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UTILIZATION OF EMPTY HOLES BY TWO ADRIATIC ENDOLITHIC BLENNIES UNDER EXPERIMENTAL CONDITIONS – PRELIMINARY RESULTS

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ABSTRACT

The present research aimed at studying the relationships between dominance rank and access to holes in two captive blenniid species (Parablennius incognitus *and* Parablennius zvonimiri) *competing for territory. The fish preference for hole length, diameter and inclination was assessed. The specimens used in the experiments were caught in the Gulf of Trieste by SCUBA diving. Two different types of experiments were performed with three subsamples each: (a) the number of test males was higher than the number of available holes, and (b) fish number was lower than the number of holes. Moreover, each experiment was also separately performed with specimens of* P. zvonimiri *and* P. incognitus *and in a third set with both species together. The results indicate that* P. zvonimiri *is the dominant species, with a strong positive correlation between the dominance ranks and the access to shelters.*

Key words: *Parablennius zvonimiri*, *Parablennius incognitus*, experimental conditions, holes availability, intra- and interspecific competition, northern Adriatic Sea

USO DI FORI VUOTI IN DUE SPECIE ENDOLITICHE DI BLENNIDI ADRIATICI IN CATTIVITÀ – RISULTATI PRELIMINARI

SINTESI

La presente ricerca è stata mirata allo studio delle relazioni tra il rango di dominanza e l'accesso ai fori in due specie di blennidi tenute in cattività (Parablennius incognitus *e* Parablennius zvonimiri) *ed in competizione per il territorio. È stata inoltre valutata la preferenza dei pesci per lunghezza, diametro ed inclinazione dei fori. Gli individui usati negli esperimenti sono stati catturati nel Golfo di Trieste con tecniche subacquee. Sono stati eseguiti due tipi di esperimenti: (a) numero di maschi superiore al numero di fori disponibili, e (b) numero di maschi inferiore al numero di fori disponibili. Ogni esperimento è stato ripetuto separatamente con individui di* P. zvonimiri, *di* P. incognitus *e una terza serie con individui di entrambe le specie contemporaneamente. I risultati evidenziano che* P. zvonimiri *è la specie dominante, con una forte correlazione positiva fra il rango di dominanza e l'accesso ai fori.*

Parole chiave: *Parablennius zvonimiri*, *Parablennius incognitus*, esperimenti, disponibilità di fori, competizione intra- ed interspecifica, Adriatico settentrionale

INTRODUCTION

Males of most intertidal and subtidal fish species establish their breeding territories, and due to the abundance of fishes in this depth range the competition for space is assumed to be high. The majority of blennies (family Blenniidae) are considered to be residents of rocky habitats, since after the larval stage, they live primarily on rocky habitats and spawn there (Gibson, 1982). Members of this family also exhibit male parental care, especially egg guarding. These males show common courtship behaviour of signalling the nest and leading the female to the entrance of the nesting cavities (Almada & Santos, 1995). The Shy blenny *Parablennius incognitus* (Bath, 1968) and the Zvonimir's blenny *Parablennius zvonimiri* (Kolombatović, 1892) are thought to be very closely related (Bath, 1976; Zander, 1986). In the Gulf of Trieste, these two species showed to be partially syntopic (Orlando-Bonaca & Lipej, 2007), so their existence in the same habitat offers the opportunity to study their interactions and competition for the access to shelters.

P. incognitus is very common in the rocky sublittoral Mediterranean and Adriatic Sea, as well (Goldschmid & Kotrschal, 1981; Kotrschal & Goldschmid, 1981; Patzner, 1985; Kotrschal, 1988; Illich & Kotrschal, 1990; Orlando-Bonaca & Lipej, 2005). In Slovenian coastal waters, it is widespread and it was defined as the least selective blenniid species in terms of microhabitat choice (Orlando-Bonaca & Lipej, 2007; Lipej *et al.*, 2008). It was found nesting mostly in empty date mussel's *(Lithophaga lithophaga)* holes, and occasionally in *Gastrochaena dubia* holes, empty oyster's shells, crevices and in plastic tubes, from the water surface down to 4 meters of depth (Orlando-Bonaca & Lipej, 2008). In Slovenian coastal waters, the cryptobenthic blenny *P. zvonimiri (sensu* Miller, 1979, 1996), defined also as a photophobous species (Pallaoro, 1989), showed a strong preference for rocks covered by precoralligenous bioformations, in a depth range from 3 to 10 m, where it is nesting mostly in empty date mussel's holes (Orlando-Bonaca & Lipej, 2008). Endolithic bivalves bore holes that are optimal shelters for breeding, with relatively small entrances, but wide enough interiors for spawning and guarding eggs (Kotrschal, 1988).

In the past, *P. zvonimiri* was confused with *P. incognitus* (Segantin, 1968, since both species have similar body length, shape of the head and supra-orbital tentacles, and can exhibit similar red basic colouration. The presence of *P. zvonimiri* in Slovenian coastal waters was confirmed only recently (Lipej *et al.,* 2005), but had previously been known for the North Adriatic (Patzner, 1985; Kotrschal, 1988). *P. incognitus* co-occurs in the same habitat with *P. zvonimiri*, since it is a more opportunistic species (Koppel, 1988).

There is a considerable amount of literature concerning the territorial behaviour of blennioids (Stephens *et al.*, 1970; Wirtz, 1978; Nursall, 1981; Almada *et al.*, 1983, 1992, 1994; Gonçalves & Almada, 1998; Gonçalves *et al.*, 2000). However, to our knowledge, only two attempts were made in the past to investigate the spatial resource partitioning among Mediterranean blennies *ex situ* (Koppel, 1988; Faria & Almada, 2001), while another attempt is known from Mexico (Lindquist, 1985). *P. incognitus* was one of the species studied under experimental conditions by Koppel (1988), while for *P. zvonimiri* this is the first experimental investigation of holes utilization by this species.

The aim of this work was to study the relationships between size related dominance rank and access to holes (shelters and nesting sites) in captivity groups of *P. incognitus* and *P. zvonimiri*, species preferences for holes characteristics, as well as intra- and interspecific competition in utilization of holes.

MATERIAL AND METHODS

Populations of *P. incognitus* and *P. zvonimiri* were observed in their natural habitat in Slovenian coastal waters (Gulf of Trieste, northern Adriatic Sea) by SCUBA diving, during the spring-summer period from 2003 to 2005.

Six males of each species *(P. incognitus* and *P. zvonimiri)* were captured in July 2005 in the Cape Madona Nature Monument near Piran (Slovenia), at a depth between 3 and 5 m. All specimens were residents, egg-guarding males thriving in holes and were caught with the method proposed by Kotrschal (1988). The opening of a plastic bag was held tightly around a selected hole. The male was then disturbed with a tight wand contained in the bag. The fish darted out of its hole and was caught in the bag. Total length as well as head width and height of the evicted fish were measured (Tab. 1) while confined and stretched out within the bag. The fish were then transported to the biological laboratory of the Marine Biology Station (National Institute of Biology) in Piran.

Two aquaria were used, both 80 litres of capacity. In the first, specimens were contained that were not used in the experiment at that moment, while in the second the experiment was carried out. Water temperature in the aquaria ranged from 18 to 23ºC. A light-dark regime of 12 h was maintained. The aquarium under observation contained only two air-stones connected with air pumps and one experimental block of siporex with different types of holes. The siporex was selected as it is a soft material to drill. After boring the holes, the siporex block was well washed off before placed in the experimental aquarium. Since the siporex is very light, it was weighted with cryptic weights.

Tab. 1: Measurements of the blenny males used in experiments.
Tab. 1: Meritve samčkov babic, ki so bili uporabljeni v poskusih.

Species	Parameter		
	Total length (mm)	Head width (mm)	Head height (mm)
P. zvonimiri	67	8	11
	55	8	10
	49	7	9
	49	7	9
	48	7	9
	46	6	8
	45	6	8
P. incognitus	57	8	10
	54	7	9
	50	6	8
	44	5	7
	40	5	7
	32	4	6
	30	4	6

Tab. 2: List of experiments with all variables in each experiment.
Tab. 2: Preglednica poskusov z vsemi spremenljivkami v posameznih poskusih.

Experiment	Species	No. specimens	Observation time (h)	Holes			
				No.	Length (cm)	Diameter (mm)	Inclination (°)
1a	*P. zvonimiri*	6	8	1	5	16	90
				1	7		
				1	9		
				1	12		
1b	*P. incognitus*	6	8	1	5	16	90
				1	7		
				1	9		
				1	12		
1c	*P. zvonimiri*	3	8	1	5	16	90
				1	7		
	P. incognitus	3		1	9		
				1	12		
2a	*P. zvonimiri*	4	12	6	5	16	90
				6	7		
				6	9		
				6	12		
2b	*P. incognitus*	4	12	6	5	16	90
				6	7		
				6	9		
				6	12		
2c	*P. zvonimiri*	3	12	6	5	16	90
				6	7		
	P. incognitus	3		6	9		
				6	12		
3a	*P. zvonimiri*	6	8	1	12	8	90
				1		10	
				1		12	
				1		16	
				1		18	

Experiment	Species	No. specimens	Observation time (h)	Holes			
				No.	Length (cm)	Diameter (mm)	Inclination (°)
3b	*P. incognitus*	6	8	1	12	8	90
				1		10	
				1		12	
				1		16	
				1		18	
3c	*P. zvonimiri*	3	8	1	12	8	90
				1		10	
	P. incognitus	3		1		12	
				1		16	
				1		18	
4a	*P. zvonimiri*	4	12	5	12	18	90
				5		10	
				5		12	
				5		16	
				5		18	
4b	*P. incognitus*	4	12	5	12	8	90
				5		10	
				5		12	
				5		16	
				5		18	
4c	*P. zvonimiri*	3	12	5	12	8	90
				5		10	
	P. incognitus	3		5		12	
				5		16	
				5		18	
5a	*P. zvonimiri*	6	8	1	7	16	0
				1			45
				1			90
				1			135
5b	*P. incognitus*	6	8	1	7	16	0
				1			45
				1			90
				1			135
5c	*P. zvonimiri*	3	8	1	7	16	0
				1			45
	P. incognitus	3		1			90
				1			135
6a	*P. zvonimiri*	4	12	5	7	16	0
				5			45
				5			90
				5			135
6b	*P. incognitus*	4	12	5	7	16	0
				5			45
				5			90
				5			135
6c	*P. zvonimiri*	3	12	5	7	16	0
				5			45
	P. incognitus	3		5			90
				5			135

Each experiment started after 16 hours of acclimatization of the involved specimens to the new aquarium. During the experiment, the time that each fish spent in each hole was noted down, as well as the frequency of agonistic encounters among fishes (inter- and intraspecific).

In order to assess the fish preference for hole length, diameter and inclination, two different types of experiments were performed: firstly, in the experimental aquarium the number of fishes was higher than the number of holes, and secondly the number of fishes was smaller than the number of empty holes. Moreover, each experiment was repeated three times: firstly only with specimens of *P. zvonimiri*, secondly with specimens of *P. incognitus*, and thirdly with specimens of both species.

For those experiments, where the number of holes was higher than the number of fishes, the maximum time of hole occupancy was calculated by multiplying the observation time by the number of involved blennies (following Koppel, 1988). For those experiments, where the number of fishes was higher than the number of holes, the maximum time of hole occupancy was calculated by multiplying the observation time by the number of holes. The total time that specimens spent in holes is the sum of the time that each blenny spent in holes.

Six experiments with eighteen sub-experiments were performed (Tab. 2). The angles of inclination of the hole were defined following Koppel (1988): vertical holes – 0º, horizontal holes – 90º, downwards from entrance – 45º and upwards from entrance – 135º.

Assessment of the preference for hole length

Experiment 1a, 1b, 1c. In the aquarium, the number of fishes was higher than the number of holes. In a siporex block, 4 holes were drilled with the same diameter (16 mm) and different lengths (5, 7, 9 and 12 cm). All holes were horizontal (90º) and with the same height of the substrate (6 cm). The experiment had three subsamples: 1a – with 6 *P. zvonimiri*, 1b – with 6 *P. incognitus,* 1c – with 3 *P. zvonimiri* and 3 *P. incognitus*. The time of each experiment was two days; observations 4 hours per day. The maximum time of hole occupancy was = 480 min x 4 holes = 1920 min.

Experiment 2a, 2b, 2c. In the aquarium, the number of fishes was lower than the number of holes. In a siporex block, 24 holes were randomly drilled, with the same diameter (16 mm) and different lengths (six holes of 5 cm, six of 7 cm, six of 9 cm and six of 12 cm). All holes were horizontal (90º). The experiment had three subsamples: 2a – with 4 *P. zvonimiri*, 2b – with 4 *P. incognitus,* 2c – with 3 *P. zvonimiri* and 3 *P. incognitus*. The time of each experiment was three days; observations 4 hours per day. The maximum time of hole occupancy for 2a and 2b was = 720 min x 4 blennies = 2880 min, while for 2c was = 720 min x 6 blennies = 4320 min.

Assessment of the preference for hole diameter

Experiment 3a, 3b, 3c. In the aquarium, the number of fishes was higher than the number of holes. In a siporex block, 5 holes were drilled with the same length (12 cm) and different diameters (8, 10, 12, 16, 18 mm). All holes were horizontal (90º) and with the same height of the substrate (6 cm). The experiment had three subsamples: 3a – with 6 *P. zvonimiri*, 3b – with 6 *P. incognitus,* 3c – with 3 *P. zvonimiri* and 3 *P. incognitus*. The time of each experiment was two days; observations 4 hours per day. The maximum time of hole occupancy was = 480 min x 5 holes = 2400 min.

Experiment 4a, 4b, 4c. In the aquarium, the number of fishes was lower than the number of holes. In a siporex block, 25 holes were randomly drilled with the same length (12 cm) and different diameters (five holes of 8 mm, five of 10 mm, five of 12 mm, five of 16 mm, five of 18 mm). All holes were horizontal (90º). The experiment had three subsamples: 4a – with 4 *P. zvonimiri*, 4b – with 4 *P. incognitus,* 4c – with 3 *P. zvonimiri* and 3 *P. incognitus*. The time of each experiment was three days; observations 4 hours per day. The maximum time of hole occupancy for 4a and 4b was = 720 min x 4 blennies = 2880 min, while for 4c was = 720 min x 6 blennies = 4320 min.

Assessment of the preference for hole inclination

Experiment 5a, 5b, 5c. In the aquarium, the number of fishes was higher than the number of holes. In a siporex block, 4 holes were drilled with the same length (7 cm) and the same diameter (16 mm), with different inclination (0º, 45º, 90º and 135º). The experiment had three subsamples: 5a – with 6 *P. zvonimiri*, 5b – with 6 *P. incognitus,* 5c – with 3 *P. zvonimiri* and 3 *P. incognitus*. The time of each experiment was two days; observations 4 hours per day. The maximum time of hole occupancy was = 480 min x 4 holes = 1920 min.

Experiment 6a, 6b, 6c. In the aquarium, the number of fishes was lower than the number of holes. In a siporex block, 20 holes were randomly drilled, with the same length (7 cm) and the same diameter (16 mm), with different inclination (five holes of 0º, five of 45º, five of 90º and five of 135º). The experiment had three subsamples: 6a – with 4 *P. zvonimiri*, 6b – with 4 *P. incognitus,* 6c – with 3 *P. zvonimiri* and 3 *P. incognitus*. The time of each experiment was three days; observations 4 hours per day. The maximum time of hole occupancy for 6a and 6b was = 720 min x 4 blennies = 2880 min, while for 6c was = 720 min x 6 blennies = 4320 min.

The time spent in holes in the first series of experiments (1, 3, 5) with more fish than holes is the result of intra- (a, b) and interspecific (c) competition and size related dominance in utilization of holes, influenced by possible interactions of these factors. The second series

of experiments (2, 4, 6) with more holes than fish is mostly answering the question on preferences for holes characteristics by size or species.

RESULTS

Assessment of the preference for hole length

During experiment 1a, the largest specimen among six *P. zvonimiri* showed to be the dominant male in the aquarium (Tab. 2). It occupied mostly 12 cm and 9 cm long holes (Fig. 1), while smaller males occupied other empty holes. The five subordinate males spent most of the time in the 7 cm long hole. Agonistic encounters for the possession of holes occurred during the entire observation time. Jointly, the six males spent in holes 53.4% of the maximum time of hole occupancy.

During experiment 1b, the largest specimen among six *P. incognitus* showed to be the dominant male in the aquarium. It occupied mostly the 9 cm long hole (Fig. 1), while the five subordinate males spent most of the time in the 5 cm long hole. Agonistic encounters for the possession of holes occurred during the entire observation time and the males spent more time in agonistic encounter in front of the holes than in holes. Jointly, the six males spent in holes 20.9% of the maximum time of hole occupancy.

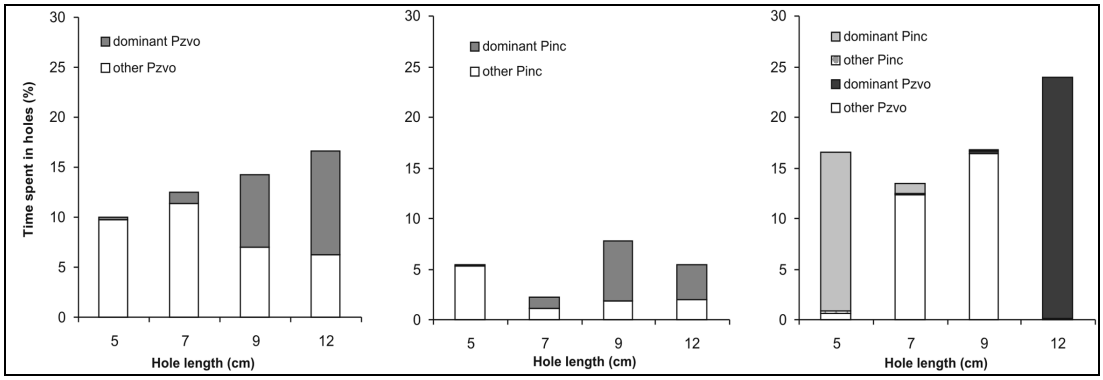

***Fig. 1: Settling experiments performed with** P. zvonimiri **and** P. incognitus **under laboratory conditions with 4 holes of varying lengths. Hole diameter: 16 mm; hole inclination: 90º (horizontal). Experiments: 1a: with 6** P. zvonimiri, **1b: with 6** P. incognitus, **1c: with 3** P. zvonimiri **and 3** P. incognitus.*
***Sl. 1: Poskusi s** P. zvonimiri **in** P. incognitus **v eksperimentalnih razmerah, s 4 rovi različnih dolžin. Premer rovov: 16 mm; naklon rovov: 90º (horizontalni). Poskusi: 1a: s 6** P. zvonimiri, **1b: s 6** P. incognitus, **1c: s 3** P. zvonimiri **in 3** P. incognitus.*

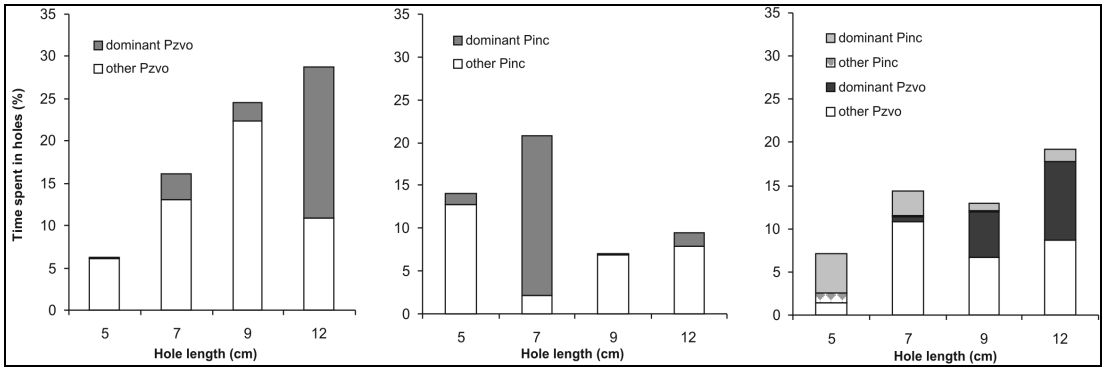

***Fig. 2: Settling experiments performed with** P. zvonimiri **and** P. incognitus **under laboratory conditions with 24 holes of varying lengths (six holes of 5 cm, six of 7 cm, six of 9 cm and six of 12 cm). Hole diameter: 16 mm; hole inclination: 90º (horizontal). Experiments: 2a: with 4** P. zvonimiri, **2b: with 4** P. incognitus, **2c: with** 3 P. zvonimiri **and 3** P. incognitus.*
***Sl. 2: Poskusi s** P. zvonimiri **in** P. incognitus **v eksperimentalnih razmerah, s 24 rovi različnih dolžin (šest rovov 5 cm, šest rovov 7 cm, šest rovov 9 cm, šest rovov 12 cm). Premer rovov: 16 mm; naklon rovov: 90º (horizontalni). Poskusi: 2a: s 4** P. zvonimiri, **2b: s 4 P. incognitus, 2c: s 3** P. zvonimiri **in 3** P. incognitus.*

During experiment 1c, *P. zvonimiri* showed to be the dominant species, and the larger specimen of *P. zvonimiri* was the dominant male in the aquarium. Males of *P. zvonimiri* occupied the three longer holes (Fig. 1), while the dominant male of *P. incognitus* occupied the 5 cm long hole. Agonistic encounters for the possession of holes occurred during the entire observation time. Jointly, the three *P. zvonimiri* males spent in holes 53.8% of the maximum time of hole occupancy, the three *P. incognitus* males only 17.1%.

During experiment 2a (Tab. 2), the dominant male of *P. zvonimiri* occupied mostly 12 cm long holes (Fig. 2), while smaller males showed a preference for 9 cm holes. The number of agonistic encounters for the possession of holes was negligible. Jointly, the four males spent in holes 75.7% of the maximum time of hole occupancy. They spent almost all the time (96.5%) in holes in the lower half of the experimental block.

During experiment 2b, the dominant male of *P. incognitus* occupied mostly 7 cm long holes (Fig. 2), while smaller males showed a preference for 5 cm holes. Despite the high number of empty holes, the dominant male continuously dislodged subordinates from each hole it visited. Jointly the four males spent in holes 51.5% of the maximum time of hole occupancy; 93.3% of that in holes in the lower half of the experimental block.

During experiment 2c, the dominant *P. zvonimiri* mostly occupied 12 cm long holes, while the other two specimens of this species spent more time in 7 cm long holes (Fig. 2). The dominant male of *P. incognitus* mostly occupied 5 cm long hole. Jointly, the three *P. zvonimiri* males spent in holes 42.5% of the maximum time of hole occupancy (96.2% of that in holes in the lower half of the experimental block), the three *P. incognitus* males only 11.1% (91.1% in the lower half of the block).

Assessment of the preference for hole diameter

During experiment 3a (Tab. 2), the dominant male of *P. zvonimiri* occupied mostly the hole with 18 mm of diameter (Fig. 3), while smaller males showed a preference for 10 and 12 mm large holes. Agonistic encounters for the possession of holes occurred during the entire observation time. Jointly, males spent in holes 88.7% of the maximum time of hole occupancy.

During experiment 3b, the dominant *P. incognitus* occupied mostly holes with 16 and 18 mm of diameter (Fig. 3), while the five subordinate males spent most of the time in holes 8 and 10 mm large. Agonistic encounters for the possession of holes occurred during the entire observation time. Jointly, males spent in holes 72.8% of the maximum time of hole occupancy.

During experiment 3c, the dominant *P. zvonimiri* occupied mostly the hole with 18 mm of diameter, while the two subordinates of this species occupied mostly the 10 mm large hole (Fig. 3). Dominant males of both species fought for the possession of 16 and 18 mm large holes. The two smaller specimens of *P. incognitus* occupied the 8 mm large hole. Agonistic encounters for the possession of holes occurred during the whole observation time. Jointly, *P. zvonimiri* males spent in holes 59.5% of the maximum time of hole occupancy, *P. incognitus* males only 10.1%.

During experiment 4a (Tab. 2), the dominant male of *P. zvonimiri* occupied mostly 18 mm large holes (Fig. 4). Smaller males showed a preference for 10 mm large holes, avoiding completely the narrowest holes of 8 mm. There were no agonistic encounters for the possession of holes. Jointly, males spent in holes 93.2% of the maximum time of hole occupancy (94.7% in holes in the lower half of the experimental block).

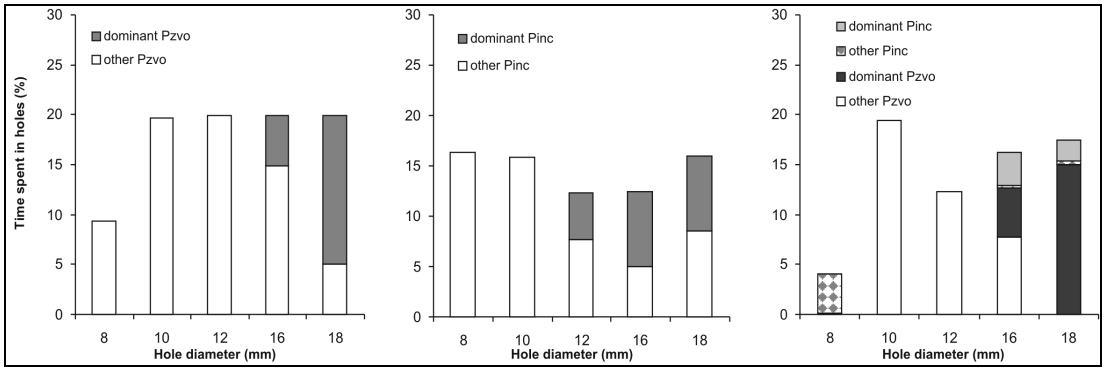

***Fig. 3: Settling experiments performed with** P. zvonimiri **and** P. incognitus **under laboratory conditions with 5 holes of varying diameter. Hole length: 12 cm; hole inclination: 90º (horizontal). Experiments 3a: with 6** P. zvonimiri, **3b: with 6** P. incognitus, **3c: with 3** P. zvonimiri **and 3** P. incognitus.*

***Sl. 3: Poskusi s** P. zvonimiri **in** P. incognitus **v eksperimentalnih razmerah, s 5 rovi različnih premerov. Dolžina rovov: 12 cm; naklon rovov: 90º (horizontalni). Poskusi: 3a: s 6** P. zvonimiri, **3b: s 6** P. incognitus, **3c: s 3** P. zvonimiri **in 3** P. incognitus.*

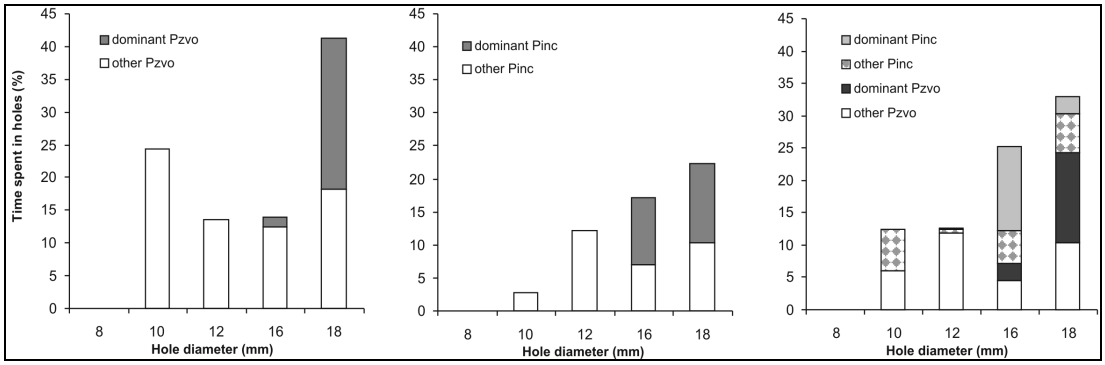

***Fig. 4: Settling experiments performed with** P. zvonimiri **and** P. incognitus **under laboratory conditions with 25 holes of varying diameter (five holes of 8 mm, five of 10 mm, five of 12 mm, five of 16 mm, five of 18 mm). Hole length: 12 cm; hole inclination: 90º (horizontal). Experiments: 4a: with 4** P. zvonimiri, **4b: with 4** P. incognitus, **4c: with 3** P. zvonimiri **and 3** P. incognitus.*
***Sl. 4: Poskusi s** P. zvonimiri **in** P. incognitus **v eksperimentalnih razmerah, s 25 rovi različnih premerov (pet rovov 8 mm, pet rovov 10 mm, pet rovov 12 mm, pet rovov 16 mm, pet rovov 18 mm). Dolžina rovov: 12 cm; naklon rovov: 90º (horizontalni). Poskusi: 4a: s 4** P. zvonimiri, **4b: s 4** P. incognitus, **4c: s 3** P. zvonimiri **in 3** P. incognitus.*

During experiment 4b, the dominant *P. incognitus* occupied holes with 16 and 18 mm of diameter (Fig. 4), while the others spent most of the time in holes 12 mm large, avoiding completely the narrowest holes of 8 mm. The dominant male was aggressive against subordinates, despite the high number of empty holes. Jointly, males spent in holes 54.3% of the maximum time of hole occupancy (91.6% in holes in the lower half of the experimental block).

During experiment 4c, the dominant *P. zvonimiri* occupied mostly holes with 18 mm of diameter, while the dominant *P. incognitus* persisted mostly in 16 mm large holes (Fig. 4). The dominant *P. zvonimiri* always persecuted the dominant *P. incongnitus* when it stopped in the largest holes. The other two *P. zvonimiri* mostly occupied 12 mm large holes. Subordinates *P. incognitus* mostly persisted in holes with 10 mm diameter, avoiding completely the narrowest holes of 8 mm. Jointly *P. zvonimiri* males spent in holes 49.2% of the maximum time of hole occupancy (98.2% of that in holes in the lower half of the experimental block). *P. incognitus* males spent in holes 34.0% of the maximum time (93.9% in the lower half of the block).

Assessment of the preference for hole inclination

During experiment 5a (Tab. 2), the dominant male of *P. zvonimiri* occupied mostly the horizontal hole (90º) (Fig. 5). All the males avoided the hole with 135º inclination. Subordinate males stopped almost equally in vertical (0º) and sloping upwards holes (45º). Jointly, males spent in holes 70.4% of the maximum time of hole occupancy.

During experiment 5b, the dominant male of *P. incognitus* occupied mostly the horizontal hole (90º) (Fig. 5). Subordinate males spent most of the time in the hole with 135º inclination. Agonistic encounters for the possession of holes occurred during the entire observation time and the males spent more time in agonistic encounter in front of the holes than in holes. Jointly, males spent in holes 48.3% of the maximum time of hole occupancy.

During experiment 5c, the dominant male of *P. zvonimiri* constantly persecuted the dominant male of *P. incognitus* in all the holes occupied by the latter. The dominant male of *P. zvonimiri* stopped mostly at the hole with 135º inclination (Fig. 5), while the dominant male of *P. incognitus* occupied mostly the horizontal hole (90º). The other two males of the latter species fought for the sloping upwards hole (45º). Subordinates of *P. zvonimiri* mostly occupied the vertical hole (0º). Jointly, *P. zvonimiri* males spent in holes 71.7% of the maximum time of hole occupancy, *P. incognitus* males only 17.5%.

During experiment 6a (Tab. 2), the dominant male of *P. zvonimiri* occupied mostly holes with 135º inclination (Fig. 6), while the subordinates occupied mostly horizontal holes (90º). There were no agonistic encounters for the possession of holes. Jointly, males spent in holes 73.8% of the maximum time of hole occupancy.

During experiment 6b, the dominant male of *P. incognitus* occupied mostly holes with 135º inclination (Fig. 6), while the subordinates occupied mostly horizontal holes (90º). The dominant male dislodged all the others that occupied holes with 135º inclination. Jointly, males spent in holes 59.3% of the maximum time of hole occupancy.

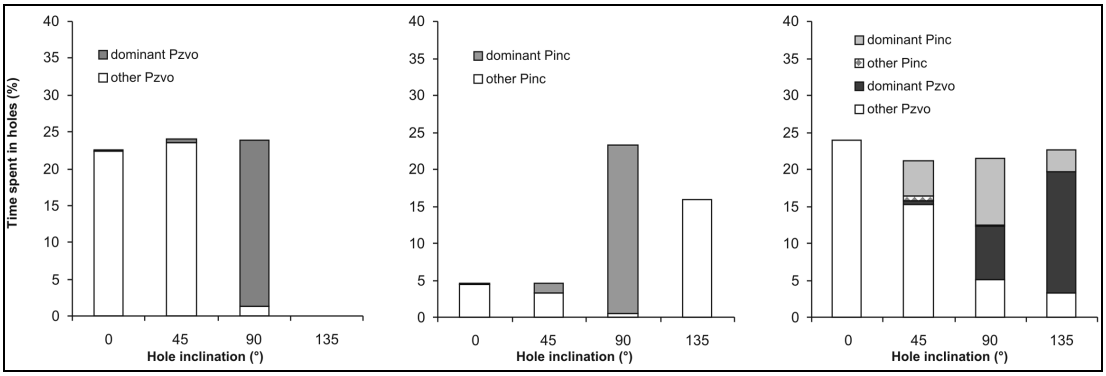

***Fig. 5: Settling experiments performed with** P. zvonimiri **and** P. incognitus **under laboratory conditions with 4 holes of varying inclination. Hole length: 7 cm; hole diameter: 16 mm. Experiments: 5a: with 6** P. zvonimiri, **5b: with 6** P. incognitus, **5c: with 3** P. zvonimiri **and 3** P. incognitus.*
***Sl. 5: Poskusi s** P. zvonimiri **in** P. incognitus **v eksperimentalnih razmerah, s 4 rovi različnih naklonov. Dolžina rovov: 7 cm; premer rovov: 16 mm. Poskusi: 5a: s 6** P. zvonimiri, **5b: s 6** P. incognitus, **5c: s 3** P. zvonimiri **in 3** P. incognitus.*

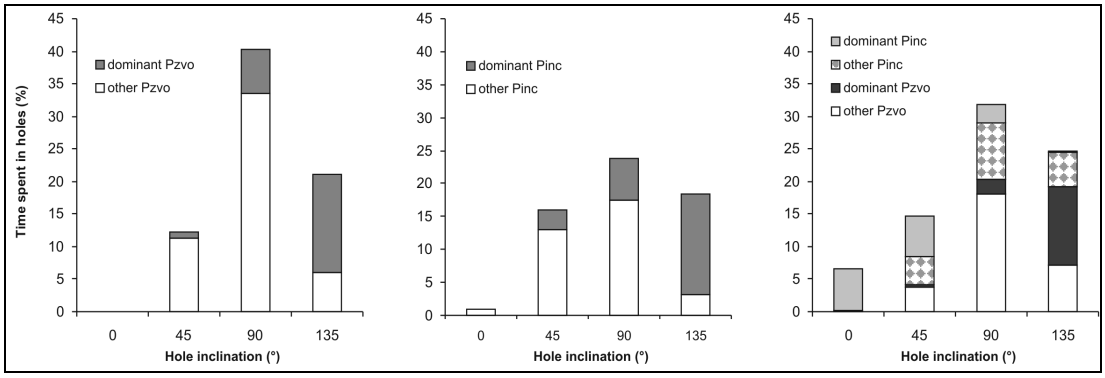

***Fig. 6: Settling experiments performed with** P. zvonimiri **and** P. incognitus **under laboratory conditions with 20 holes of varying inclination (five holes of 0º, five of 45º, five of 90º and five of 135º). Hole length: 7 cm; hole diameter: 16 mm. Experiments: 6a: with 4** P. zvonimiri, **6b: with 4** P. incognitus, **6c: with 3** P. zvonimiri **and 3** P. incognitus.*
***Sl. 6: Poskusi s** P. zvonimiri **in** P. incognitus **v eksperimentalnih razmerah, z 20 rovi različnih naklonov (pet rovov 0º, pet rovov 45º, pet rovov 90º, pet rovov 135º). Dolžina rovov: 7 cm; premer rovov: 16 mm. Poskusi: 6a: s 4** P. zvonimiri, **6b: s 4** P. incognitus, **6c: s** 3 P. zvonimiri **in 3** P. incognitus.*

During experiment 6c, the dominant *P. zvonimiri* occupied mostly holes with 135º inclination (Fig. 6), while subordinates of this species mostly persisted in horizontal holes (90º). The dominant *P. zvonimiri* always immediately dislodged the dominant *P. incongnitus* when it entered horizontal holes and holes with 135º inclination. The dominant *P. incognitus* mostly persisted in vertical holes (0º) and in sloping upwards holes (45º). Subordinates *P. incognitus* mostly occupied horizontal holes (90º). Jointly, *P. zvonimiri* males spent in holes 43.7% of the maximum time of hole occupancy, *P. incognitus* males 34.1%.

DISCUSSION

The results of the present study attest that between *P. incognitus* and *P. zvonimiri*, the latter is the dominant species where the two coexist. The ecological differences between the two species in the natural environment indicate that *P. zvonimiri* is more specialized of the two blennies regarding habitat choice, since it is found in a smaller number of different microhabitats and has a very high affinity for date mussel holes (Patzner, 1985; Kotrschal 1988; Orlando-Bonaca & Lipej, 2007). Thus it defends more aggressively its territory and its nesting place from males of other less specialized species. Moreover, *P. incognitus*, which lives in a higher

number of microhabitats and uses different type of shelters as nesting places, resulted to be less territorial. Also in the experiments performed with two species by Koppel (1988) *L. canevae,* more specialized than *P. incognitus,* resulted more territorial and dominant throughout the year. Males of *L. canevae* constantly defend their territories from males of the opportunistic species *P. incognitus,* although they have different feeding habits (Goldschmid & Kotrschal, 1981; Koppel, 1988). Also for three sympatric chaenopsid blennies of the genus *Acanthemblemaria* from Mexico, resulted that the more specialized species has the highest competitive ability for the available shelters (Lindquist, 1985).

For *P. zvonimiri* and *P. incognitus*, the results of this research point out a strong positive correlation between the dominance rank and the access to shelters. The dominant male dislodges subordinates from shelters, and when the number of fishes per aquarium increased (or the number of available holes decreased), the number of agonistic encounters and dislodgements increased, as well. This had previously been noted for other two blennies, *L. canevae* and *C. galerita* (Koppel, 1988; Faria & Almada, 2001). In *P. zvonimiri* and *P. incognitus*, the dominance rank is positively correlated to the body size of the fish. For both species, the dominant male was the bigger one. During our experiments, dominant males did not restrict their visits only to the selected holes, but they temporarily visited other nearby holes and expelled subordinates from them. When the preferred hole remained vacant, it was temporarily occupied by subordinate males. Dominant males did not limit their access to a single hole, but they dislodged subordinates also from holes they visited less frequently. This observation agrees with the conception of a "diffuse territoriality", proposed by Gibson (1968), where a male would not defend a single shelter, but a network of familiar holes scattered in its home range. Our field experiences (Orlando-Bonaca & Lipej, 2007), however, confirms the findings of Almada *et al.* (1983, 1990): in the natural environment where females are present, the "diffuse territoriality" for breeding males would change to a "traditional territorial defence", where males tend to concentrate their visit to a single hole.

P. zvonimiri chose holes that were much longer and larger than its body, which is in agreement with our field observations (Orlando-Bonaca & Lipej, 2008). Since the species did not choose holes that closely matched its body size, we can assume that it is probably less exposed to interspecific competition for holes than the other species. In experiments with two species, *P. incognitus* chose holes that are negligible longer and larger than its body, which could prevent small males from being dislodged by bigger ones. It seems likely that during its membership in a group, each individual acquires information about which individuals are dominants and which shelter it could invade. This observation is supported also by the results of Faria & Almada (2001). In the natural environment, with avoiding competition for the nesting place, the species provides for itself a more successful reproduction. Like in our field observations, also in the aquarium both species showed a preference for horizontal holes. However, it is interesting to note that the dominant *P. zvonimiri* never entered the hole with 135° inclination during a single species experiment with 4 holes, while it was fighting for the possession of this hole with the dominant *P. incognitus* during the experiment with two species. Probably the two dominant males acquire information about each other during the months passed in aquaria. Both species showed a preference for holes positioned in the lower half of the experimental block, which for *P. zvonimiri* is in accordance with the position of occupied holes in boulders in the natural environment (*own observations*). *P. zvonimiri* were found *in situ* mostly in holes in the shade of boulders and rocks (Orlando-Bonaca & Lipej, 2008).

The number of agonistic encounters and dislodgement was the highest when in the aquaria with more fish than available holes. Although this is true for both species, the dominant *P. incognitus* remained aggressive towards its subordinates even in experiments with less fish than holes, which was not the case of *P. zvonimiri*. Anyhow, since dominant males of both species always won intraspecific fights with subordinates, the preference of these smaller males for hole variables was evident only in experiments with much more holes than fish.

The results suggest that agonistic interactions among males of *P. zvonimiri* and *P. incognitus* play an important role in the control of a network of holes, used as shelters and in the natural environment also as nesting sites. Further experimental work needs to be carried out in order to verify if this conclusion could be confirmed for other Mediterranean blennies living on rocky bottom.

CONCLUSIONS

Under experimental conditions it was established that between *P. incognitus* and *P. zvonimiri* the latter is the dominant species. Males of *P. incognitus* were always subordinated to males of *P. zvonimiri.* In experiments with both species, *P. incognitus* chose holes that were negligible longer and larger than its body, which could prevent small males from being dislodged by bigger ones. *P. zvonimiri* always chose holes that were much longer and larger than its body. Dominant males did not limit their access to a single hole, but they dislodged subordinates also from holes they visited less frequently. Agonistic interactions among males of *P. zvonimiri* and *P. incognitus* play an important role in the control of a network of holes.

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UPORABA PRAZNIH ROVOV PRI DVEH VRSTAH JADRANSKIH ENDOLITSKIH BABIC V EKSPERIMENTALNIH RAZMERAH – PRELIMINARNI REZULTATI

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POVZETEK

Avtorja opisujeta izsledke raziskave o tekmovanju za prostor pri dveh vrstah jadranskih babic (Parablennius incognitus *in* Parablennius zvonimiri) *v smislu dominance in zasedenosti izbranih rovov. Ocenila sta preference babic za dolžino, premer in naklon rova. Babice so bile ulovljene v slovenskem obalnem morju z uporabo avtonomne potapljaške opreme. Opravila sta dva niza laboratorijskih poskusov s po tremi podvzorci, v katerih je bilo (a) število samcev večje od števila razpoložljivih rovov ali pa (b) je bilo rovov več kot rib. Dva niza poskusov sta bila opravljena z vsako vrsto posebej, v tretjem pa z obema vrstama skupaj.*

Na podlagi rezultatov se je izkazalo, da je jelenjeroga babica (P. zvonimiri) *dominantna vrsta, ki kaže veliko premosorazmerno korelacijo med dominanco in zasedenostjo rovov. V vseh poskusih je jelenjeroga babica izrinila jelenko* (P. incognitus).

Ključne besede: *Parablennius zvonimiri*, *Parablennius incognitus*, eksperimentalne razmere, razpoložljivost rovov, intra- in interspecifično tekmovanje, severni Jadran

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