

Unusual colour patterns of territorial damselfish (Pomacentridae: *Stegastes*) in the south-western Atlantic

ALLAN T. SOUZA^{1,2}, MARTINA I. ILARRI^{1,2}, PAULO ROBERTO MEDEIROS³, CLÁUDIO L.S. SAMPAIO⁴
AND SERGIO R. FLOETER⁵

¹CIMAR/CIIMAR Centro Interdisciplinar de Investigação Marinha e Ambiental, Universidade do Porto, Rua dos Bragas 289, 4050-123, Portugal, ²ICBAS—Instituto de Ciências Biomédicas de Abel Salazar, Universidade do Porto, Lg. Prof. Abel Salazar, 2, 4099-003 Porto, Portugal, ³Centro de Ciências Exatas e da Natureza, Universidade Federal da Paraíba, 58059-900, João Pessoa, PB, Brasil, ⁴Departamento de Pesca, Universidade Federal de Alagoas, Campus Arapiraca, Unidade de Ensino Penedo, 57200-000, Alagoas, AL, Brasil, ⁵Departamento de Ecologia e Zoologia, Universidade Federal de Santa Catarina, Florianópolis, SC, 88019-970, Brasil

Reef fish usually display a remarkable variety of colours and coloration patterns. The colour patterns are largely used for species identification, and some morphologically conservative genera are highly dependent on coloration for this purpose. In this context, this paper aims to briefly describe unusual colour patterns recorded for territorial damselfish of the genus Stegastes in the south-western Atlantic Ocean. Four unreported coloration pattern types were observed in three species (S. fuscus, S. rocasensis and S. pictus). The pale morph which is characterized by individuals presenting whitish marks over the regular coloration pattern was recorded in S. fuscus in north-eastern reefs and S. rocasensis in Fernando de Noronha archipelago. On the other hand, S. fuscus and S. pictus presented other types of unusual coloration patterns, which are characterized by an irregular cover (blue or dusky) over the regular colour pattern. Another type of unusual coloration pattern was recorded for S. fuscus, which presented a yellowish/reddish dorso-anterior band. Additionally, two distinct colour patterns of adult S. variabilis, from the south-eastern and north-eastern Brazilian reefs are reported.

Keywords: Brazil, pale morph, reef fish, *Stegastes variabilis*

Submitted 28 September 2011; accepted 25 October 2011

INTRODUCTION

Coloration is an important characteristic for coral reef organisms, since it is used for multiple purposes, including mimicry (Cheney & Marshall, 2009), sexual selection (Gray & McKinnon, 2007), intraspecific communication (DeMartini & Donaldson, 1996) and camouflage (Marshall, 2000). Thus, reef fish possess a wide diversity of colours (both discrete and vivid colours), and coloration patterns (e.g. plain, blotched, striped, spotted, etc.) (Humann & Deloach, 2002).

Coloration pattern of reef fish is largely used for species identification, but this could be problematic for many groups that possess highly variable colour phases (e.g. Labridae, Pomacanthidae and Scaridae), sexual dichromatism or even anomalous individuals. Moreover, fish can change their colour patterns for short periods of time (Kodric-Brown, 1998), for example, during the night, when many species become mottled, barred or blotched, presenting patterns of colour that blend with the environment; and/or during breeding (e.g. some labrids, labrisomids and pomacentrids), to indicate that they are prepared for reproduction (Deloach & Humann, 1999).

Among pomacentrids, the most common type of change in colour pattern is related to early life stages and to reproductive periods. The genus *Stegastes* is morphologically conservative and its classification is highly dependent upon colour patterns (Allen, 1991; Novelli *et al.*, 2000). In this paper we aim to report the colour variations of territorial damselfish (*Stegastes* spp.) found in the south-western Atlantic coastal reefs and oceanic islands, emphasizing the description of underreported colour morph variations based upon underwater observations, photographic records and laboratory examination.

MATERIALS AND METHODS

Six species of territorial damselfish (genus *Stegastes*) occur in the south-western Atlantic, namely the Brazilian damsel *S. fuscus* (Cuvier 1830), the Yellowtip damselfish *S. pictus* (Castelnau 1855), the Rocas gregory *S. rocasensis* (Emery 1972), Saint Paul's gregory *S. sanctipauli* Lubbock & Edwards 1981, the Cocoa damselfish *S. variabilis* (Castelnau 1855) and *S. uenfi* Novelli, Nunan & Lima 2000, as well as the subspecies Trindade gregory *S. fuscus trinidadensis* Gasparini, Moura & Sazima, 1999 (Gasparini *et al.*, 1999; Gasparini & Floeter, 2001). In order to report variations in colour patterns of *Stegastes* spp., photographic records were made in coastal and oceanic waters (1 to 35 m depth). Whenever possible,

Corresponding author:

A.T. Souza

Email: allantsouza@gmail.com

individuals presenting unusual coloration patterns were collected with a hand net for further species examination in the laboratory and then deposited in the fish collection of the Museu de Zoologia of the Universidade Federal da Bahia. Taxonomic identifications were confirmed in the laboratory according to Carvalho-Filho (1999) and Humman & Deloach (2002).

Underwater observations were made during daytime using skin and SCUBA dives in several sites along coastal reefs (Abrolhos—BA, Armação dos Búzios—RJ, Arraial do Cabo—RJ, Arvoredo—SC, Ilha Grande—RJ, Guarapari—ES, Maceió—AL, Maracajaú—RN, Picãozinho—PB and Salvador—BA) and oceanic islands (Atol das Rocas—RN, Fernando de Noronha—PE and Trindade—ES) in Brazil, spanning a latitudinal gradient of $\sim 24^\circ$ (from $3^\circ 51'N$ – $27^\circ 30'S$). These reefs comprised different habitats, including rocky subtropical reefs in the south-eastern coast, coral reefs in the north-eastern coast and oceanic archipelagos. In addition, individuals were observed using the focal-animal methodology for describing any unusual behavioural pattern (Lehner, 1996; Bell & Kramer, 2000). Field observations were performed by all authors, totalling approximately 1000 hours of diving time unevenly distributed between sampling sites (60% in north-eastern Brazilian reefs, 30% in southern and south-eastern Brazilian reefs and rocky shores and 10% in Brazilian oceanic archipelagos).

The oceanic archipelago of São Pedro and São Paulo ($0^\circ 55'N$ $29^\circ 21'W$) was not sampled in the present study, thus the Saint Paul's gregory *S. sanctipauli* could not be investigated, since the species is endemic there.

RESULTS

Four species of *Stegastes* (*S. fuscus*, *S. rocasensis*, *S. pictus* and *S. variabilis*) presented coloration patterns unreported in the literature. Detailed description of each pattern is presented below.

Pale morph—*S. rocasensis* and *S. fuscus*

This pattern was recorded only in adult phases of two of the six species found in the study area, namely, *S. fuscus* and *S. rocasensis* (Figure 1). Pale morph is characterized by individuals presenting whitish marks over the regular coloration pattern (corresponding to its life phase), with the posterior parts of their bodies temporarily shifting to a marked pale, whitish colour, which often extends from the dorsal portion of the head to the caudal peduncle or tail. However, the pale morph may vary, for instance, extending obliquely in the

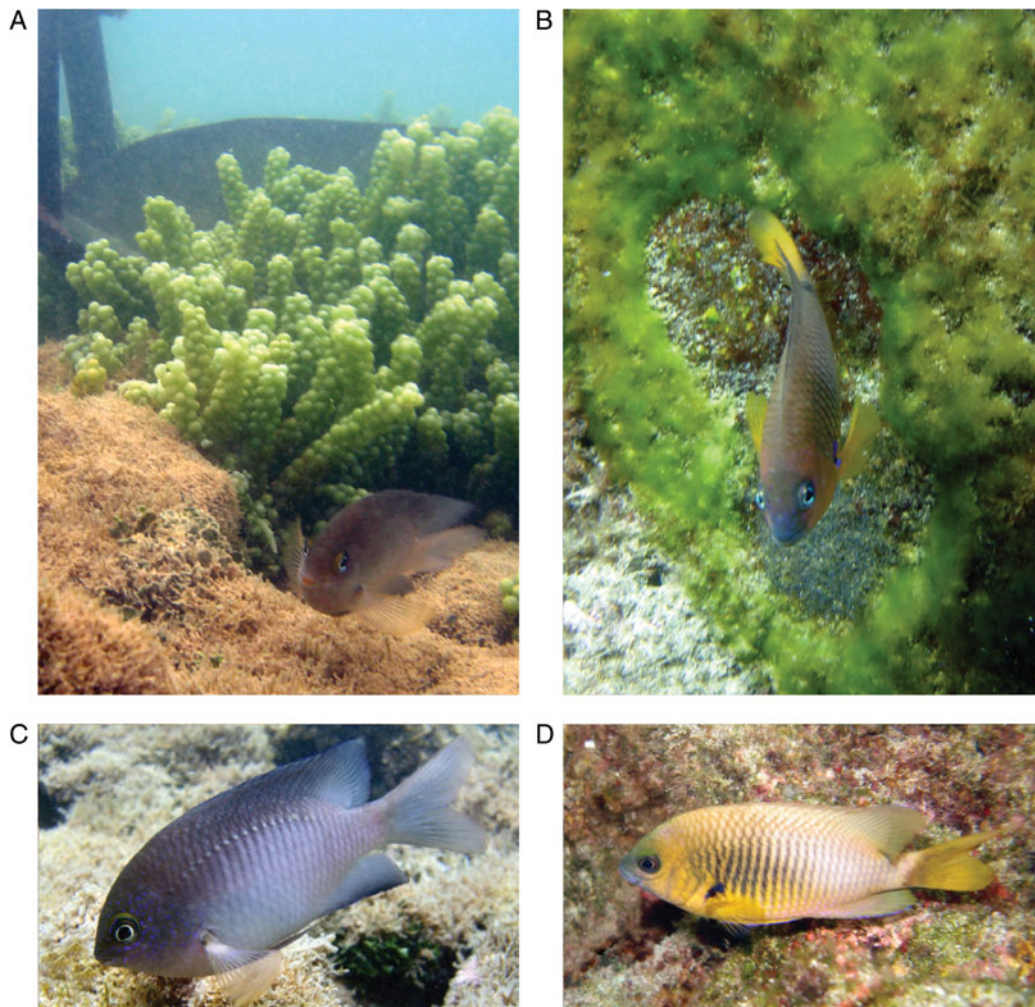


Fig. 1. (A) *Stegastes fuscus* individual displaying a pale colour pattern on a human-disturbed reef; (B) *S. rocasensis* pale individual defending an egg clutch at shallow waters of Fernando de Noronha oceanic archipelago, north-eastern Brazil. Pale individuals of *S. fuscus* (C) and *S. rocasensis* (D). Photographs by Allan T. Souza.

ventral part from the tip of the caudal fin to the base of the pectoral fin.

Pale individuals of the Rocas gregory (*S. rocasensis*) were mostly recorded in areas where egg clutches were observed in Fernando de Noronha archipelago (3°50'N 32°24'W), and in 77% of the events they were guarding eggs (A.T.S., personal observation; Figure 1). The pale coloration pattern is noticeably brief, during approximately 3 minutes (N = 9; 2.88 ± 1.36 minutes). Pale individuals of *S. rocasensis* were observed during the morning and afternoon.

For the dusky damselfish (*S. fuscus*), pale individuals were recorded in Picãozinho (7°07'S 34°48'W) and Abrolhos reefs (17°57'S 38°42'W). In the former reef, pale individuals were most frequently observed near areas disturbed by human activity (Figure 1), while in the latter, they were recorded near to reproductive grounds.

The proximity of pale morph individuals with egg clutches and areas disturbed by human activities was not tested in this study, thus the possible relation between these observations cannot be properly verified.

Unusual colour patterns—*S. pictus* and *S. fuscus*

Three uncommon coloration patterns were recorded in two damselfish species, being one in *S. pictus* and two in *S. fuscus*.

A single individual of the Yellowtip damselfish (*S. pictus*) was collected by a professional ornamental fisherman at Bahia State, north-eastern Brazil. This specimen (UFBA 3922) was identified in the laboratory according to its morphological characteristics. This individual (UFBA 3922) presented a yellowish base colour with an irregular dusky cover, extending over the dorsum and sides from the operculum to the base of the caudal fin (Figure 2A). This colour anomaly was previously unknown for the species (see Michael, 2008; Sampaio & Nottingham, 2008).

The second unusual coloration pattern was recorded in adult *S. fuscus* in north-eastern Brazilian reefs. This colour morph differs from the common type mainly by the presence of a diffuse blue cover over the dusky base which extends from the dorsal portion of the body (including the head and operculum) to the mid part of their body, and has diffuse irregular dark marks over the scales (Figure 2B). This coloration pattern has been recorded in different areas of Bahia State, including Salvador and Abrolhos reefs and was also unreported in the literature.

Another distinct coloration pattern was recorded in juvenile *S. fuscus* in Alagoas, Bahia and Espírito Santo States. It presented a yellowish/reddish dorso-anterior band (Figure 2C). This colour morph was previously recorded in different areas of the Brazilian coast (Araújo *et al.*, 2009), and could be associated with a variation of the common pattern. It is notable that this colour morph is very similar to *S. fuscus trinidadensis* (Gasparini *et al.*, 1999) (Figure 3).

Locally restricted variants—*Stegastes variabilis*

A noticeable variation in the *S. variabilis* coloration pattern was recorded in specific sites of north-eastern Brazilian reefs, namely in Picãozinho reef (7°07'S 34°48'W) and several coastal reefs in Bahia State. Usually the Cocoa damselfish displays a bright yellow-orange coloration pattern during

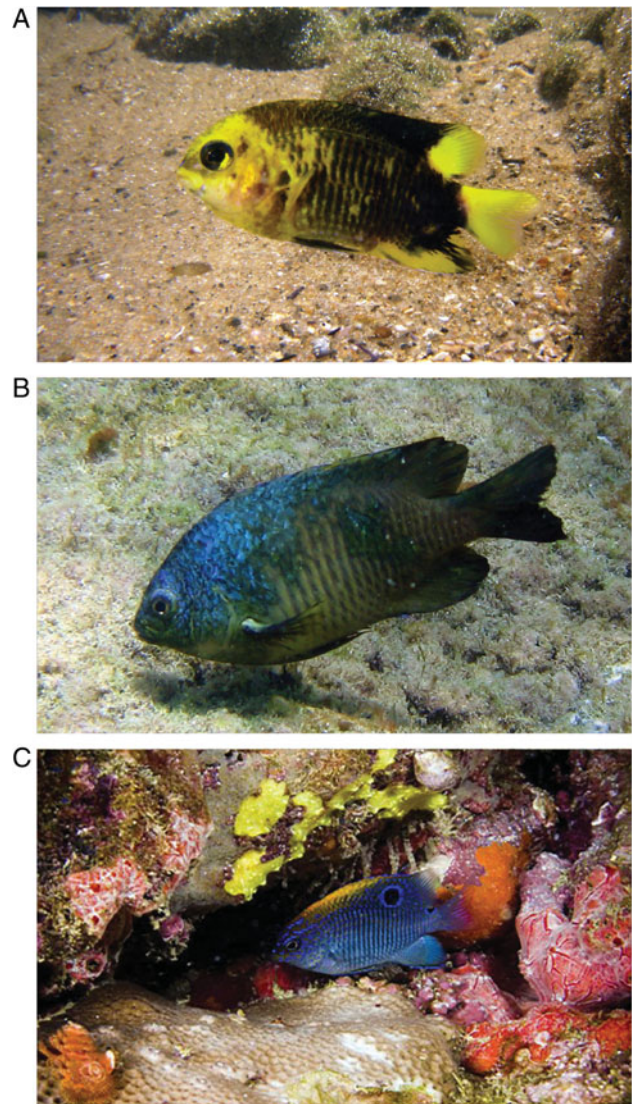


Fig. 2. *Stegastes* spp. individuals showing unusual colour patterns: (A) *S. pictus* individual exhibiting a remarkably distinct colour pattern in north-eastern Brazil; (B) *S. fuscus* adult individual with a distinct colour pattern in north-eastern reefs of Brazil, probably caused by a disease; (C) *S. fuscus* juvenile displaying a dorso-anterior band in yellowish and reddish colours recorded in the northern reefs of Brazil. Photographs by Cláudio L.S. Sampaio (A, B) and Athila Bertoncini (C).



Fig. 3. *Stegastes fuscus trinidadensis* juvenile individual displaying its typical colour morph. Photograph by João Luiz Gasparini.

the adult phase in south-eastern reefs and north-eastern deep reefs, but in specific reefs, the Cocoa damselfish exhibit a dusky coloration pattern during the adult phase (Figure 4).

DISCUSSION

The occurrence of intraspecific variation on coloration patterns in reef fish populations is relatively common and has several causes, such as ontogenetic shifts, behavioural responses and/or communication displays, as well as genetic differentiation (see Leclercq *et al.*, 2010).

Our records may point toward an existing relation between pale coloration and two specific circumstances (reproduction and human induced stress). Nevertheless, since we did not compare the occurrence of pale individuals between areas with and without egg clutches and frequented by tourists, we are not able to confirm or even refute these hypotheses.

The hidden reason behind the coloration abnormalities recorded for *S. pictus* (Figure 2A) and *S. fuscus* (Figure 2B) could be various, such as nutritional deficiencies, excessive water clarity or turbidity, stress and/or social interactions (Leclercq *et al.*, 2010). Therefore, without further investigation any kind of explanation for the fact could be too speculative.

The yellowish/reddish *S. fuscus* pattern (Figure 2C) recorded in the present study was also recorded in other systems in Pernambuco and Paraíba States and also on the south-eastern coast by Araújo *et al.* (2009). The similarity to the subspecies *S. fuscus trinidadensis* may be indicative that the subspecies actually presents a colour variation of *S. fuscus*. However, further genetic investigation is necessary to

compare the abnormal *S. fuscus* individuals found on the coast with the subspecies found in Trindade Islands in order to test if the subspecies is valid indeed.

Although damselfish showed somewhat similar coloration patterns among the studied sites, intraspecific variation was also observed. For instance, *S. variabilis* populations from north-eastern reefs, namely Picãozinho reef (A.T.S., personal observation) and Tamandaré reef (Pacheco, 2008), are predominantly dusky when adults, and this pattern differs from the yellowish pattern commonly found on southern reefs or in deeper reefs (>20 m) in the north-east. This range of colour patterns could be merely explained by dissimilarities among populations with highly different phenotype expressions, given that distinct genotypes have been previously acknowledged for the species (Molina & Galetti Jr, 2004). This distinct coloration pattern of *S. variabilis* has been reported mainly in north-eastern Brazilian shallow coastal reefs, and could be related to environmental (reef type and water temperature) distinctiveness between southern and northern reefs (see Floeter *et al.*, 2001). However, in this case, the possibility of undescribed species could not be disregarded, and genetic investigations should be performed in order to test this hypothesis.

Finally, fish exhibiting chromatic anomalies are of great interest and highly valuable in the international ornamental fish market (Michael, 2001; Luiz, 2003; Sampaio *et al.*, 2006). Due to the scarcity of these abnormal fish in the wild, and to their ecological and genetic relevance, the capture and the trade of these fish should be strongly regulated and monitored or even prohibited, in order to prevent the decrease in natural morphological and genetic variability of the species.

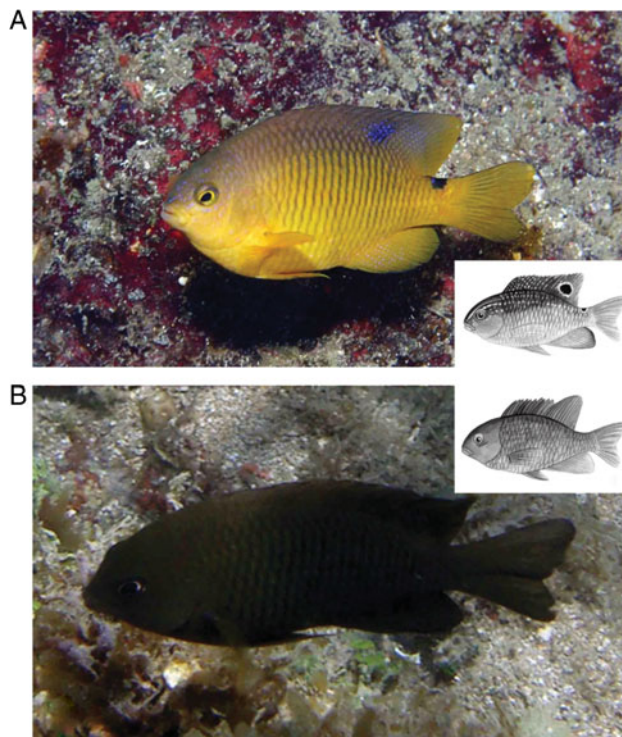


Fig. 4. (A) Two distinct colour patterns of *Stegastes variabilis* adults, from the Brazilian south-eastern and north-eastern deep reefs; (B) north-eastern Brazilian shallow reefs. Inset: scheme of the two distinct colour morphs. Photographs by João Paulo Krajewski (A) and Allan T. Souza (B); schemes by Felipe Ribas.

ACKNOWLEDGEMENTS

The authors would like to thank Alfredo Carvalho-Filho, Athila Bertoncini, Diego Barneche, João Luiz Gasparini, João Paulo Krajewski and Osmar Luiz for kindly providing photographs and/or information and comments. The authors would like also to thank Felipe Ribas for the fish drawings and the two anonymous referees for their valuable comments.

REFERENCES

- Allen G.R. (1991) *Damselfishes of the world*. Melle, Germany: Mergus Publications.
- Araújo M.E., Maranhão H.A., Vêras D.P. and Hazin F. (2009) Unusual coloration pattern in juveniles of *Stegastes fuscus* (Actinopterygii: Pomacentridae). *Zootaxa* 2081, 67–68.
- Bell T. and Kramer D.L. (2000) Territoriality and habitat use by juvenile blue tangs, *Acanthurus coeruleus*. *Environmental Biology of Fishes* 58, 401–409.
- Carvalho-Filho A. (1999) *Peixes da costa brasileira*. São Paulo, Brazil: Melro.
- Cheney K.L. and Marshall N.J. (2009) Mimicry in coral reef fish: how accurate is this deception in terms of color and luminance? *Behavioral Ecology* 20, 459–468.
- Deloach N. and Humann P. (1999) *Reef fish behavior*. Jacksonville, FL: New World Publications.

- DeMartini E.E. and Donaldson T.J.** (1996) Color morph–habitat relations in the arc-eye hawkfish *Paracirrhites arcatus* (Pisces: Cirrhitidae). *Copeia* 1996, 362–371.
- Floeter S.R., Guimarães R.Z.P., Rocha L.A., Ferreira C.E.L., Rangel C.A. and Gasparini J.L.** (2001) Geographic variation in reef-fish assemblages along the Brazilian coast. *Global Ecology and Biogeography* 10, 423–433.
- Gasparini J.L., Moura R.L. and Sazima I.** (1999) *Stegastes trindadensis* n. sp. (Pisces: Pomacentridae), a new damselfish from Trindade Island, off Brazil. *Boletim do Museu de Biologia Professor Mello Leitão* 10, 3–11.
- Gasparini J.L. and Floeter S.R.** (2001) The shore fishes of Trindade Island, south-western Atlantic. *Journal of Natural History* 35, 1639–1656.
- Gray S.M. and McKinnon J.S.** (2007) Linking color polymorphism maintenance and speciation. *Trends in Ecology and Evolution* 22, 71–79.
- Humann P. and Deloach N.** (2002) *Reef fish identification: Florida, Caribbean, Bahamas*. Jacksonville, FL: New World Publications.
- Kodric-Brown A.** (1998) Sexual dichromatism and temporary color changes in the reproduction of fishes. *American Zoologist* 38, 70–81.
- Leclercq E., Taylor J.F. and Miguad H.** (2010) Morphological skin colour changes in teleosts. *Fish and Fisheries* 11, 159–193.
- Lehner P.N.** (1996) *Handbook of ethological methods*. Cambridge: Cambridge University Press.
- Luiz O.J.** (2003) Colour morphs in a queen angelfish *Holacanthus ciliaris* (Perciformes: Pomacanthidae) population of St. Paul's Rocks, NE Brazil. *Tropical Fish Hobbyist* 51, 82–90.
- Marshall N.J.** (2000) Communication and camouflage with the same 'bright' colours in reef fishes. *Proceedings of the Royal Society—Biological Sciences Series B* 355, 1243–1248.
- Michael S.W.** (2001) *Reef fishes. A guide to their identification, behavior, and captive care*. Neptune City, NJ: TFH Publications.
- Michael S.W.** (2008) *Damselfishes and anemonefishes. Complete illustrated guide to their identification, behaviors, and captive care*. Neptune City, NJ: TFH Publications.
- Molina W.F. and Galetti P.M. Jr** (2004) Multiple pericentric inversions and chromosomal divergence in the reef fishes *Stegastes* (Perciformes, Pomacentridae). *Genetics and Molecular Biology* 27, 543–548.
- Novelli R., Nunan G.W. and Lima N.R.W.** (2000) A new species of the damselfish genus *Stegastes* Jenyns, 1842 (Teleostei: Pomacentridae) from the coast of Brazil. *Boletim do Museu Nacional* 413, 1–12.
- Pacheco A.C.G.** (2008) *Partilha de habitat entre peixes territorialistas nos recifes de Tamandaré—PE*. MSc thesis. Universidade Federal de Pernambuco, Recife, Brasil.
- Sampaio C.L.S., Carvalho-Filho A., Feitoza B.M., Ferreira C.E.L., Floeter S.R., Gasparini J.L., Rocha L.A. and Sazima I.** (2006) Peixes Recifais Endêmicos e Ameaçados das Ilhas Oceânicas Brasileiras e do Complexo recifal dos Abrolhos: Uma Síntese. In Alves R.J.V. and Castro J.W.A. (eds) *Ilhas Oceânicas Brasileiras—da pesquisa ao manejo*. Brasília: Secretaria de Biodiversidade e Florestas, pp. 217–234.
- and
- Sampaio C.L.S. and Nottingham M.** (2008) *Guia para Identificação de peixes ornamentais brasileiros*. Brasília: IBAMA.
- Correspondence should be addressed to:**
 A.T. Souza
 CIMAR/CIIMAR Centro Interdisciplinar de Investigação
 Marinha e Ambiental
 Universidade do Porto, Rua dos Bragas 289, 4050-123,
 Portugal
 email: allantsouza@gmail.com