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BRIEF COMMUNICATIONS

Comparative behaviour of two species of *Lepadogaster* (Pisces: Gobiesocidae) living at different depths

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The two clingfish species studied occupied similar habitats but occurred at different depths. When compared with the subtidal species *Lepadogaster candollei*, the intertidal species *Lepadogaster l. purpurea* was less active, spent more time in shelters, visited fewer shelters, showed more site fidelity, and spent less time swimming. Feeding, swimming, and agonistic behaviours were performed mainly in close contact with the substrate in this species. It is hypothesized that these contrasts in behaviour may have evolved under different levels of turbulence.

Key words: *Lepadogaster*; clingfish; turbulence; behaviour; depth distribution.

Clingfishes are distributed widely on rocky coasts of temperate and tropical waters (Briggs, 1955, 1986, 1990). However, knowledge of their behaviour and ecology is extremely poor. This is related to their small size (Thresher, 1984), which enables them to occupy very cryptic microhabitats (e.g. among the spines of sea-urchins *Diplecogaster bimaculatus pectoralis* Briggs, 1955; Patzner *et al.*, 1992). Available data concerning clingfish behaviour is restricted to the descriptions of reproductive behaviour of *Gobiesox strumosus* Cope, 1870 (Jachowski, 1970) and *Acyrtops beryllinus* (Hildebrand & Ginsburg, 1927) (Martin & Martin, 1971), and agonistic behaviour of *Lepadogaster lepadogaster purpurea* (Bonaterre, 1788) (Gonçalves *et al.*, 1996).

In Portuguese waters, two closely related species of gobiesocids *Lepadogaster candollei* Risso, 1810 and *L. l. purpurea* are common under boulders in rocky shores, and differ in depth distribution. This paper describes behavioural differences between *L. l. purpurea* and *L. candollei*, and interprets them in terms of the different ecological conditions in which both species are found.

This study was conducted at Arrábida coast (38°28′N, 8°59′W) Portugal, and in aquaria. The relative distribution of both species with depth was assessed through the inspection of 10 transects (with a length that varied between 21 and 34 m) by scuba diving during high tide. A rope marking every metre was placed perpendicular to the coast line between 1·3 and −9·0 m. Five boulders were checked in each metre and the number of fishes of each species observed was recorded. The hour and depth measured at each sampling point were used to calculate the height of this point to the zero chart datum based on the tide tables for the nearest port (Setúbal) (for details see Almada *et al.*, 1992).

Due to the difficulty of observing these fishes in their natural environment (most of their behavioural activities are performed under boulders), behavioural observations were made in aquaria, *Lepadogaster candollei* was caught with a hand-net by scuba diving, while *L. l. purpurea* was collected during low tide under boulders that remain out of

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TABLE I. Percentage of time spent in shelters and number of shelters visited on 48 focal observations (30 min each) of 12 individuals of each species

	Time in shelters (%)		Time in main shelter* (%)		No. of shelters visited	
	L.l.p.	*L.c.*	*L.l.p.*	*L.c.*	*L.l.p.*	*L.c.*
Mean	76·4	39·2	93·2	65·2	1·1	3·9
S.D.	38·7	35·3	14·7	28·1	0·8	2·8
Range	0–100	0–100	51·5–100	20·6–100	0–4	0–10
Mann–Whitney test	Time in shelters (%)		Time in main shelter (%)		No. of shelters visited	
z	− 4·59		− 4·79		− 5·14	
P	<0·001		<0·001		<0·001	

*Percentage calculated based on the total time spent in shelters (first column).
L.l.p., *Lepadogaster lepadogaster purpurea*; *L.c.*, *Lepadogaster candollei*.

water. They were kept in 63 × 32 × 31-cm and 80 × 40 × 38-cm aquaria with gravel and boulders to provide shelter, and fed daily with pieces of shrimp and common cockles and several live marine invertebrates.

The qualitative descriptions of behavioural patterns were made on 24 *L. l. purpurea* [80 h of *ad libitum* observations and 110 h of focal sampling (sensu Martin & Bateson, 1993)] and 10 *L. candollei* (12 h of *ad libitum* observations and 8 h of focal sampling). Quantitative measurements of swimming activity and the temporal patterns of shelter use were made on two groups of six individuals (three males and three females) for each species. A total of 12 h of focal observations (30 min each) was recorded for each group, with a Sony TR-805 Hi8 video camera. Frame-by-frame and slow motion analyses were used for a detailed description of the behaviour patterns. Statistical analysis of the data was performed using the Statsoft PC computer program Statistica (version 4·0).

Lepadogaster candollei showed a clear preference for the subtidal zone, while *L. l. purpurea* appeared in the upper subtidal and in the intertidal (distance to the zero chart datum: mean = − 0·40 m, S.D. = 1·67, range = − 8·98–0·85 m, n = 139, for *L. candollei*; mean = 0·31 m, S.D. = 0·96, range = − 4·65–1·32 m, n = 263, for *L. l. purpurea*; Mann–Whitney test: z = − 7·93; P < 0·001). Although the behavioural repertoire of the two species was similar, probably reflecting their strong phylogenetic affinity, several differences were found.

Lepadogaster l. purpurea usually swam near the bottom propelled by synchronized beating of the pectoral fins in bouts of a few movements, while the sucker slid along the substrate. When swimming in the water column, they did so at higher speeds using alternated movements of the pectoral fins and undulations of the posterior part of the body and tail (Gonçalves *et al.*, 1996). *Lepadogaster candollei* usually swam propelled by simultaneous beating of the pectoral fins (which can reach 10 beats per second). This species was able to swim for longer periods in the water column, although the general swimming pattern was also short in duration and length (swimming in the water column: mean = 2·61 s, S.D. = 2·59, range = 1–30 s, n = 1220, for *L. candollei*; mean = 2·16 s, S.D. = 1·09, range = 1–6 s, n = 50, for *L. l. purpurea*; Mann–Whitney test: z = − 0·016; P = NS).

Quantitative measurements of the patterns of shelter use and of the swimming activity performed by these fishes, showed that *L. l. purpurea* was a less active species, spent more time in shelters, visited fewer shelters, and showed more site fidelity (Table I). Furthermore, this species spent less time swimming and usually did so near the bottom [Table II(a)].

TABLE II. (a) Number of observations of fishes swimming near the bottom and in the water column. $\chi^2=106{\cdot}50$, d.f.=1, $P<0{\cdot}001$

	Swimming near the bottom	Swimming in the water column
L. l. purpurea	142	50
L. candollei	680	1220

(b) Agonistic interactions inside and outside shelters. $\chi^2=53{\cdot}70$, d.f.=1, $P<0{\cdot}001$

	Fights inside shelters	Fights outside shelters
L. l. purpurea	109	18
L. candollei	76	9

Lepadogaster l. purpurea typically fed by a quick and direct swimming from a shelter, usually upsidedown. After capturing prey a fish returned immediately to the shelter using the same swimming pattern. In contrast, *L. candollei* captured prey both near its shelter, and more often by means of an active search outside the shelter. The approach to food was similar to the one described for *L. l. purpurea*, but after prey capture *L. candollei* did not return to the initial shelter, but instead clung to a place near the point where the food was captured.

The agonistic interactions of *L. l. purpurea* often involved physical contact between the opponents. The most intense agonistic patterns recorded occurred when one fish charged another by rapid swimming and butting (more common in *L. candollei*) or when they engaged in mouth fighting (more common in *L. l. purpurea*). In these latter fights, the opponents opened their mouths and pushed against each other using the pectoral fins and tail movements (as described by Gonçalves *et al.*, 1996). In *L. candollei* the time the fishes remain in contact was always short (about 1 s), while in *L. l. purpurea* it reached 6 s (Gonçalves *et al.*, 1996). In this species, fights occurred predominantly in the shelters, while in *L. candollei* more than half of the recorded fights took place outside the shelters [Table II(b)].

Several lineages of teleost fishes colonized the rocky intertidal habitat independently and present a remarkable number of convergent behavioural, morphological and physiological traits (Gibson, 1969, 1982; Almada & Santos, 1995). Almada & Santos (1995) argue that, for fishes of the family Blenniidae, adaptations to the turbulent conditions of the intertidal zone involved behavioural modifications that minimize movement in the water column and loss of contact with the substrate. Such modifications affect even the form of the displays involved in agonistic and reproductive behaviour (Almada & Santos, 1995; Gonçalves & Almada, 1998).

The two species of *Lepadogaster* studied in this work present a number of similarities with the situation described for the blennies by Almada & Santos (1995). *Lepadogaster l. purpurea* occurred predominantly in the surf zone (near the low tide mark) where turbulence is very high, whereas *L. candollei* occurred predominantly in the subtidal zone, deeper than the zone of highest turbulence. *Lepadogaster candollei* was the more active species, moving considerable distances away from shelter, feeding frequently on exposed rock surfaces, and swimming frequently in the water column. These patterns were also confirmed during behavioural observations in nature. For *L. l. purpurea*, the extreme reduction of excursions outside shelter and its patterns of movement in close contact with the substrate, are consistent with the hypothesis that these behaviours may be adaptive in turbulent conditions. The differences in the details of the swimming movements also agree with this interpretation. However, other hypotheses cannot be excluded. For instance, the more cryptic behaviour of *L. l. purpurea* could result from selective pressures imposed by higher levels of predation in the intertidal. This seems unlikely however since, living under large boulders, *L. l. purpurea* is out of reach of avian predators, while aquatic predators are more abundant in the subtidal (Gibson, 1988). More experimental and comparative work on other gobiesocids with close phylogenetic affinities and contrasting ecology is needed to further test these ideas.

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