horizontal or slightly inclined bedrock covered with diverse green algae, red algae and brown algae.

Flat bedrock without aufwuchs (FU), sunny (+) or shady (-): Exactly the same horizontal or slightly inclined bedrock, only covered with algal turf.

2.3. Data analysis

The numerical richness is mainly used in aquatic studies and can be defined as the number of species per specified number of individuals (Kempton 1979). Calculations were performed with "R for Windows GUI 3.2.3". The package "rich 0.3" (Rossi 2011) was used to calculate the average richness. One way to investigate the biodiversity at different depths is to calculate the Shannon-Wiener index (Illich & Kotrschal 1990). "BiodiversityR 2.5-4" (Kindt & Coe 2005) was used to calculate the Shannon-Wiener and Simpson indices, as well as to produce the rank abundance curves. These curves can be used to illustrate the abundance, where the abundance of each species is plotted against the rank (Magurran 1988). The Shannon-Wiener indices for each depth were created with "Statistiklabor 2.1". The kite diagram of the depth distribution of each species was created with the packages "plotrix 3.6-3" (Lemon 2006) and "reshape 0.8.5". For the statistical analysis "R Studio 0.99.903" was used.

3. Results

Altogether on both locations in all transects 4970 observations of 14 species with different frequencies were made.

3.1. Blenniidae

Aidablennius sphynx (Valenciennes, 1836): Out of a total of 240 observations only nine were recorded on the sheltered area. The majority of the individuals was found directly under the water surface or on flat, sunny bedrock with algal turf. 12 % were detected on similar rocks but with aufwuchs. The depth distribution (fig. 2) shows, that the number of observations decrease with depth and end at 60 cm. On the sheltered area *A. sphynx* ranks 11th with an observation frequency of 0.5 %, on the wave exposed site this species reaches rank 6 with 7.7 % of all observations.

Coryphoblennius galerita (Linnaeus, 1758): Altogether 258 findings of this species were recorded, 78 % on the water level and 14 % on steep rock walls. The observations decreased with depth, 39 individuals were discovered in 10 cm and ten in 20 cm depth. Nine individuals were found in 40 cm depth. *C. galerita* has the lowest ranking observation frequency with 0.3 % on the sheltered site, while on the wave exposed site this species reaches rank 4 with 8.4 %.

Lipophrys trigloides (Valenciennes, 1836): 48 % out of 237 observations were made in holes of *L. lithophaga*, observations were less common under the water level or on flat, sunny bedrock with algal turf. A maximum of 56 observations was recorded in 20 cm depth, maximum depth on both sites was 50 cm, with an exception of 60 cm on the exposed location. *L. trigloides* showed an observation frequency of 7.2 % on the exposed and 0.7 % on the sheltered area.

Microlipophrys adriaticus (Steindachner & Kolombatović, 1883): Only one out of nine observations was made on the wave exposed site in 20 cm depth. 67 % of this species were found directly under the water surface. Respectively there observations were recorded on flat, sunny bedrock with aufwuchs and on steep rock walls.

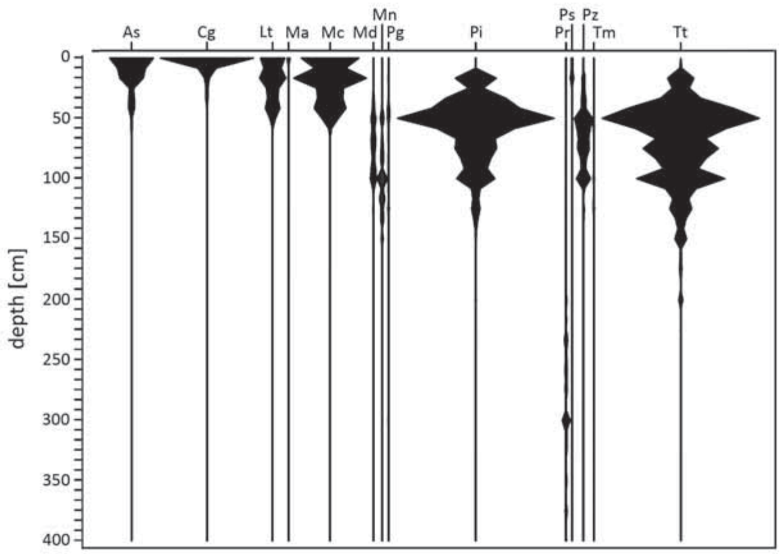

Fig. 2: Depth distributuion of the individual species. As = *A. sphynx*, Cg= *C. galerita*, Lt = *L. trigloides*, Ma = *M. adriaticus*, Mc = *M. canevae*, Md = *M. dalmatinus*, Mn = *M. nigriceps*, Pg = *P. gattorugine*, Pi = *P. incognitus*, Pr = *P. rouxi*, Ps = *P. sanguinolentus*, Pz = *P. zvonimiri*, Tm = *T. melanurum*, Tt = *T. tripteronotum*.
Abb. 2: Tiefenverteilung der einzelnen Arten. As = *A. sphynx*, Cg= *C. galerita*, Lt = *L. trigloides*, Ma = *M. adriaticus*, Mc = *M. canevae*, Md = *M. dalmatinus*, Mn = *M. nigriceps*, Pg = *P. gattorugine*, Pi = *P. incognitus*, Pr = *P. rouxi*, Ps = *P. sanguinolentus*, Pz = *P. zvonimiri*, Tm = *T. melanurum*, Tt = *T. tripteronotum*.

On the northern less exposed location *M. adriaticus* was present with 0.3 % in the observations, whereas on the wave exposed site fish were only frequently found in tide pools.

Microlipophrys canevae (Vinciguerra, 1880): A total of 567 observations was recorded with an observation frequency of 15.1 % on the exposed and 5.9 % on the sheltered site, thus this species reaches rank 3 on both locations. 41 % of all observations were made in endolithic holes. Commonly the individuals were detected under the water level, on steep rock walls or on sunny, flat bedrock without aufwuchs. Most fish were found in 20 cm depth or immediately under the water level, less common in 40 cm and only one individual down to 60 cm depth (fig. 2).

Microlipophrys dalmatinus (Steindachner & Kolombatović, 1883): Altogether 75 observations were made on both study sites with an observation frequency of 3.4 % on the northern site and 0.3 % on the south-western site. The individuals were found between 25 and 140 cm depth, whereas an observation maximum was detected at 1 m depth (fig. 2). The 87 % majority of this species was observed on flat, sunny bedrock with aufwuchs.

Microlipophrys nigriceps (Vinciguerra, 1883): This species was found only on the northern sheltered area. Due to its nuptial plumage, the yellow cheeks, *M. nigriceps* can be relatively well distinguished from *Tripterygion melanurum*. 89 % of observations were made on steep rock walls, the remaining 11 % were recorded in endolithic holes. Fish were spotted from 20 to 150 cm depth, most were found in 100 cm depth (fig. 2).

Parablennius gattorugine (Linnaeus, 1758): The majority of observations with a frequency of 1.4 % was recorded on the less exposed site. More than half of all observations were made in cavities and respectively 16 % on steep rock walls and on sunny, flat bedrock with aufwuchs. Depth distribution reaches from 20 cm to 325 cm with the maximum of observations at 40 and 50 cm (fig. 2).

Parablennius incognitus (Bath, 1968): With 1175 observations and a frequency of 38.6 %, *P.*

incognitus was the most abundant species on the wave exposed location. On the sheltered site 217 observations with a frequency of 10.7 % were recorded. Commonly flat, sunny bedrock with aufwuchs was occupied, less frequently holes made by bivalves. Depth range reaches from 20 to 200 cm with a maximum of observations occurring at 60 cm depth (fig. 2).

Parablennius rouxi (Cocco, 1833): Out of a total of 70 observations, 52 with a frequency of 2.6 % were made on the sheltered site. On the exposed site this species showed a frequency of 0.6 %. Observations started from 175 cm down to 4 m. The majority of sightings was made at 3 m on sunny, flat bedrock with algal turf. This species was found less frequently on shady or sunny, flat bedrock with aufwuchs, only few were recorded in endolithic holes.

Parablennius sanguinolentus (Pallas, 1814): This species was found only on the sheltered site with an observation frequency of 0.7 %. Most findings were recorded in 20 cm depth on flat, sunny bedrock without aufwuchs. Less frequently these fishes were detected on the same rocks in the shade, on sunny bedrock with aufwuchs or directly under the water surface.

Parablennius zvonimiri (Kolombatović, 1892): 203 findings with an observation frequency of 4.2 % on the exposed and 4 % on the sheltered location were recorded. The majority occupied steep rock walls, less common individuals sojourned in endolithic holes, cavities and on flat, sunny bedrock with aufwuchs. Depth distribution ranges from 20 to 180 cm, with a maximum of observations between 50 and 100 cm.

3.2. Tripterygiidae

Tripterygion melanurum (Guichenot, 1850): This species was only seen on the northern sheltered location with an observation frequency of 0.8 %. All observations were made on shady, steep rock walls in 60 to 130 cm depth.

Tripterygion tripteronotum (Risso, 1810): Out of 1803 observations, 528 with an observation frequency of 17 % were recorded on the wave exposed site. With a frequency of 65 % in the observations, this species was the most abundant on the sheltered northern site. Depth distribution ranges from 10 to 225 cm, most fish were detected at 0.5 m depth. Commonly steep rock walls and flat, sunny bedrock with aufwuchs were occupied.

Tab. 1: Average abundance on both locations and habitat utilization of each species. - = < 10 % rare, + = ≥ 10 % and < 30 % intermediate abundance, ++ = ≥ 30 % common. For abbreviations see "types of habitats". SW = south-western site, N = northern site.

Tab. 1: Habitat-Präferenz einzelner Arten. - = < 10 % selten bis nie, + = ≥ 10 % und < 30 % mittlere Abundanz, ++ = ≥ 30 % hohe Abundanz sowie ihr Abundanz-Mittelwert an beiden Standorten. Abkürzungen der Habitat-Typen im Text. SW = Südwest-Seite, N = Nord-Seite.

	habitat								abundance	
species	WL	EH	CA	RW	FB+	FB-	FU+	FU-	SW	N
A. sphynx	++	-	-	-	+	-	++	-	11.55	0.45
C. galerita	++	-	-	+	-	-	-	-	12.6	0.3
L. trigloides	+	++	-	-	-	-	+	-	11.1	0.75
M. adriaticus	++	-	-	+	+	-	-	-	0.05	0.4
M. canevae	+	++	-	+	-	-	+	-	22.6	5.75
M. dalmatinus	-	-	-	-	++	-	-	-	0.4	3.3
M. nigriceps	-	-	-	++	-	-	-	-	0	4
P. gattorugine	-	-	++	+	-	-	+	-	0.25	1.35
P. incognitus	-	+	-	-	++	-	-	-	57.85	10.5
P. rouxi	-	-	+	-	-	+	++	+	0.9	2.6
P. sanguinolentus	+	-	-	-	-	+	++	+	0	0.7
P. zvonimiri	-	+	+	++	+	-	-	-	6.25	3.9
T. melanurum	-	-	-	++	-	-	-	-	0	0.4
T. tripteronotum	-	-	-	++	++	-	-	-	26.4	63.75

Tab. 2: Mean values of the Shannon-Wiener and Simpson indices as well as the species richness of both locations.
Tab. 2: Mittelwerte der Shannon-Wiener- und Simpson-Indices sowie der Spezies Richness beider Standorte.

	Shannon-Wiener index	Simpson index	richness
south-western site	1.7043663	0.7680688	8.10
northern site	1.3033731	0.5517655	10.05

3.3. Comparison of the fish communities

Ten blenniid species and one tripterygiid species were found on the southwestern exposed location, twelve blenniid species and two tripterygiid species were found on the sheltered study area facing north (tab. 1). The mean richness, the Shannon-Wiener and Simpson index showed differences (tab. 2). The exposed site revealed a 0.4 higher Shannon-Wiener index and a 0.2 higher Simpson index, whereas the mean richness is lower by two species.
Figure 3 depicts the differences in the frequencies of the two investigated study areas. Because of the unequal frequencies of observation, the sheltered location shows a hyperbole, whereas the exposed site reveals a linear curve. Although the performance of a Wilcoxon sign rank test with a p-value of 0.2502 showed no significance. *Tripterygion tripteronotum* and *Parablennius incognitus* are represented on both areas with high abundances.

3.4. Diversity at varying depths

The Shannon-Wiener index at varying depths revealed a very similar species diversity by depth on both investigation sites (fig. 4). A maximum of diversity was found at a depth of 20 to 25 cm.

3.5. Depth distribution

The studied species showed depth limits in their ranges. *Aidablennius sphynx*, *Coryphoblennius galerita*, *Lipophrys trigloides*, *Microlipophrys adriaticus*, *Microlipophrys canevae* and *Parablennius sanguinolentus* occurred only in narrow depths down to 50 cm (fig. 2). *Tripterygion tripteronotum, Tripterygion melanurum*, *Parablennius incognitus*, *Parablennius zvonimiri, Microlipophrys nigriceps* and *Microlipophrys dalmatinus* were spotted down to 2 m. Only *Parablennius rouxi* and *Parablennius gattorugine* were observed in depths between 3 and 4 m.

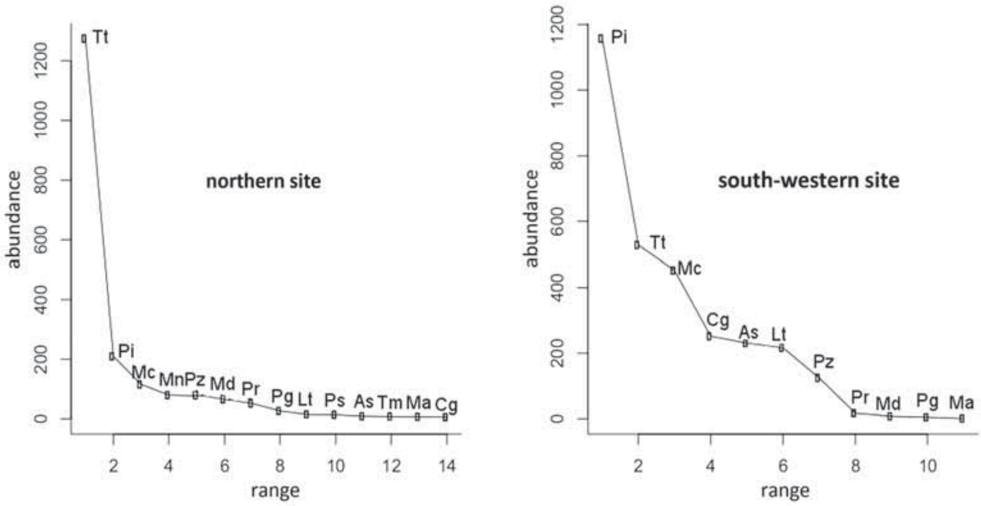

Fig. 3: Rank-abundance curves from both study areas. For abbreviations see fig. 2.
Abb. 3: Rang-Abundanz Kurven beider Ausrichtungen. Abkürzungen wie Abb. 2.

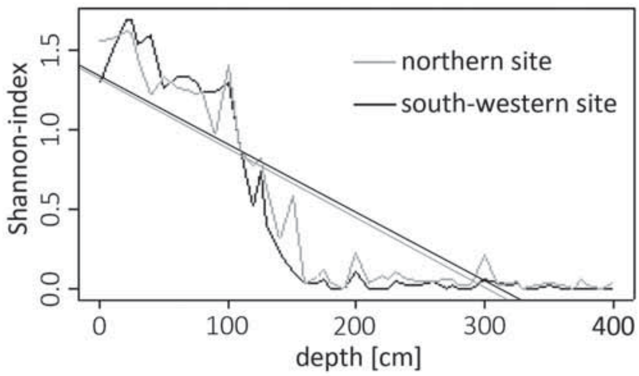

Fig. 4: Shannon-Wiener index at varying depths.
Abb. 4: Shannon-Wiener Index der jeweiligen Tiefe.

3.6. Habitat utilization

The overall habitat utilization is presented in figure 5. More than a quarter of observations, 1885 out of 4970, were recorded on sunny, flat bedrock with aufwuchs (FB+), only 136 observations were made on exactly the same rocks in the shade (FB-). 1125 individuals occupied steep rock walls (RW), 174 were found in cavities (CA) and 719 in endolithic holes (EH). 480 findings were recorded immediately at water level (WL) and 407 on sunny, level rock with algal turf (FU+), 44 observations were made on exactly the same rocks in the shade (FU-).

4. Discussion

The study indicates that the direction and thus the wave action is an important factor for the diversity and species richness of blenniids and tripterygiids. This correlates with results from studies about cryptobenthic (Santin & Willis 2007) and littoral fish communities (Zander 1972b; Zander et al. 1999; de Raedemaecker et al. 2010). It is not the mechanical stress induced by the wave action that has the greatest impact on the fish community. It is the indirect effect of the wave motion on the microhabitats that

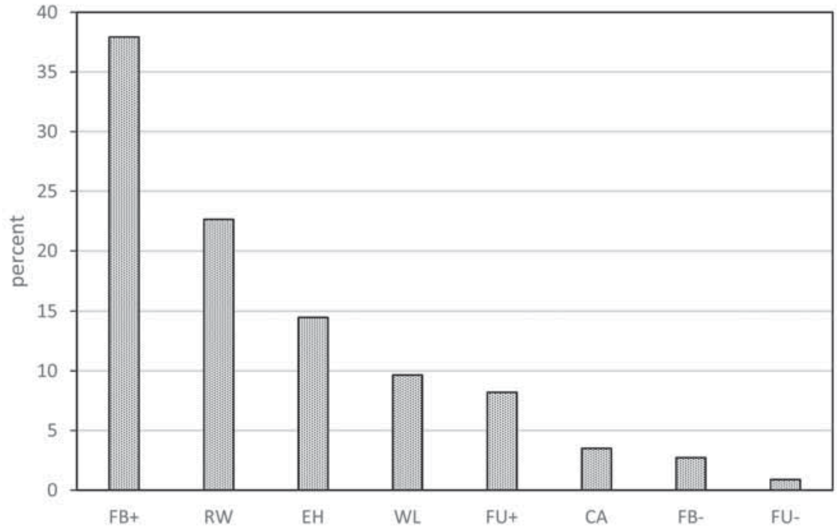

Fig. 5: Overall observations of the respective habitats. For abbreviations see "types of habitats".
Abb. 5: Gesamtbeobachtungen in den jeweiligen Habitaten. Abkürzungen siehe Habitattypen.

causes a change in the algal composition (Santin & Willis 2007). The comparison of the richness and diversity between the exposed and sheltered area contradicts other results (de Raedemaecker et al. 2010), which present a similar species richness on both sites and higher diversity on the sheltered area. Only the abundances showed similarities, which were lower on the sheltered location. The deviations might have resulted due to different sampling times, because it is known that diurnal (Santos et al. 2002) and seasonal (Nieder 2000) variations in the abundances of fish communities occur.

Data of single species showed, that the widely distributed species *Aidablennius sphynx* (Orlando-Bonaca & Lipej 2007) prefers wave exposed habitats (Santin & Willis 2007). These fish favor endolithic holes, obligatory for nesting or shelter, that are exposed to sunlight (Orlando-Bonaca & Lipej 2008) and they sojourn in very shallow depth (Zander et al. 1999). The semi-amphibious *Coryphoblennius galerita* is highly selective. This herbivorous species inhabits the mediolittoral belt and is therefore the species occurring in the most shallow locations (Nieder 2000). At high tide the level of activity of these fish rises and it sojourns on rocky plateaus (Faria & Almada 2008) without aufwuchs (Zander 1972a). The carnivorous *Lipophrys trigloides* moves in shallower depths at night, because many piscivores, e.g. *Scorpaena* spp., inhabit depths less than 2 m during night time (Nieder 2000). This euryphotic species (Zander 1972b) prefers exposed coastal areas (Santin & Willis 2007) and facultatively uses holes made by *L. lithophaga* (Orlando-Bonaca & Lipej 2008).

Microlipophrys adriaticus, a species more or less endemic in the Adriatic (Patzner & Moosleitner 1994a), shows preferences for exposed habitats (Santin & Willis 2007). Findings in endolithic holes cannot be confirmed (Orlando-Bonaca & Lipej 2008). The preference of *Microlipophrys canevae* for sheltered sites (Santin & Willis 2007) contradicts this study, apart from the utilization of endolithic holes made by *L. lithophaga* (Orlando-Bonaca & Lipej 2008), which it successfully defends against *Parablennius incognitus* (Illich & Kotrschal 1990).

Another species that occupies holes is *Microlipophrys dalmatinus*. These fish inhabit sunlit holes made by *Rocellaria dubia* with an entrance diameter slightly bigger than their heads to prevent displacement by larger rivals (Kotrschal 1983; Orlando-Bonaca & Lipej 2007, 2008). The observation, that occasionally multiple individuals co-occur on flat rocks, matches with existing data (Patzner 1985) as well as observations of an affinity for sheltered areas (Santin & Willis 2007). *Microlipophrys nigriceps* was observed in sheltered locations at 0.5 m depth. However, typically this species inhabits depths from 2 to 10 m (Illich & Kotrschal 1990; Patzner 1999; Orlando-Bonaca & Lipej 2007). The largest species of all blenniids, *Parablennius gattorugine*, prefers deeper habitats, usually depths down from 5 m. Shallow waters are mostly inhabited by juveniles (Zander 1972a; Patzner & Moosleitner 1994b). A preference for exposed sites (Santin & Willis 2007) cannot be confirmed.

P. incognitus is considered a generalist (Kovačić et al. 2012), due to his low microhabitat selectivity (Orlando-Bonaca & Lipej 2007) and his euryphotic lifestyle (Zander 1972b). This aspect and the small territory size of 7 to 11 cm (Koppel 1988), which indicates low intraspecific competition among males, could explain the high abundances of this species. These fish inhabit endolithic holes bored by *L. lithophaga* during spawning period and for shelter that are exposed to sunshine, with an irrelevant inclination (Orlando-Bonaca & Lipej 2008). *Parablennius rouxi* occurs in horizontal or downward pointing endolithic holes in shady parts of boulders (Orlando-Bonaca & Lipej 2008), primarily downwards from a depth of 2 m (Patzner & Moosleitner 1994b), on white rocky substratum or on boulders (Heymer & Zander 1975; Macpherson 1994).

The low abundances of *Parablennius sanguinolentus* can represent good water quality (Patzner 1985). On the Slovenian coast (Orlando-Bonaca & Lipej 2007) and Rovinj (Illich & Kotrschal 1990) fish were recorded in 1.5 m depth. In the harbor of Aurisina this species was found at 3 m depth hidden in cans or bottles (Patzner 1985). In the northern Adriatic Sea

P. sanguinolentus was found more frequently on exposed locations (SANTIN & WILLIS 2007) and in the east of the Aegean Sea only on sheltered areas (DE RAEDEMAECKER et al. 2010). Hence an explanation about the exposition preference of this species cannot be made.

The mostly cryptobenthic sojourning species *Parablennius zvonimiri* (KOVAČIĆ et al. 2012), facultatively in holes made by *L. lithophaga* (ZANDER & HEYMER 1976; ORLANDO-BONACA & LIPEJ 2007), generally cannot be found near the water surface (PATZNER 1984). Due to the similar rank-abundances on both sites, a preference for exposed habitats (SANTIN & WILLIS 2007; DE RAEDEMAECKER et al. 2010) cannot not be confirmed. *Tripterygion melanurum* as well as *M. nigriceps* were only found on the sheltered study area. This is not surprising, since both occur in similar habitats (PATZNER 1985; DE RAEDEMAECKER et al. 2010). When disturbed, *T. melanurum* withdraws in cavities in 2 to 8 m depth. In sheltered areas this species was found up to a depth of 1 m (PATZNER 1999). *Tripterygion tripteronotum* is a common species on the rocky shores of the Mediterranean Sea (PATZNER 1985). These fish are present on both expositions with higher abundances on sheltered coasts (DE RAEDEMAECKER et al. 2010). This triplefin blenny sojourns on steep rock walls (MACPHERSON 1994) and in the algal phytal (LA MESA et al. 2006) with a preference for sunny patches clad in *Wrangelia* and *Padina* (ORLANDO-BONACA & LIPEJ 2005). Depth ranges from 20 to 100 cm down to 3 m (PATZNER 1985).

The rank-abundance of *P. incognitus* and *T. tripteronotum* generally corresponds with other studies (ILLICH & KOTRSCHAL 1990; ORLANDO-BONACA & LIPEJ 2007), which is not surprising for *P. incognitus,* since this fish can account for up to 35 % of a shallow water fish community (PATZNER & MOOSLEITNER 1994a). A disparity is shown by *M. dalmatinus.* It reached rank 6 with an observation frequency of 3.4 % on the northern sheltered area and rank 9 with a frequency of 0.3 % on the southwestern location in this study. In other studies, it occupied rank 2. This result is explainable through the high bias of the underwater visual census method. Biases that can occur on account of the observer are delays, multiple counts of individuals, inattention or too much attention to a particular area (SALE & SHARP 1983; LABROSSE et al. 2002). In addition, there may be interactions between the animal and the observer. The fish can, depending on the species, behavior and lifestyle, flee or feel attracted to the observer (SALE & SHARP 1983; LABROSSE et al. 2002). Fish which are in a cryptic position at the time of observation will be missed, therefore a significant portion of the population will be overlooked, which can decrease qualitative and quantitative results (ALZATE et al. 2014). The most accurate results are obtained through examinations with high fish density and slow speed, because during visual sampling fewer fish are counted than really exist (BROCK 1982; HARMELIN-VIVIEN & FRANCOUR 1992). Destructive methods such as the use of toxic substances, for example quinaldine (GIBSON 1967; KOVAČIĆ et al. 2012) and rotenone, lead to more realistic results. Additionally, it should be noted that the position and orientation of the sample surface has an influence on the result, thus the study areas should be as homogeneous as possible (LABROSSE et al. 2002). Since this is the smallest species of all blennies in the Mediterranean, which is often found in holes of *Rocellaria dubia* (ORLANDO-BONACA & LIPEJ 2007), it is quite easy to overlook them.

It should be mentioned that species which occur in high abundances in studies executed by SCUBA diving in the Northern Adriatic were missing, for example *Salaria pavo*, *Parablennius tentacularis* and *Tripterygion xanthosoma* (former *T. delaisi*). *T. xanthosoma* was spotted on the island Orjule (FREINSCHLAG & RENNER pers. comm.), on the mainland at Crikvenica with high abundance (observation by R.P.), around Rovinj (ZANDER & JELINEK 1976) and on the island Krk (KOVAČIĆ et al. 2012). At Krk the observation frequency of *T. xanthosoma* was even higher than that of *P. incognitus* and *T. tripteronotum*. A repetition of the survey with SCUBA could likely reveal different results, because the depth range of this species begins at 3 m (PATZNER & MOOSLEITNER 1995). Another example for a species living in greater depths is *P. tentacularis*.

The only representative from the family Clinidae in the Mediterranean *Clinitrachus argentatus* has not been discovered, despite intensive search in the phytal. It is absent in the index of the Kvarner Bay (Zavodnik & Kovačić 2000), but inhabits the Gulf of Trieste (Patzner 1985; Lipej et al. 2003).

The habitat utilization of all species showed that most individuals coexist immediately under the water surface or on level, sunny rock with aufwuchs. Only a few species like *P. rouxi* and *P. sanguinolentus* inhabited shady rock without aufwuchs. This is likely because *P. sanguinolentus* feeds on algal turf and is strictly herbivorous (Orlando-Bonaca & Lipej 2007). *P. rouxi* nourishes on Porifera, but food preferences change with depth (Heymer & Zander 1975; Patzner & Moosleitner 1994b). Habitat preferences of single species indicated that species with a high degree of spatial niche overlap and that a similar depth distribution differs in other ecological niches, like shelter characteristics and feeding habits (Zander 1996; Nieder 2000). *P. incognitus* and *M. canevae* utilize endolithic holes made by *Lithophaga lithophaga*, but show an ecological separation in their food preferences. *P. incognitus* is an omnivorous fish while *M. canevae* is herbivore (Goldschmid et al. 1980; Nieder 2000). *T. tripteronotum*, *T. melanurum*, *P. zvonimiri* and *M. nigriceps* showed similar habitat preferences. They were all found on dark, steep rock walls and overhangs but they differ in their microhabitat utilization. *T. tripteronotum* prefers substratum covered with algae and *T. melanurum* favors bare rock bottom (la Mesa et al. 2006). When disturbed *M. nigriceps* was found in endolithic holes, which matches published data from Ibiza (Patzner 1999) but differs from findings on the Slovenian coast (Orlando-Bonaca & Lipej 2007, 2008).

The stenotopic behavior of *Parablennius zvonimiri* (Kovačić et al. 2012) correlates with studies from the Gulf of Trieste (Patzner 1985). There are few differences from observations on the Slovenian coast (Orlando-Bonaca & Lipej 2007) and Ibiza (Patzner 1999). At these locations this species was found downwards from 2 m depth. Due to the fact that *P. zvonimiri* is a photophobic species inhabiting cavities (Zander 1972b; Orlando-Bonaca & Lipej 2007), varieties in the coastal and therefore habitat topology could be decisive for the different result.

All fieldwork of this research, like for many other studies on the ecology of epi- and cryptobenthic fish communities, was performed during the daytime in summer and autumn. Only a few studies were conducted at night (Zander 1983; Nieder & Zander 1994; Santos et al. 2002), at different tides (Faria & Almada 2006, 2008) or in winter (Kotrschal 1983; Patzner 1985). At temperatures around 10 °C only a few individuals were observed, despite the use of quinaldine. Since these fishes have a life expectancy of 2 to 5 years (Kotrschal & Goldschmid 1981), the question that arises is in which habitats and depths they do hibernate?

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