Short communication

Trapped in their own ‘home’: unexpected records of intertidal fish desiccation during low tides

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Introduction

Intertidal fishes are recognized mainly by some extraordinary morphological, physiological and behavioural adaptations that allow them to occupy intertidal environments (Gibson and Yoshiyama, 1999; Martin and Bridges, 1999; White and Brown, 2013). Tidal cycles generate two distinct ecological scenarios for intertidal fishes. During the flood tide, large predators and other non-resident fishes (from the subtidal habitat) visit the intertidal habitat and increase the risk of predation and competition with the resident fishes. In contrast, for many fish species during the ebb tide the intertidal habitat is restricted to isolated tidepools, which may have extreme environmental conditions (e.g. high salinity, temperature). Thus, adaptations of resident species to intertidal life increases the competition for resources as well as the resistance to physicochemical variations of water characteristics during the ebb tide, in the absence of subtidal predators and competitors (Gibson, 1986; Gibson and Yoshiyama, 1999).

Some resident species live in two or more tidepools in order to better exploit the resources (e.g. food, shelter and nesting sites) or to avoid adverse conditions during reef emersion (Gibson, 1999; Thyssen et al., 2014). Often, fishes that live in naturally harsh habitats such as tidepools, exhibit a wide range of sensory mechanisms for spatial mapping (Gibson, 1999; Braithwaite and De Perera, 2006) and several studies have described the noteworthy site fidelity and homing performance of intertidal fishes (e.g. Griffiths, 2003; White and Brown, 2013, 2014). Occurrences of residents and opportunists of intertidal fish species trapped in tidepools during low tides (i.e. exposed to air and desiccated) in two sites in the Atlantic Ocean (Brazil) are reported here, and the ecological and behavioural aspects of these events are discussed.

Materials and methods

The intertidal sites studied were Rocas Atoll (03°51’S; 33°49’W), an oval-shaped oceanic atoll 266 km off the Brazilian coast and dominated by a mesotidal regime (up to 3.8 m; Gherardi and Bosence, 2001), and a coastal flat reef at Castelhanos Beach (20°49’S; 40°36’W), located in southeastern Brazil and under the influence of a microtidal regime (up to 1.8 m; Macieira and Joyeux, 2011). Dead fishes were unexpectedly found in tidepools during low tides in August (Castelhanos Beach) and September (Rocas Atoll) of 2014 during a scientific survey of the intertidal environment at these sites. Physicochemical parameters (water temperature, pH and salinity) in neighbouring tidepools during the period of records were also measured. Fishes were collected, measured (total length, 1 mm precision) and classified in relation to their degree of residency as Permanent Resident (PR) or Opportunist (O), adapted from Macieira and Joyeux (2011) and Macieira et al. (2015). All individuals were externally examined and deposited in the fish collection of the Universidade Federal do Espírito Santo (CIUFES; http://splink.cria.org.br/).

Results

Fourteen specimens belonging to five species (five families; 11 permanent residents and three opportunists; Table 1) were found trapped in tidepools: 13 in Rocas Atoll and one in Castelhanos Beach in the spring tide periods. On the occurrence dates, differences in water levels between high and low tides were 2.1 m in Rocas Atoll and 1.4 m at Castelhanos Beach. Individuals were found highly desiccated at 00:10, 01:08, 01:58, 02:08 hours after peak low tide in depressions –5 m from the nearest (filled) tidepool. In Rocas Atoll, where 93% of the fish were found, mean water temperature in neighbouring tidepools during the sampling period was 30.9°C. Mean water pH and salinity were 8.4 and 37, respectively. External examination evidenced no anomaly, pathology or predation wound in any specimen.

Discussion

Blenniidae and Gobiidae are the most abundant families in intertidal fish communities and which display emergence behaviours to avoid desiccation, such as skipping or hopping.
to adjacent pools (Aronson, 1951; Martin and Bridges, 1999) or by seeking refuge in small humid crevices or under small algae patches (Ikebe and Oishi, 1997; Braithwaite and De Perera, 2006; White and Brown, 2013). However, fishes of these two families (and others) were trapped in small crevices (Fig. 1), which suggests that they were seeking suitable refuge, whereby the depression dried up, an occurrence that is by itself uncommon.

Resident tidepool fishes perform daily movements and return to their home pools during ebb tides using complex spatial navigation abilities (Bshary et al., 2001; Braithwaite and De Perera, 2006; Jorge et al., 2012). Although homing failure is probably uncommon in resident species, we hypothesize that the fishes could not find their home pools and were stranded in dry depressions not having usable outlets. However, it is unlikely that several individuals would suffer the same fate at the same place, particularly because they were of different species (as in Fig. 1), unless high-tide movements were involving cohesive multi-species groups or following behaviour. Alternatively, predators such as sharks and piscivorous teleosts of all sizes gain access to intertidal habitats to forage during high tide (e.g. Castro and Rosa, 2005; Wetherbee et al., 2007; both at Rocas Atoll). Tidepool fishes seek refuge in shallow pools and occasionally may emerge to avoid predation (Gibson, 1999). The foraging or simple presence of potential predators could have forced tidepool fish to escape to unsuitably dry areas, precluding their return to their home tidepool. Neither hypothesis appears wholly convincing, and we suspect stranding of tidepool fishes results from a variable conjunction of factors that include, but are not limited, to those discussed. Among these plausible reasons are the drying out of carbonate pools due to sudden habitat alteration.

Desiccation in intertidal habitats can affect vagile as well as sessile organisms (Grant and McDonald, 1979; Sebens, 1982; Ji and Tanaka, 2002), but the former in particular exhibit complex behavioural adaptations to withstand stresses associated with low tide levels (Finke et al., 2007; Dabruzzi et al., 2011). Here, the evidence of tidepool fish desiccation highlights the inter-play between biological interactions and pressure in shaping natural populations and intertidal fish communities.

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<table>
<thead>
<tr>
<th>Family / Species</th>
<th>Site</th>
<th>Date</th>
<th>Time</th>
<th>Residency status</th>
<th>Number of specimens</th>
<th>Voucher number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pomacentridae</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><em>Stegastes rocasensis</em></td>
<td>Rocas Atoll</td>
<td>26/IX/2014</td>
<td>14:00</td>
<td>PR</td>
<td>1</td>
<td>3247</td>
</tr>
<tr>
<td>Labridae</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Thalassoma noronhanum</em></td>
<td>Rocas Atoll</td>
<td>24/IX/2014</td>
<td>10:58</td>
<td>O</td>
<td>2</td>
<td>3248</td>
</tr>
<tr>
<td>Blenniidae</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Oblioblennius trinitatis</em></td>
<td>Miranda Ribeiro 1919</td>
<td>24/IX/2014</td>
<td>10:58</td>
<td>PR</td>
<td>9</td>
<td>3250</td>
</tr>
<tr>
<td>Gobiidae</td>
<td></td>
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<td></td>
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<tr>
<td><em>Bathygobius geminatus</em></td>
<td>Tornabene, Baldwin &amp; Pezold 2010</td>
<td>14/VIII/2014</td>
<td>13:49</td>
<td>PR</td>
<td>1</td>
<td>3251</td>
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<tr>
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<tr>
<td><em>Acanthurus chirurgus</em></td>
<td>Rocas Atoll</td>
<td>25/IX/2014</td>
<td>13:40</td>
<td>O</td>
<td>1</td>
<td>3249</td>
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</table>

Fig. 1. Intertidal fish trapped in crevices of a tidepool in Rocas Atoll, 2014. Scale reference: *Thalassoma noronhanum* individual (white belly) total length is 47 mm. White arrows = crevices. Note that fish were pushed out of the crevices for the photographic record. Photo by R. Andrades.

Table 1

Fish family and species, sites, dates, time, residency status and number of individuals found dead in this study. Family order follows Nelson (2006). Fish were deposited at the fish collection of Universidade Federal do Espírito Santo (CIUFES; http://splink.cria.org.br/). Species were classified according to degree of residency in tidepools (Residency status) based on Macieira and Joyeux (2011) and Macieira et al. (2015). Residency status correspond to Permanent resident (PR) and Opportunist (O).
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