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Snake eels (Ophichthidae) of the remote St. Peter and St. Paul's Archipelago (Equatorial Atlantic): Museum records after 37 years of shelf life

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Despite of its major zoogeographical interest, the biological diversity of central Atlantic oceanic islands are still poorly known because of its remoteness. Incomplete species inventories are a hindrance to macroecology and conservation because knowledge on species distribution are important for identifying patterns and processes in biodiversity and for conservation planning. Records of the snake-eel family Ophichthidae for the St. Peter and St. Paul's Archipelago, Brazil, are presented for the first time after revision of material collected and deposited in a museum collection 37 yrs ago. Specimens of *Apterichtus kendalli* and *Herpetoichthys regius* were collected using rotenone on sand bottoms and one *Myrichthys* sp. was observed and photographed swimming over a rocky reef. Remarkably, these species were not seen or collected in the St. Peter and St. Paul's Archipelago ever since despite the substantial increase of biological expeditions over the past two decades, suggesting that the unjustified rotenone sampling prohibition in Brazil is hindering advancement of the nation's biological diversity knowledge.

Key words: Central Atlantic islands, Anguilliformes, sampling bias, rotenone prohibition.

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INTRODUCTION

Museum collections are an invaluable resource for biodiversity research, having provided, among other things, innumerable new species that were discovered among preserved specimens. However, species 'shelf life' - i.e. the period from the first collection of a specimen of a new species to its formal description and naming in the scientific literature - is decades long on average (Fontaine et al. 2012). Consequently, long shelf-life periods of new species in museum collections delays taxonomic progress and is a major factor contributing to the Linnean shortfall (i.e. the knowledge discrepancy between formally described species and the number of species that actually exist; Hortal et al. 2015).

Likewise, known species that have been collected in a given locality for the first time can also face a long shelf life period until the new occurrence is reported in the literature, potentially resulting in incomplete knowledge about their geographical distribution, or the Wallacean shortfall (Hortal et al. 2015). The Wallacean shortfall has important implications for biogeography and macroecology because data on the distribution of species are vital for identifying broad-scale patterns in biodiversity and the processes driving those patterns. The Wallacean shortfall can also influence estimates of conservation

threat status since geographic range size is frequently used in conservation planning, in which species with small ranges are given higher priority (Hoffmann et al. 2008).

New occurrences of species' geographic records are acquiring momentum in the context of climate change (Fogarty et al. 2017) and biological invasions (Luiz et al. 2013; Pajuelo et al. 2016). Consequently, effort towards diminishing specimens' shelf life in museum collection records is becoming increasingly important, especially for remote places where sampling is scarce due to logistic and financial constraints. Here we bring to light details of the first geographic records of two snake eel species (Anguilliformes: Ophichthidae) from the remote Saint Peter and Saint Paul's Archipelago (hereafter SPSPA) that were collected 37 years ago and another that was subsequently photographed in 1981 by a scuba diver.

The SPSPA - formerly known in the biological literature as Saint Paul's Rocks (Lubbock and Edwards 1981; Luiz and Edwards 2011) - is a group of barren islets in the equatorial Atlantic Ocean, on the mid-Atlantic ridge (00°55'N, 29°21W), located at 960 km off Cape of São Roque, north-eastern coast of Brazil and 1890 km south-west off Senegal, West Africa. The fauna of SPSPA is of considerable zoogeographical interest because of peculiar characteristics of isolation, small area and high endemism. Despite the SPSPA's renown as a regular stopover during important 19th century expeditions, including those of Charles Darwin on the H.M.S. Beagle in 1832 and of H.M.S. Challenger in 1873 (Luiz & Edwards 2011), detailed studies of its ichthyofauna are relatively recent. The first inventory of demersal fishes of the SPSPA was done in 1979 (Lubbock & Edwards 1981). Subsequent expeditions primarily intended to study demersal fishes in the SPSPA took place only after 1998 after the construction of a research station by the Brazilian Navy. Currently, there are approximately 60 species of demersal fishes recorded in the SPSPA (Feitoza et al. 2003; Ferreira et al. 2009). So far, the order Anguilliformes were represented in the SPSPA only by the family Muraenidae, with seven species recorded (Feitoza et al. 2003, Vaske et al. 2005). In this note we report the occurrence of three additional species of anguilliforms belonging to the snake eel family (Ophichthidae).

MATERIALS AND METHODS

The snake eel specimens were collected in 1981 by Alex Smart, a former zoology student in the University of Florida (UF) and a photograph taken (the specimen was not collected) by Alexander MacPherson while scuba diving in 1981. Those specimens, along with further material photographed and collected by A. Smart in the SPSPA, are deposited in the Florida Museum of Natural History (FLMNH) and the California Academy of Sciences (CAS). Specimens were analysed and identified by JEMC and the late Eugenia Böhlke. Voucher numbers are given below.

RESULTS AND DISCUSSION

Apterichtus kendalli (Gilbert, 1891) (Figure 1)
Sphagebranchus kendalli Gilbert 1891. Type locality: Off Florida, Gulf of Mexico, USA.

Fig. 1. Specimens of *Apterichtus kendalli* collected with rotenone in the Saint Paul's archipelago

Examined material: FLMNH —UF 44624 (8), Center Islands Bay, St. Paul's Rocks, Brazil,

Atlantic Ocean, 01 July 1981, Coll. Alex Smart, at a depth of 10 m, rotenone station.
Distribution: From the western Atlantic from the Carolinas, Florida, Bermuda, Bahamas, Lesser Antilles and Brazil, and from St. Helena Island, and now St. Paul's Rocks. Known from 6-401 m (mostly 30-80 m) depth (Edwards & Glass 1987; Robertson & Van Tassell 2017, McCosker & Hibino 2015).
Remarks: These distinctive specimens were identified by the late Eugenia B. Böhlke and the second author.

***Herpetoichthys regius* (Richardson, 1848)**
(Fig. 2)
Ophisurus regius Richardson, 1848. Type locality: St. Helena Island, South Atlantic.

Fig. 2. *Herpetoichthys regius* collected with rotenone in the Saint Peter archipelago.

Examined material: FLMNH - UF 172077 (2) and CAS 227182 (2), St. Paul's Rocks, Brazil, Atlantic Ocean, 04 July 1981, Coll. Alex Smart, at a depth of 15m, rotenone station.
Distribution: Ascension Island, St. Helena Island and St. Paul's Rocks in the South Atlantic and Mauritania Coast in Eastern Atlantic (Edwards " Glass 1987; Wirtz et al. 2017). Santa Catarina State on the Brazilian Coast, south-western Atlantic (Anderson et al. 2015). Known from 15-170 m (McCosker 2016).
Remarks: Our specimens do not differ in morphology or in meristics from specimens reported by McCosker et al. (1989).

***Myrichthys* sp.** (Fig. 3)
Examined material: A photograph taken by Alexander MacPherson, at a depth between the surface and 10 m at St. Peter's Rocks during May/June 1981.

Fig. 3. *Myrichthys* sp. Photo: Alexander MacPherson taken at St. Peter's Rocks, between 0 - 10 m.

Distribution: See Remarks below.
Remarks: Our identification of this eel is based solely on a photograph, however its appearance is unique and clearly that of a *Myrichthys*. *Myrichthys* is easily recognized within the family due its prominent dorsal-fin origin and usually spotted or striped coloration. It is also unlike most ophichthids which spend the majority of their lives buried in the substrate. There are two closely related gold-spotted *Myrichthys* in the Atlantic, *M. ocellatus* (Lesueur, 1825) and *M. pardalis* (Valenciennes, 1839), separated by their vertebral numbers. They have previously been synonymized (Gunther 1870; Fowler 1936). However, McCosker et al. (1989) recognized them as distinct species. *Myrichthys ocellatus*, described from a Barbados specimen, has 151-159 total vertebrae, and is an insular species, known from Bermuda, the Florida Keys, throughout the West Indies, and south to Brazil (McCosker & Rosenblatt 1993). *Myrichthys pardalis*, described from a Canary Island specimen has 164-173 total vertebrae and is also an insular species, known from the "islands of the eastern Atlantic including São Tomé, the Cape Verde Islands, the Canaries and Annoban, and the Gulf of Guinea (McCosker 2016). Lacking a specimen and the ability to examine its meristics and morphometrics, and ultimately its cytogenetics, we are unable to identify

this species and are prepared for the possibilities that it might be an endemic species or that the two species are synonymous.

The occurrence of these three snake eel species in the SPSPA is not unexpected given that they are found in the relatively close St. Helena Island and Ascension Island. Nevertheless, to the best of our knowledge, this represents the first record of *Apterichtus kendalli* for Brazilian waters. It is intriguing, however, that those species have never been found in the many expeditions to the SPSPA performed by Brazilian researchers during the last decade. The sharp snouts and tails and muscular and cylindrical bodies of snake eels are well adapted for burrowing, and many of those species (especially *A. kendalli*) spend most of their adult lives buried in the shallow sand and soft sediment. It is necessary to use specific methods to catch them, the most efficient being rotenone ichthyocides over sand bottoms.

Sampling with rotenone is prohibited in Brazil since the late 1990's despite being one of the best tools available for discovering vital information about the biodiversity of marine fishes (Robertson & Smith-Vaniz 2008). Over the past decades, the use of rotenone has become a concern to environmental and animal rights groups. As a result, its use has been challenged, halted, or discouraged based on evidence of effects on non-target fauna and health concerns on mammals (Pan-Montojo et al. 2012; Dalu et al. 2015; Melo et al. 2015). Nevertheless, rotenone sampling can be completely safe and potential environmental impacts largely minimized if rotenone is used with caution (Finlayson et al. 2000; Robertson & Smith-Vaniz 2008).

Rotenone use is not an alternative sampling method, but a complementary one that is essential for ensure broad taxa coverage in fish assemblage surveys around the globe, especially of cryptobenthic, turbid-habitat and deep-reef species (Ackerman & Bellwood 2000; Ross & Quattrini 2007; Grubich et al. 2009; Ilves et al. 2011). It is well known that fish biodiversity surveys relying only on visual sampling fail to detect a large proportion of species present in the area, particularly cryptic species that live within the habitat matrix and out of sight of divers (Ackerman & Bellwood 2002, Ilves et al. 2011). Therefore, it is very likely that modern researchers are overlooking an important section of the nation's fish diversity because of sampling limitations.

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