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SHORT REPORT

Behavioral and ontogenetic colour changes of a poorly known lutjanid

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Abstract
Despite its high economic value to fisheries, little is known about the ecology of the recently described *Lutjanus alexandrei*. This is the first report on the array of colouration exhibited by this species in its natural habitats: coral reefs, algal beds and mangroves. Five colour patterns occur in *L. alexandrei*, and they are related to different life phases or behaviour. Variable colouration is shown on the head, body and fin edges. Colour patterns range from uniform to barred and blotched, from white to red and brown. This variable colouration is mostly related to camouflage on different backgrounds. Some of these patterns are also displayed during interspecific associations. Further investigations are necessary to expand our knowledge on the ecology of this recently described species.

Key words: Lutjanus alexandrei*, southwestern Atlantic, snapper, reef fish behaviour*

Introduction

Colour patterns displayed by animals may serve different purposes during life cycles, such as thermoregulation, camouflage and communication (Endler 1978; Gilmore & Jones 1992; Siebeck 2004). The ability to rapidly change colour is commonly used as a signal during diverse social and environmental scenarios (Kodric-Brown 1998). Changes in colour patterns reflect changes in behaviour at both spatial and temporal scales (e.g. during foraging activity and reproduction).

Transient colouration patterns have been recorded extensively for marine and freshwater fishes (Kodric-Brown 1998). For reef fishes they have often been observed in scarids, serranids and lutjanids (Gilmore & Jones 1992; Mueller et al. 1994; Erisman & Allen 2005; Kline et al. 2011). In these fishes, colour displays are associated with social hierarchy (Gilmore & Jones 1992; Mueller et al. 1994; Mumby & Wabnitz 2002; Muñoz & Warner 2003) and reproduction, for agonistic encounters between males (Kline et al. 2011) or sexual recognition (Hamamoto et al. 1992; Sadovy & Eklund 1999). These ephemeral changes usually occur in head colouration, body contrast patches and fin edges (Kodric-Brown 1998).

The Brazilian snapper *Lutjanus alexandrei* Moura & Lindeman, 2007 occurs over the continental shelf in the tropical southwestern Atlantic. It ranges from the state of Maranhão (00°52′S) to the state of Bahia (18°00′S) in Brazil, but is absent from oceanic islands (Moura & Lindeman 2007). Habitats used by *L. alexandrei* include coral and rocky reefs, mangroves and other soft and hard bottom areas (Moura & Lindeman 2007). Juveniles smaller than 10 cm total length (TL) are common in shallow habitats, inhabiting mangroves, occasionally along with juvenile dog snappers *Lutjanus jocu* (Bloch & Schneider, 1801) (Moura & Lindeman 2007; Osório et al. 2011; authors' personal observations). As with some congeners, this species is uncommon on deeper reefs (Lindeman et al. 1998; Lindeman & DeMaria 2005).

Western Atlantic snappers are targeted by traditional fisheries, with a high economic value on the

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market (Polovina & Ralston 1987; Claro et al. 2001). This is especially true for the northeastern Brazilian coast, where they historically represent one of the main resources in terms of abundance and fishermens' income (Frédou & Ferreira 2005). Following the red snapper *Lutjanus purpureus* (Poey, 1866) fisheries collapse due to overexploitation during the 1980s, other lutjanids, like *L. alexandrei*, became more heavily targeted (Frédou & Ferreira 2005).

Regardless of their value to fisheries, systematic and ecological information for *L. alexandrei* is limited (Moura & Lindeman 2007). In addition, the diverse colour patterns displayed by *L. alexandrei* may have biased previous studies on snapper stocks. For instance, until recently it was misidentified as the schoolmaster *Lutjanus apodus* (Walbaum, 1792) and/or the grey snapper *Lutjanus griseus* (Linnaeus, 1758) (Moura & Lindeman 2007). Given the importance of the Brazilian snapper to fisheries, and the lack of ecological data available, information on the colour patterns displayed by *L. alexandrei* is extremely important.

Material and methods

Observations were made in the Marine Protected Area Costa dos Corais, northeastern Brazil (from 8°47′44″S, 34°47′20″W to 9°46′30″S 35°25′00″W) that encompasses 135 km of coastline and has been protected by federal law since 1997 (Figure 1). Coral reefs, algal beds and mangroves were surveyed, as these habitats are commonly used by *Lutjanus alexandrei* during its life cycle (Moura & Lindeman 2007). Observations on coral reefs and algal beds were made at Tamandaré reef complex, situated on the northeastern coast of Brazil, where the only true South Atlantic coral reef formations are found. These formations resemble fringing reefs with three reef lines running parallel to the coast and having a distinctive growth form, developing isolated columns that grow up to 5–6 m tall and then laterally expand at the top (Dominguez et al. 1990; Maida & Ferreira 1997). When these columns are densely aggregated, their tops coalesce and create large systems of interconnected caves below their surfaces (Maida & Ferreira 1997). Additionally, the algal beds analysed are found adjacent to the first reef line, with depths ranging from 0.5 to 2.5 m. Macroalgae of the genera *Sargassum*, *Padina*, *Caulerpa*, *Udotea*, *Gracilaria*, *Dictyota* and *Dictyopteris* compose dense mats (Feitosa, unpublished data). Observations on mangroves took place at the Formoso River estuary, which harbours a total of 78 fish species, more than half of which are reef fish (Paiva et al. 2008).

Individuals were photographed and video-recorded during diurnal and nocturnal free dives, with 120 h of observation. Identification of *L. alexandrei* was made by the presence of six vertical white lines (occasionally faded), on sides of body and on bright blue spots between snout and pre-operculum (Moura & Lindeman 2007).

Results

Lutjanus alexandrei displays five colour patterns depending upon life phases or behaviour. Ephemeral changes in colourations occur rapidly, as soon as an individual enters a new habitat or assumes a specific behavioural display, with transitions taking no longer than 2 s. Juveniles inhabit mangroves and have a reddish to brownish background colour with white vertical bars along the body, a diagonal black stripe, crossing the eye from the operculum to the snout, and bright red fins (Figure 2A).

Adults inhabiting coral reefs and rocky substrata have five distinct colour patterns: (1) while resting over sandy bottoms, they show a homogeneous colour pattern, ranging from white to pale red, blending with the substrate (Figure 2B); (2) when searching for invertebrates over algae, they assume a similar colour pattern to juveniles, except for the absence of the bright red fins and snout stripe, thereby matching the bottom algal cover (Figure 2C); (3) at night, they show dark blotched marks on the flanks (Figure 2D); (4) inside caves, they have a uniform reddish colour (Figure 2E); (5) when joining multi-specific foraging schools, e.g. with grunts (Haemulidae), *L. alexandrei* displays a barred colour pattern with a very distinct snout stripe (Figure 2F).

Discussion

Among larger-bodied bottom-foragers, such as parrotfishes, differences in colour patterns between juveniles and adults of the same species are generally associated with social hierarchies (Mumby & Wabnitz 2002; Muñoz & Warner 2003). However, for some lutjanids, juveniles have a more cryptic colouration (e.g. the grey snapper, *Lutjanus griseus*, and the schoolmaster, *Lutjanus apodus*), with an eye spot on the caudal peduncle that fades with growth, and aids in evading predators (Deloach 1999). As the Brazilian snapper migrates from mangroves to coral reefs throughout its life cycle, we hypothesize that the different colour displays of *Lutjanus alexandrei* are associated with its growth.

Another feature considered to be distracting for predators is a striped pattern. When schooling fishes have horizontal stripes, e.g. the common bluestripe snapper *Lutjanus kasmira* (Forsskål, 1775), their potential predators can become visually confused and not able to distinguish one individual from

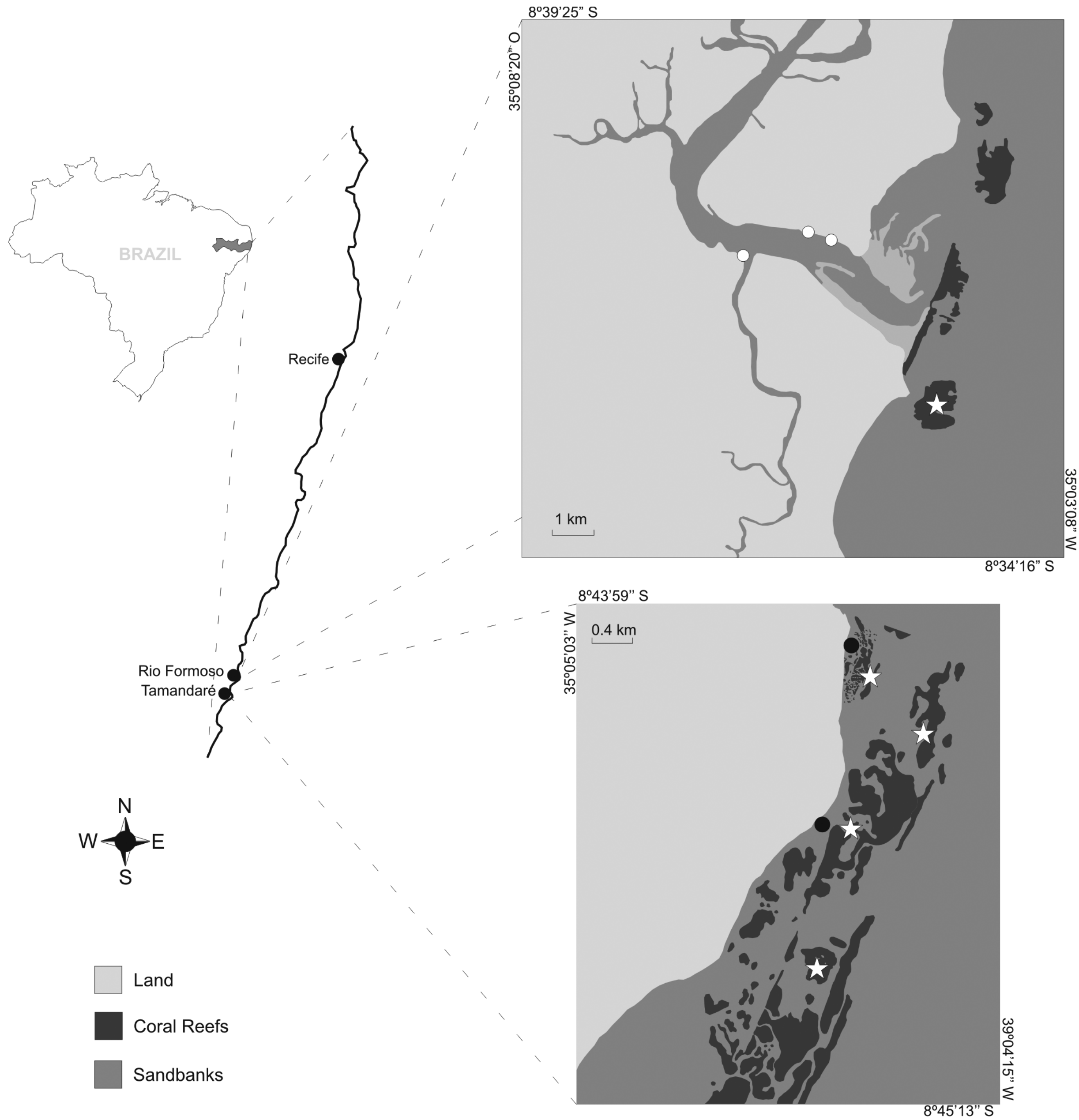

Figure 1. Map of the study area. White dots, mangrove areas surveyed; black dots, algal beds surveyed; white stars, reef areas surveyed.

another (Randall 2005; Price et al. 2008; Pereira et al. 2011a). Vertical bars, like those seen in Figure 2A, C and F, are hypothesized to be associated with foraging behaviour, as this type of colouration resembles the vertical growth of vegetation (Mueller et al. 1994; Deloach 1999), dominant in most of the feeding grounds of *L. alexandrei*. When this species goes over a sandy bottom, its bars fade away and the fish becomes less conspicuous.

Lutjanus alexandrei displays two different strategies in low-light conditions. When resting during the night, dark blotched marks on the flanks become evident. In general, diurnally active fishes change to a distinctly barred pattern after dusk (Lindquist & Clavijo 1992), although at the study area many other reef fishes appear to assume the same pattern observed for *L. alexandrei*, e.g. the barber surgeonfish *Acanthurus bahianus* Castelnau, 1855, the banded butterflyfish *Chaetodon striatus* Linnaeus, 1758, the sailor's choice *Haemulon parra* (Desmarest, 1823), and the western Atlantic seabream *Archosargus rhomboidalis* (Linnaeus, 1758) (pers. observations). It is likely that this colouration blends with rocks covered with turf algae mixed with the sandy substrate, a common bottom type in the study area. Moreover, a fish with contrasting colours that break up its body outline, are more difficult to discern at night (Helfman et al. 1997).

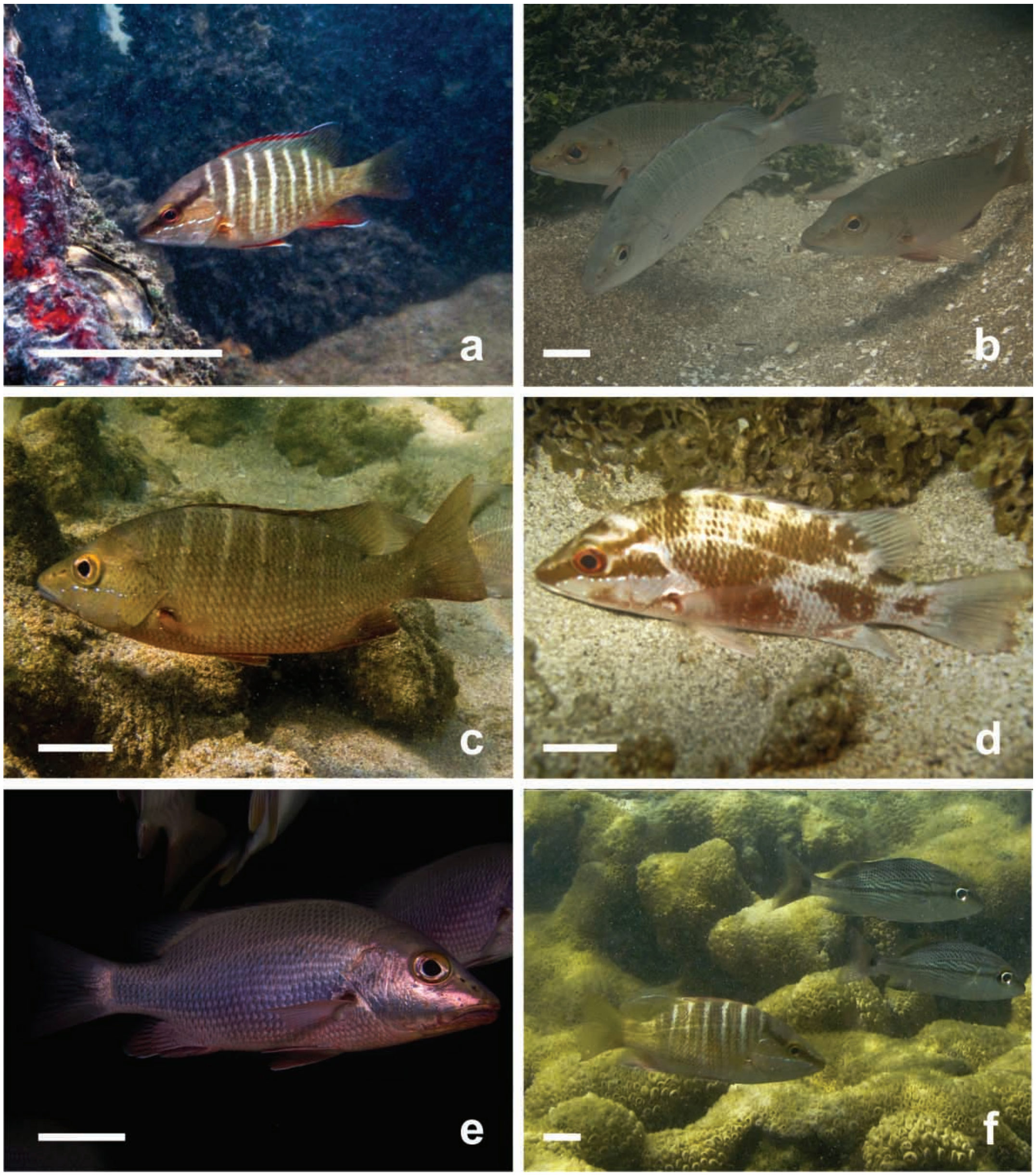

Figure 2. Different colour patterns of *Lutjanus alexandrei* (A) juveniles in mangroves, (B) over sandy bottoms, (C) over algae, (D) at night, (E) inside caves, (F) interacting with other reef fishes. Scale bars = 5 cm.

In low-light conditions, the uniform reddish colouration, found in nocturnal reef fish (e.g. Apogonidae and Holocentridae) and for *L. alexandrei* when inside reef caves is an effective disguise. Long-wavelength colours, such as red, fade away rapidly with depth, because water absorbs selectively long-wavelength colours. Therefore, reef fish with a reddish colouration will appear to be black, which together with the low level of light makes them difficult to detect inside caves.

During interspecific interactions, often while schooling with grunts (*Haemulon* spp), *L. alexandrei* presents a very distinct snout line. This same pattern has been observed for groupers and snappers in feeding associations with octopuses (Diamant & Sphigel 1985; Pereira et al. 2011b). In both cases the species showing the snout stripe benefits from the association, i.e. predator avoidance and/or new feeding strategies by joining larger schools. In other species of *Lutjanus*, the head colouration was specifically used in displacement and chasing events, associated with a hierarchical system (Mueller et al. 1994). It is possible that head displays are a way of communication among individuals of both lutjanid and serranid fishes.

This is the first report on the array of colourations exhibited by *L. alexandrei* across its range of natural habitats (Table I). Studies of social traits associated

Table I. Summary of the different colourations found for *Lutjanus alexandrei*.

Life phase	Colour pattern	Habitat/behavior	Main outcomes
Juvenile	Reddish to brownish background colour, white vertical bars and brightly red fins and a distinct snout stripe	Mangroves	Camouflage by matching substrata
Adult	Homogeneous colour pattern, ranging from white to pale red	Sandy bottoms	Camouflage by matching substrata
Adult	Reddish to brownish background colour with white vertical bars	Algae cover	Camouflage by matching substrata
Adult	Dark blotched marks on the flanks	Resting at night	Camouflage by breaking body outline
Adult	Uniform reddish colour	Inside caves and in low-light conditions	Camouflage by adapting to low-light conditions
Adult	Barred colour pattern with a very distinct snout stripe	Interspecific associations	Predator avoidance and new feeding strategies

with colour displays of *L. alexandrei* are not reported here, but could reveal (as found for other lutjanids) important aspects of its biology, such as hierarchical systems or reproductive events.

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