Invasion of the Indo-Pacific blenny *Omobranchus punctatus* (Perciformes: Blenniidae) on the Atlantic Coast of Central and South America

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We examined 108 specimens of the Indo-Pacific blenny *Omobranchus punctatus* deposited in four museum collections, and analyzed data on their collection locations to assess its invasion on the Atlantic coast of Central and South America. This species occurs in shoreline estuaries and marine habitats in the Indo-West Pacific. Previous sampling and recent records in the Tropical West Atlantic from 1920 to 2004 produced 10 records for: Panama, Colombia, Venezuela, Trinidad and Brazil. In this work, we provide data on 17 new records for the Gulf of Venezuela and Pará in Venezuela, as well as four records for Maranhão and Para states in NE Brazil. The temporal pattern of collections (1936 - 2009) and the proximity of most localities to ports and zones of ship traffic indicate that *O. punctatus* was initially introduced to the Atlantic by ships travelling from India to Trinidad. Within Brazil the introduction is linked to shipping connected to petrochemical platforms. In Maranhão and Para the introduction may have occurred as a result of fish farming in floating or hulks of ships moving between ports around the mouth of the Amazon River. Alternatively, the spread of this species along the American coast may reflect the expansion of the range of *O. punctatus* through larval dispersal northward flowing currents. We recommend monitoring of this introduced species, and studies of its ecology in West Atlantic areas.


Key words: Bio-invasions, distributional data, Exotic marine fishes, New records.

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Introduction

Biological invasions are closely related to the history of humanity (Cavalier-Smith & Major, 2006) and are among the main agents of environmental changes in the world (Occhialini & Aubrogi, 2007). There is a relationship between environments altered by mankind and the existence of invasive species (San & Brown, 2000). Among marine environments, estuaries are among the ecosystems most altered by anthropogenic actions and are the sites of the greatest number of records of invasions (Moyle et al., 1999).

Wendt et al. (2000) proposed that the invasion of a new environment by an exotic species includes three phases: dispersion, introduction and settlement. These phases, along with the survival capacity of the species to its new environment, influence its success as an invader. According to these authors, Ephemeroptera, Gobids, and Platyerechiids dominate the records of introductions to exotic locations via ballast water because such water provides conditions resembling normal habitats used by them.

The bleekeriines (Bleekeriidae), comprised about 360 species in 16 genera, are cosmopolitan in tropical and subtropical marine habitats (Nelson, 2006). The natural geographic range of Omobranchus punctatus (Valenciennes, 1836) spans from the northern Indian Ocean to the Western Pacific Ocean. In the 1960s, records of specimens collected in the Atlantic began to be reported, and currently the species is known from the Caribbean and eastern Africa (Cervigón, 1966; Springer & Gomon, 1975; Cervigón, 1994). Suez Canal and Mediterranean Sea (Birh, 1920; Golani, 2004) and Brazil (Gerhardinger et al., 2006). Omobranchus punctatus is regarded as an exotic species introduced in the Atlantic.

This work aimed to elucidate the historical information on records of O. punctatus on the Central and South Western Atlantic coast, adding new information in order to understand the process of invasion by this species in the region.

Material and Methods

Two approaches were selected in order to determine the invasion of O. punctatus: (1) field work collections and (2) museum analyses. For (1) various sampling sites were done using different fishing methods, such as hand nets, and in some cases, fish poison (Rao, 1999). For (2) an exhaustive bibliographic survey was conducted along with taxonomic of fish collections of the following Venezuelan museums: Museo de Historia Natural La Salle, Caracas (MGNLE); Museo Oceanológico Hernando Benigno Romá, Isla de Margarita, Nueva Esparta State (MOBRE-EDIMAR), and Museo de Ciencias Naturales de Guanare, Guanare, Portuguesa State (MCNP). In addition, the following fish collections were reviewed in Brazil: Departamento de Oceanografia e Limnologia, Universidade Federal de Maranhão, Maranhão (CPDOL-UFPJ); Grupo de Ecología Aquática, Pará (GEA-UFGPA), and Museu Nacional, Rio de Janeiro (MNRJ). The following collections of fishes from the United States were consulted via internet: Academy of Natural Sciences of Philadelphia, Philadelphia, ANSP; National Museum of Natural History, Smithsonian Institution, Washington (USNM); National History Museum of Florida, Gainesville, Florida (UF); Oceanography Institute, Scripps, La Jolla, California (SIO); Laboratory of Coastal Investigations of the Gulf Ocean Springs, Mississippi (CCEIL); American Museum of Natural History, New York (AMNH); and Natural History Museum, London (BMNH). The other institutional abbreviations mentioned in this essay follow Leviton et al. (1955), except MINLS, MOBR-EDIMAR, EBRQ, CPDOL-UFPJ and Laboratorio de Biología Pesquera, Universidade Federal do Pará (LEB-UFPJ). Other acronyms mentioned in this paper correspond to the ones from Institute of Investigations and Natural Museum Senckenberg (SMF), Frankfurt, Germany and from Hebrew University of Jerusalem (HUT), Jerusalem, Israel.

Results and Discussion

A description of Omobranchus genus can be found at Williams (2002). Omobranchus punctatus (Fig. 1) is characterized by having a very elongated rounded head lacking a longitudinal crest on its top, almost always 3 (2-4) pores between the eyes, lateral line with 2-4 double-pored tubes; the gill opening is restricted to above the level of the pectoral fin; dorsal fin (XII-XIII), 19-24; anal fin II, 20-26. 1 or both spines imbedded, not visible externally; tail fin with 13 (11-14) segmented rays, none filamentous; a pale-edged dark bar across the snout, a little before the origin of the dorsal fin, about 11 dark saddles across the top of the back; 3 dark bars on the lower part of the head and another on the pectoral fin base; and 4-5 slender dark stripes along the upper side of the front half of the body.

The natural range of O. punctatus includes the northern Indian Ocean and western Pacific, from the Persian Gulf (Iran) to India, Japan, the northern Australian coast and the Fiji Islands (Springer & Gomon, 1975).

In the Caribbean, the first records of O. punctatus were in 1930, when Fewer (1931) described a new species of bleekeriine, Panaeus zebra, with specimens captured on the western coast of Trinidad (Brighton beach, Gulf of Paria) (Table 1). In 1975, this species was recognized as a synonym of O. punctatus (Springer & Gomon, 1975). In 1991, Cervigón (1995) reported O. punctatus as O. daxtoni, at the Guayas on the Venezuelan coast of the same Gulf. After Fewer's initial record (1931), more specimens were collected from Trinidad in 1933, and between 1960 and 1968 (Table 1) for both the Atlantic and Pacific coasts of that Island, and the western coastal of the Gulf of Paria (Figs. 2a and b).

In Central America, this species has been recorded from Panama, with records of collections between 1957 and 1974 (Fig. 2a, Table 1). All records of the species in Panama came
from the Caribbean entrance of the Panama Channel. Fish collections made between 1935 and 1937 at the Pacific side of the Channel (Minaflora locks) by Hildebrand (1939) yielded no specimens of *O. punctatus*. Also, the species was not recorded in these areas by McCosker & Dawson (1975). To date, there is no evidence of its occurrence on the Pacific coast of Panama. The Channel first began operation in 1914. The first record of *O. punctatus* in Trinidad dates from the 1910s. The first record of *O. punctatus* in Panama, at the Caribbean entrance to the canal, are from 1967, much later than the first record from Trinidad (1930) (Table 1). Springer & Gomon (1975) and Carton (1983) suggested that it is likely that specimens of mussels blemmy from Panama originate via shipping movements from the population at Trinidad. This hypothesis was supported by strong similarities in the morphology of specimens collected from these two countries.

The Caribbean coast of Colombia has been intensively sampled over the past 30 years, and as a consequence its shore-fish fauna is well known. Intensive sampling by Ganzin-Pazarea (1910) on the Colombian coast recorded no specimens of *O. punctatus*. To date, the only record of this species (Table 1) on that coast of Colombia is a single specimen from Portete Bay, on Guajira Peninsula, in the eastern end of Colombia, just west of the Gulf of Venezuela (Fig. 2c).

There are various records of *O. punctatus* collected in the Gulf of Venezuela, adjacent to the east of Guajira Peninsula (Fig. 2c, Table 1). These include the Gulf itself, and several sites in the channel connecting lago de Maracaibo to the Gulf of Venezuela. Such specimens were captured between 1972 and 2007 and represent new records from this study. The first record of *O. punctatus* from eastern Venezuela was taken by Cervigón (1946) from the Gulf of Paria in 1961 (Table 1). Subsequently, Lasso et al. (2004) collected specimens from a rocky beach of the Oriental Delta river, in 2002 (Table 1). Other new records from Venezuela are five lots (56 specimens) collected at that same site and a nearby sandy beach in 2004 and 2006 (Table 1). An additional specimen was found in the month of Caño Macareo (58 km east of the previous location) in 2008 (Table 1), together with 14 specimens from four locations from the eastern end of South coast of the Paria Peninsula (Fig. 2c, Table 1). One of us (ER), while snorkeling at one of the latter sites, saw dozens of *O. punctatus* darting around a rocky point within 1 m of the surface of the water. Most recently (April 2009), a specimen was captured inside the shell of a dead banded attacked to the hull of the ship Beba Grande, 7 km north of the outfall from Caño Macareo.

The two regions of Venezuela where the populations of *O. punctatus* evidently are established, the (western) Gulf of Venezuela and the (eastern) Gulf of Paria include the most extensive and important estuarine areas of the northern coast of South America. Extensive sampling using small rotenone stations of shallow estuarine and marine habitats between Paria Peninsula and the Gulf of Venezuela by JP, IVT and DRR, between 2005 and 2008 failed to record any specimens of *O. punctatus*. The estuary of lago de Maracaibo and the Gulf of Paria were the only two locations in which *O. punctatus* was collected.

In Brazil, the records of *O. punctatus* date from 2002 and 2008 (Figs. 1 and 2d, Table 1). In 2002, 96 specimens were captured in the Bahia State (Gehardinger et al. 2006). In 2004, Gehardinger et al. (2006) found two specimens in Rio de Janeiro State, and six specimens were collected from fouling organisms on the hull of a ship in Santa Catarina State (Table 1). Here we report new records from the vicinity of the mouth of the Amazon River in 2001 and 2006 (Figs. 1 and 2d, Table 1). Most recently, a population was found in Pará State (Fig. 2d, Table 1).

Springer & Gomon (1975), on the basis of a morphological and historical analysis of the species in the west Atlantic concluded that the populations of *O. punctatus* are the result of an introduction to Trinidad via shipping from India between 1538 and 1614 that transported immigrant workers to Trinidad Island. They thought that ballast water or hull fouling organisms were involved in supporting *O. punctatus* individuals during the voyage.

Information presented and summarized here, based on collections of *O. punctatus* at additional sites in the Central and NE South American coast also implicates shipping movements in subsequent expansions of that species range. All new collection sites are at or very near to, ports and seaways that support heavy shipping activity: the Gulf of Venezuela and Lago de Maracaibo and the sites in NE Colombia. In this regard, the absence of records of *O. punctatus*...
Table 1. Records of *Oreobranchus punctatus* from Trinidad (T), Panama and Columbia (PC), Venezuela (V) and Brazil (B).

<table>
<thead>
<tr>
<th>Collection</th>
<th>Date</th>
<th>Site</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>1941</td>
<td>Brighton Bay, Gulf of Paria</td>
<td>BMNH 1 lot</td>
</tr>
<tr>
<td>T1</td>
<td>1943</td>
<td>Trinidad, Gulf of Paria</td>
<td>BMNH 1 lot</td>
</tr>
<tr>
<td>T3</td>
<td>1986</td>
<td>Salt Bay, east coast of Trinidad</td>
<td>BMNH 1 lot</td>
</tr>
<tr>
<td>T4</td>
<td>1985</td>
<td>Mayaro, Rodia Point, east coast of Triniad</td>
<td>BMNH 1 lot</td>
</tr>
<tr>
<td>T1</td>
<td>1991</td>
<td>Salt Bay, east coast of Trinidad</td>
<td>BMNH 1 lot</td>
</tr>
<tr>
<td>V1</td>
<td>1941</td>
<td>Cura, Delta Amacuro, Gulf of Paria</td>
<td>BMNH 1 lot</td>
</tr>
<tr>
<td>T4</td>
<td>1980</td>
<td>Chaguaramus Bay, Gulf of Paria</td>
<td>BMNH 1 lot</td>
</tr>
<tr>
<td>PC1</td>
<td>1966</td>
<td>Limote Bay, Atlantic coast, Panama</td>
<td>BMNH 1 lot</td>
</tr>
<tr>
<td>PC2</td>
<td>1966</td>
<td>Limote Bay, Atlantic coast, Panama</td>
<td>BMNH 1 lot</td>
</tr>
<tr>
<td>PC3</td>
<td>1976</td>
<td>Limote Bay, Atlantic coast, Panama</td>
<td>BMNH 1 lot</td>
</tr>
<tr>
<td>PC4</td>
<td>1976</td>
<td>Limote Bay, Atlantic coast, Panama</td>
<td>BMNH 1 lot</td>
</tr>
<tr>
<td>PC5</td>
<td>1976</td>
<td>Guato Keys, Atlantic coast, Panama</td>
<td>BMNH 1 lot</td>
</tr>
<tr>
<td>PC6</td>
<td>1976</td>
<td>Guato Keys, Atlantic coast, Panama</td>
<td>BMNH 1 lot</td>
</tr>
<tr>
<td>V2</td>
<td>1976</td>
<td>Punta Guatanga, Zulia state, Gulf of Venezuela</td>
<td>BMNH 1 lot</td>
</tr>
<tr>
<td>V3</td>
<td>1978</td>
<td>Espiritu Santo, Zulia state</td>
<td>BMNH 1 lot</td>
</tr>
<tr>
<td>V4</td>
<td>1978</td>
<td>El Tobin, Zulia state</td>
<td>BMNH 1 lot</td>
</tr>
<tr>
<td>PC7</td>
<td>1991</td>
<td>Petion Bay, Panama de La Guaira, Colombia</td>
<td>BMNH 1 lot</td>
</tr>
<tr>
<td>V1</td>
<td>2002</td>
<td>Pedárada beach, cabo Mamaca, Curoco Delta, Delta Amazonico state</td>
<td>BMNH 1 lot</td>
</tr>
<tr>
<td>V6</td>
<td>2004</td>
<td>Todos os Santos Bay, Bahia</td>
<td>BMNH 1 lot</td>
</tr>
<tr>
<td>V8</td>
<td>2004</td>
<td>Pedárada beach, cabo Mamaca, Curoco Delta, Delta Amazonico state</td>
<td>BMNH 1 lot</td>
</tr>
<tr>
<td>H1</td>
<td>2004</td>
<td>Tha Grande Bay, Rio de Janeiro</td>
<td>BMNH 1 lot</td>
</tr>
<tr>
<td>B1</td>
<td>2004</td>
<td>Bahia dos Coqueiros, Santa Catarina</td>
<td>BMNH 1 lot</td>
</tr>
<tr>
<td>V7</td>
<td>2004</td>
<td>Pedárada beach, cabo Mamaca, Curoco Delta, Delta Amazonico state</td>
<td>BMNH 1 lot</td>
</tr>
<tr>
<td>V8</td>
<td>2004</td>
<td>Pedárada beach, cabo Mamaca, Curoco Delta, Delta Amazonico state</td>
<td>BMNH 1 lot</td>
</tr>
<tr>
<td>V9</td>
<td>2004</td>
<td>Pedárada beach, cabo Mamaca, Curoco Delta, Delta Amazonico state</td>
<td>BMNH 1 lot</td>
</tr>
<tr>
<td>V10</td>
<td>2004</td>
<td>Cariba beach, Curoco Delta, Delta Amazonico state</td>
<td>BMNH 1 lot</td>
</tr>
<tr>
<td>B4</td>
<td>2004</td>
<td>Arapangua beach, Maranhao</td>
<td>BMNH 1 lot</td>
</tr>
<tr>
<td>B5</td>
<td>2004</td>
<td>Canico beach, Maranhao</td>
<td>BMNH 1 lot</td>
</tr>
<tr>
<td>B6</td>
<td>2004</td>
<td>Canico beach, Maranhao</td>
<td>BMNH 1 lot</td>
</tr>
<tr>
<td>V11</td>
<td>2007</td>
<td>Serra Cura Elliott, Zulia state</td>
<td>BMNH 1 lot</td>
</tr>
<tr>
<td>V12</td>
<td>2007</td>
<td>Porro grande, Esthela de Lago de Maracaibo, Estado Zulia</td>
<td>BMNH 1 lot</td>
</tr>
<tr>
<td>V13</td>
<td>2007</td>
<td>Ia de Peixas, Esthela de Lago de Maracaibo, Estado Zulia</td>
<td>BMNH 1 lot</td>
</tr>
<tr>
<td>V14</td>
<td>2008</td>
<td>Pun Paracuro beach, cabo Mamaca, Curoco Delta, Delta Amazonico state</td>
<td>BMNH 1 lot</td>
</tr>
<tr>
<td>V15</td>
<td>2008</td>
<td>Carapea, Paro Pampa, Surinam state</td>
<td>BMNH 1 lot</td>
</tr>
<tr>
<td>V16</td>
<td>2008</td>
<td>Genaro, Paro Pampa, Surinam state</td>
<td>BMNH 1 lot</td>
</tr>
<tr>
<td>V17</td>
<td>2008</td>
<td>Paro Point, Paro Pampa, Surinam state</td>
<td>BMNH 1 lot</td>
</tr>
<tr>
<td>V18</td>
<td>2008</td>
<td>Ilha de Reina, Para</td>
<td>BMNH 1 lot</td>
</tr>
<tr>
<td>B1</td>
<td>2008</td>
<td>Estoril, Para</td>
<td>BMNH 1 lot</td>
</tr>
<tr>
<td>BF</td>
<td>2008</td>
<td>APA Algodal-Para, Para</td>
<td>BMNH 1 lot</td>
</tr>
<tr>
<td>V19</td>
<td>2009</td>
<td>Boca Grande, Artubo Da Parque</td>
<td>BMNH 1 lot</td>
</tr>
</tbody>
</table>

*punctatus* on the Venezuelan coast between the Griffs of Paria and Venezuela, on the Panamanian coast, east of the Panama Channel, and along most of the coast of Colombia are particularly revealing. Gehardinger et al. (2006) and Hoistm et al. (2007) linked recent records of this species at sites on the east coast of Brazil to ship movements and shipping supply of offshore oil platforms. On the NE coast of Brazil, the collection site reported here supports heavy shipping. However, some expansion of the geographic range of *O. punctatus* through larval dispersal on nearshore ocean currents may well be involved in expansions along the eastern coast of South America. The south equatorial current flowing across the Atlantic nearshore to the Caribbean, and the South Brazil current flowing south to about the tropic of Capricorn. These currents are thought to be important in promoting dispersal of *O. punctatus* (see Roche, 2003). The former could be involved in spreading *O. punctatus* along the NE coast of Brazil and the latter in spreading it along the southern Brazilian coast.

Although it is hard to know the natural distribution of *O. punctatus* (Jeffrey Williams, personal communication, 2009), there are records of likely introductions of this species elsewhere in the world. Springer & Gunson (1975) noted that specimens captured at Mozambique in 1951 and 1970 likely came from a population introduced by ballast water. Subsequent captures at Kenya (USNM 299017) and the northern tip of South Africa (BMNH 1903.21.57) likely
Fig. 2. Distribution of *Omobranchus punctatus* in Central and South American coasts. a) Full circle represents new records and open circle represents records from literature, b) Catch sites of *Omobranchus punctatus* in the eastern coast of Venezuela (Gulf of Paria) and Trinidad (see Table 1), c) Localities with records of *Omobranchus punctatus* in western Venezuela (Gulf of Venezuela) and Colombia (Cauca Peninsula) (see Table 1) and d) Localities with records of *Omobranchus punctatus* from Maranhão and Pará states, northern Brazil (see Table 1).

resisted from the same or later introductions. Both (1980) recorded *O. punctatus* (SMF 15216) captured in 1879 within the Suez Canal, between the Mediterranean Sea and the Red Sea, while Gelati (2004) recorded it (HUI 18977), on the Mediterranean coast of Israel.

In addition to *O. punctatus*, introductions of three other species of the same genus have been recorded: *O. biaculeatus* in Hawaii in 1951 (Walford & Wicklund, 1973), and subsequently, in Guam in 1992 (Eldredge, 1994). *O. obliquus* in Hawaii and Kiribati (Myers, 1991) and *O. ferox* (Herr, 1977) in continental waters from the United States since 1908 (Barrley, 2006). All these introductions are regarded as having led to the establishment of resident populations, potentially leading to competition with native species (Albins & Hixon, 2008).

Other exotic species have been introduced to the Caribbean Sea. Pezzoli & Cage (2002) found *Eucistrocus picta* (Eelrididae), from western Venezuela. Its natural distribution encompasses the Pacific coast of the America between Mexico and Ecuador. Lasso-Alcalá et al. (2005a) and Lasso-Alcalá et al. (2003b) found the electric *B. latifrons* and the gobiod *Gobiosoma bosc*, near the capture points of *O. punctatus* on the north side of the Orinoco Delta River. *B. latifrons* and *G. bosc*, which naturally occur from east Africa to the West Pacific (Papua New Guinea) (Dawson, 1973; Miller & Wourms, 1990) had also been collected from the Pacific side entrance (Miraflores locks) to the Panama Canal (Dawson, 1973). Western Central Atlantic: Port Harcourt, Nigeria (Miller et al., 1989). *B. ferox* (Henvin et al., 2003) and mouth of Nilson river in Cameroon (Stauney et al., 2008). The natural range of *G. bosc* is the north west Atlantic, from the western Gulf of Mexico to Massachusetts, on the Atlantic coast of the US (Bakke & Robins, 1966; Castro-Aguirre et al., 1999; Williams, 2005).

In the last ten years, the Indo-Pacific lionfishes *Pterois volitans* (Lamarr, 1738) and *P. miles* (Bennett, 1838) have been recognized as the most alarming cases of introduction.
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and invasion in the Western Atlantic (Schofield, 2009). From 1999 to 2010, the dispersion of *Parrinus volitans* is confirmed on the east coast of US (New York to Florida), Bermuda, North Caribbean (Bahamas to US Virgin Islands), Gulf of Mexico (Florida and Yucatan Peninsula), Western Caribbean (Mexico, Belize, Honduras, San Andrés and Providencia Archipelago, Costa Rica, Panama) and South Caribbean Sea (Colombia coast, Curaçao and Bonaire islands) (Wainwright et al., 2002; Cheveralier et al., 2008; Guerra & Franco, 2008; Gonzalez et al., 2009; Schofield, 2009; USGS-IFAS, 2010; Aguilar-Pereira & Tuiz-Sulub, 2010). In Venezuela, this species has been recently observed and collected in 12 locations at the coast and islands of the central region (Lazo-Alcâncio & Posada, 2010).

In Brazil, Caires et al. (2007) found the benthic fish *Ophonus beta*, in several sites in southern Brazil (in São Paulo and Paraná States), to where its thought to have been introduced in ship ballast water.

We recommend performing research focused on inventories of coastal regions near port and aquaculture facilities or with intense maritime traffic to seek other introduced species in Central and South America. Monitoring and studying the bio-ecology of the introduced species and already established populations of *Omobranchus punctatus* is also recommended. In addition, studies on population dynamics (population structure, reproduction, diet, age and growth), macroecology, behavior, competition with native species, and its use and genetic variation will provide information to a complete monitoring of the *O. punctatus*.


**Acknowledgements**

The present paper represents part of the academic activities by the first author in the Programa Integrado de Estudos de Postgraduação em Zoologia Agrícola, Universidad Central de Venezuela, thanks to Fernando Cervigón (UMN), Armando Acevedo (UMN-CECIMAR / DIVEMAR), Maria Elisa de Araujo (UFPE) and Jeff Williams (USNM) for the assistance and suggestions on the manuscript. Also to the directors and personnel from the fish collections consulted for their cooperation with the revision of the material and providing information over the records of the species: Juan Carlos Capelo (MOBR-EDIMAR), Donald Taphorn (MCNG), Francisco Biobio (ERRE), Luz M. Mejía-Ladino, Gabriel Navas (IVN - PEC), Mark Sabaj, John G. Jensen (USNM), Robert Robins, Georeg Burgess (UP), Philip Hastings (USNM), Sara LaCroix (CCRL), Scott Schnafer (AMNH), Patrick Campbell and Oliver Crummen (BMNH), Paulo Barboza (MNRJ).

**The Institute Socialistas de Pesca y Acuicultura (DISOBESCA) grazed the scientific fishing permits required in Venezuela. T. Guimarães acknowledges financial support by the Fundação de Amparo à Pesquisa do Estado do Pará (FAPEPAR) (Project number: 137/2008 - Universal).**

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Invasion of the Indo-Pacific blenny Oxeidichthys punctatus.


Submitted September 14, 2010
Accepted July 4, 2011
Published September 18, 2011