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Are There One or Two Species of *Halobatrachus* Toadfishes (Teleostei: Batrachoididae) in the Eastern Atlantic?

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The genus *Halobatrachus* has been considered to be represented by a single valid species in the eastern tropical Atlantic Ocean, *H. didactylus* (Bloch and Schneider, 1801). Discovery of a second morphotype off West Africa raised the question of whether a second species, *H. conspicillum* (Cuvier, 1829) should also be recognized. *Halobatrachus didactylus* has a small eye (5.3–7.9% SL) and wide interorbital width (12.2–16.1% SL), whereas the other morphotype represented by *H. conspicillum* has a large eye (7.8–11.1% SL) and a narrow interorbital width (8.8–12.1% SL). *Halobatrachus didactylus* is the common species in Europe but is also found along the coast of West Africa, whereas the large-eyed form is the more common along the coast of West Africa, but the two overlap in distribution. The two competing hypotheses are discussed.

The family Batrachoididae is currently represented by five species in the eastern tropical Atlantic Ocean (Roux 1971a, 1981, 1990): *Batrachoides liberiensis* (Steindachner, 1867), *Chatrabus damaranus* (Barnard, 1927), *Halobatrachus didactylus* (Bloch and Schneider, 1801), *Perulibatrachus elminensis* (Bleeker, 1863), and *Perulibatrachus rossignoli* (Roux, 1957).

While preparing the toadfish account for the latest edition of the FAO species identification guide for the Eastern Tropical Atlantic at a workshop at Tenerife, Canary Islands, the first two authors found specimens of two distinct morphotypes in the genus *Halobatrachus*, one with large eyes and a narrow interorbital width, and the other with small eyes and a wider interorbital width. *Halobatrachus didactylus* is the name that has been used for a species that has been widely studied in Europe (see selected references in Discussion section), and thus, if more than one species is present, it would have serious implications for much of the research that has been conducted. Because of his long experience with *Halobatrachus didactylus* in Portugal, the third author has joined the first two to describe the differences between the two morphotypes, address the question of whether there are one or two species, and explore available names in case the second morphotype is a valid species.

Methods and Materials

Counts and measurements follow Hubbs and Lagler (1964) except that the last two fin rays are

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not counted as one unless it is clear that they are joined at the base. Measurements were made to the nearest 0.1 mm using dial calipers and are expressed as percentage of standard length (SL) or one body part stepped into another. Certain measurements were taken from photographs or illustrations. Measurements and photographs of holotypes were taken by various museum curators. Institutional abbreviations are as listed in Leviton et al. (1985) with the addition of COC, Centro Oceanográfico de Canarias, Santa Cruz de Tenerife.

Material examined

H. didactylus, small-eyed form: 5 (165-236 mm SL): Europe: MCZ 22424-5 (2, 222-236), Spain, Cadiz; Don Juan Elizola, received Aug. 1863. Africa: MCZ 12787 (1, 187), Gambia, Bathurst. USNM 217413 (1, 180), Ghana; 1961; G Bane 837. COC 1/12/7 B (1, 165), West Africa.

H. didactylus, large-eyed form: 12 (82.1-229 mm SL) from West Africa: USNM 205060 (1, 229), Sierra Leone, 7-53N/12-58W; La Rafale; Nov. 19, 1963, BB Collette 916. USNM 205062 (1, 134), Sierra Leone, 7-18-30N/12-41W; Nov. 15, 1963, BB Collette 898. USNM 205063 (1, 153), Sierra Leone, 7-17-30N/12-41-30W; Nov. 15, 1963, BB Collette 899. USNM 205064 (1, 105), Liberia, 6-41N/11-23W; Nov. 11, 1963, BB Collette 881. USNM 205065 (1, 161), Liberia, 6-40N/11-23 W; Nov. 11, 1963; BB Collette 882. UF 216983 (orig. UMML 16893) (2, 82.1-91.5), Ivory Coast, 5-05N/4-59W, Pillsbury 48. UF 216854 (orig. UMML 16854) (4, 82.7-99.4), Ghana, 4-40N/2-00W; Pillsbury 28. COC 1/12/8 MR (1, 150), West Africa.

We have examined photographs of the type specimens or figures in the original publications of all the nominal species involved:

Batrachus didactylus Bloch & Schneider 1801:42. Holotype ZMB 817. Guinea, listed by Paepke 1999:50. Photographs by P. Bartsch.

Batrachus tau not of Linnaeus 1758, Bloch & Schneider 1801, ZMB 2252, listed by Paepke 1999:51. Photographs by P. Bartsch.

Batrachus conspicillum Cuvier 1829:253. Based on *Batrachus tau* Bloch & Schneider 1801, ZMB 2252, listed by Paepke 1999:51. Preoccupied by *Gadus tau* Linnaeus 1758 = *Opsanus tau* Linnaeus. Photographs by P. Bartsch.

Batrachus punctatus Agassiz in Spix & Agassiz 1831:133, plate 74. Atlantic Ocean "off Brazil". Name given as "*Batrachus punctatus* Cuv. In litt." in text but as *Batrachus punctulatus* on the plate.

Batrachus borealis Nilsson 1832:99. Kattegat, near the fisherman's village Mölle, Norway. Holotype ZMUL, photographs by S. Kullander.

Batrachus barbatus Valenciennes in Cuvier & Valenciennes 1837:498. A replacement name for *Batrachus didactylus* Bloch & Schneider, therefore based on the same type specimen.

Batrachus algeriensis Guichenot 1850:81, name on drawing only, plate 5.

Batrachus planifrons Guichenot 1850:81–82, plate 5. Mediterranean Sea at Oran, Algeria.

Batrachus guentheri Bleeker 1863:101. Elmina, Guinea. Lectotype RMNH 2114. Photograph in Boeseman 1963: plate 6, fig. 1.

Results

All the specimens of *Halobatrachus* that we examined are very similar in most respects, having the same fin-ray and vertebral counts: D III, 20–21; A 15–17, usually 16; P 24–25; vertebrae 11 + 19 = 30. They all have two opercular and one subopercular spines. There are no differences in head length (Costa 2004) but there appear to be two poorly defined groups based on eye diameter and interorbital width (Figs. 1–2). The many specimens examined by Costa (2004) from Portugal have relatively small eyes and a wide interorbital width but specimens from West Africa previously reported in the literature and most of our specimens have larger eyes and a narrower interorbital width. The proportions that we find are eye size 5.3–7.9% SL, 5.1–8.0 times in head length and interorbital distance 12.2–16.1% SL in the small-eyed form of *H. didactylus* compared to eye size

7.8–11.1% SL, 3.6–5.1 times in head length and interorbital width 8.8–12.1% SL in the large-eyed form (Table 1).

Range.—The small-eyed *Halobatrachus didactylus* (Fig. 3) is the northernmost of the two forms, recorded from the Kattegat (Nilsson 1832), through the Iberian Peninsula (Costa et al. 2003) to northern Africa, south to Morocco, Mauritania, Gambia, Sierra Leone, and Ghana. The large-eyed form is confined to the coast of Africa with definite records from Sierra Leone, Liberia, and Ghana where it overlaps with the small-eyed *H. didactylus*.

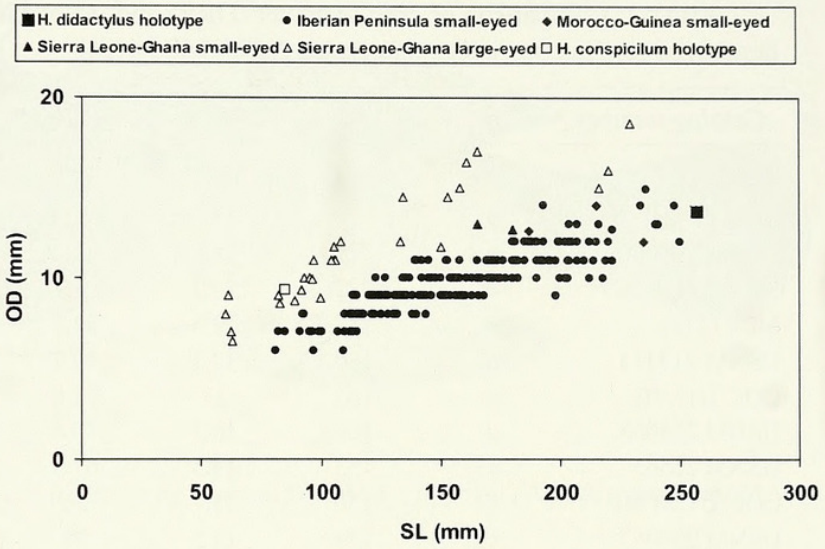

FIGURE 1. Orbit diameter (OD) plotted against standard length (SL) for small-eyed and large-eyed *Halobatrachus didactylus*.

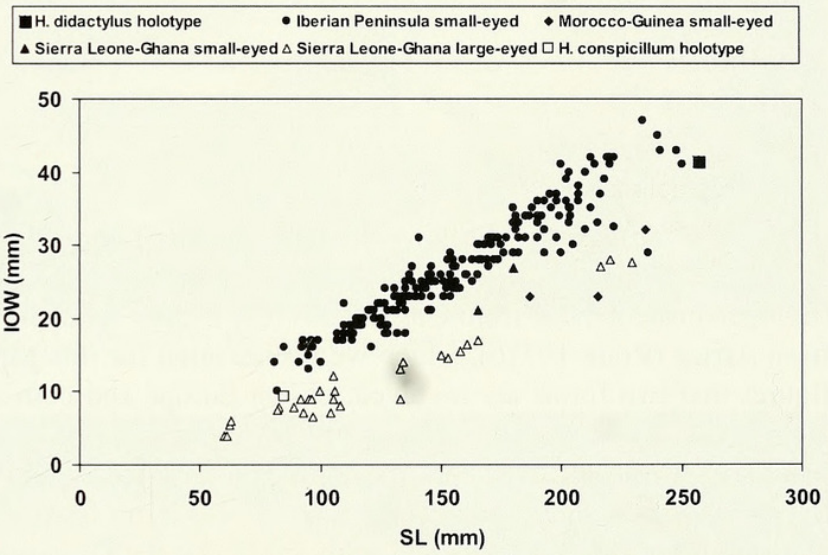

FIGURE 2. Interorbital width (IOW) plotted against standard length (SL) for small-eyed and large-eyed *Halobatrachus didactylus*.

Discussion

Roux (1971a) listed seven synonyms of *H. didactylus*: *H. conspicillum* (Cuvier, 1829), *H. punctatus* (Agassiz, 1831), *H. borealis* (Nilsson, 1832), *H. barbatus* (Valenciennes, 1837), *H. algeriensis* (Guichenot, 1850), *H. planifrons* (Guichenot, 1850), and *H. guentheri* (Bleeker, 1863). Peter Bartsch kindly measured the holotype of *H. didactylus* for us and found that it has a relatively small eye (orbit into head 7.6–7.9) and a wide interorbital width (orbit into interorbital width 3.1) (Fig.4). The types of all the other synonyms except *H. conspicillum* also had a small eye and wide interorbital width, confirming their status as junior synonyms of *H. didactylus*. Peter Bartsch also assisted us by measuring the holotype of *H. conspicillum* and found that it had a larger eye (orbit into head 3.6) and a narrow interorbital width (orbit into interorbital width 0.97) (Fig. 5). If the large-eyed form proves to be a distinct species, *Halobatrachus conspicillum* would be the correct name for it.

There is a general tendency for larger *Halobatrachus* to have smaller eyes and a wider interorbital width than smaller specimens (Table 1), so we were concerned that we might be identifying larger specimens (165–257 mm SL) as the small-eyed *H. didactylus* and smaller specimens (84.7–134 mm SL) as the large-eyed form. We compared a 229-mm specimen with a relatively small eye (8.1% SL) with slightly smaller and larger specimens (222 and 236 mm SL) which have larger eyes (5.5–6.3% SL). Similarly, a 165-mm SL specimen has a wider interorbital width (12.7%

TABLE 1. Comparison of orbit diameter (ORB) and interorbital width (INT) in small-eyed (d) and large-eyed (c) *Halobatrachus didactylus*.

Catalog number	*Sp.*	*SL*	*ORB*	*ORB/SL*	*INT*	*INT/SL*	*INT/ORB*
ZMB 817	d	257	13.7	113	41.5	16.1	3.03
MCZ 22424	d	236	14.9	103.8	29	12.3	1.95
USNM 205060	c	229	18.6	100.8	27.7	12.1	1.49
MCZ 22425	d	222	12.7	97.7	32.4	14.6	2.55
MCZ12787	d	187	12.6	82.3	22.9	12.2	1.82
USNM 217413	d	180	12.7	79.2	26.8	14.9	2.11
COC 1/12/7B	d	165	13	72.6	21	12.7	1.62
USNM 205065	c	161	16.4	70.8	16.4	10.2	1.00
USNM 20563	c	153	14.5	67.3	14.6	9.5	1.01
COC 1/12/8 MR	c	150	11.7	66	15	10	1.28
USNM 205062	c	134	14.5	59	13.9	10.4	0.96
USNM 205064	c	105	11.7	46.2	12.2	11.6	1.04
UF 210854	c	99.4	8.9	43.7	10	10.1	1.12
UF 210854	c	96.3	9.9	42.4	8.9	9.2	0.90
UF 216983	c	91.5	9.3	40.3	8.9	9.7	0.96
UF 216854	c	89.1	8.7	39.2	7.8	8.75	0.90
UF 216854	c	82.7	8.6	36.4	7.9	9.5	0.92
UF 216983	c	82.1	9	36.1	7.4	9	0.82
ZMB 2252	c	84.7	9.3	37.3	9.3	11	1.00

SL) than three slightly smaller specimens, 150–161 mm SL, (9.5–10.0% SL). We were still not completely convinced so we plotted our specimens on graphs of eye size and interorbital width vs. SL together with those from Costa (2004) for a large series from Portugal and scattered specimens from Africa (Roux 1971b), which we re-measured for this paper (Figs. 1–2). It seems from these figures that two forms are involved, one in Europe and both along the coast of Africa. Thus, the question is, do these two morphotypes represent separate species? Based on research with other toadfishes, we would expect to find additional differences between the two forms. It is possible that the differences in interorbital width and eye size result from plasticity and consequent morphological variability, which is evident for this species on the Portuguese coast (Costa et al. 2003). Deeper-dwelling fishes tend to have larger eyes (Rosenblatt 1963), and *Halobatrachus* in northern areas (Arias 1976; Jager 1993; Costa and Costa 2002; Costa 2004) tend to live in shallower waters than in southern areas (Roux 1971b; Diouf 1996) where the large-eyed form seems to be confined.

Most of the illustrations in the literature, and photographs on the web appear to be of the small-eyed form, *H. didactylus*, and not of the large-eyed form. It is fortunate that *H. didactylus* appears to be the common, and probably the only form in Europe, because it is the only eastern Atlantic toadfish for which there is much biological data, on diet (e.g., Cárdenas 1977; Costa et al. 2000), reproductive biology (e.g., Palazón-Fernández et al. 2001; Modesto 2003), parasitism (e.g., Marques et al. 2005a), sound production (Santos et al. 2000), and morphological variation (e.g., Costa et al. 2003; Marques et al. 2005b).

We are unable to come to a firm conclusion at this point so we present our combined data and information on the types of nominal species of *Halobatrachus* so that subsequent investigators with access to additional material from West Africa will have this information available. We suggest that it would be desirable to utilize molecular characters to attempt to solve this problem but we have not been able to obtain the necessary material from West Africa.

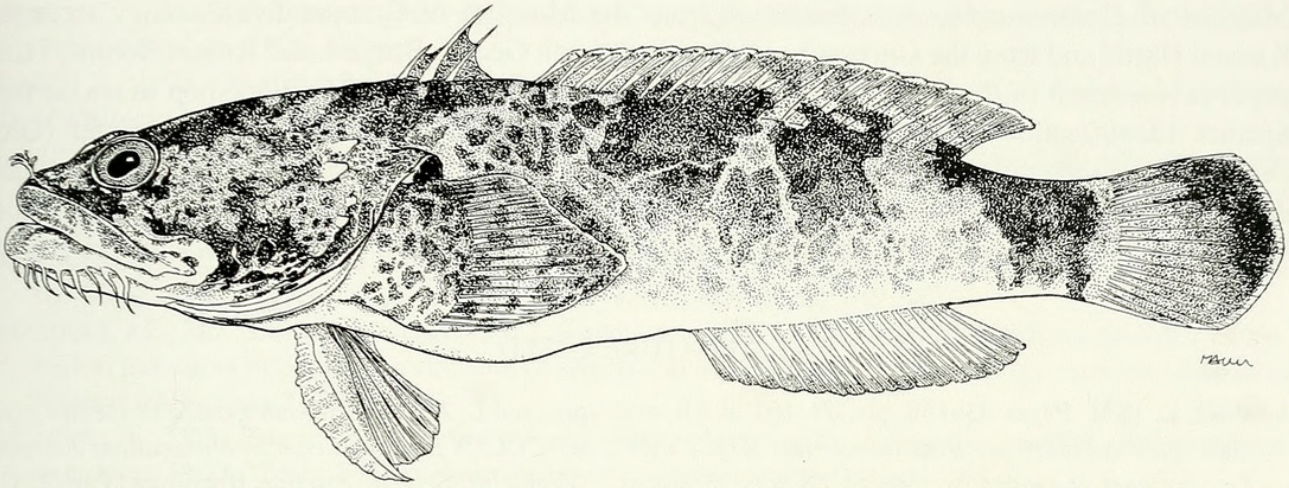

FIGURE 3. Drawing of *Halobatrachus didactylus*. Drawn by Manuela D'Antoni. Copyright FAO, all rights reserved, used with permisssion of FAO.

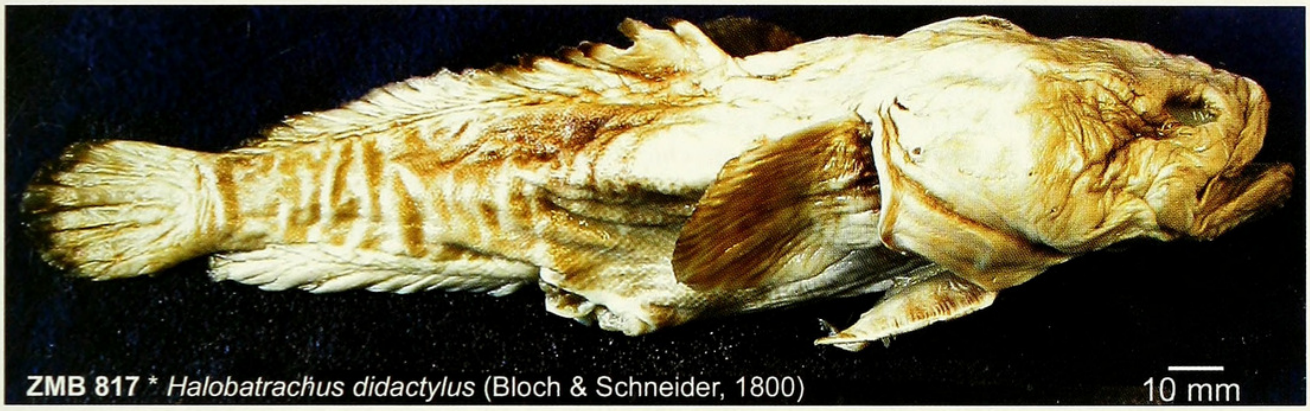

FIGURE 4. Holotype of *Halobatrachus didactylus* (ZMB 817). Photograph by Peter Bartsch.

FIGURE 5. Holotype of *Halobatrachus conspicillum* (ZMB 2252). Photograph by Peter Bartsch.

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Dr. Peter Bartsch (Humboldt University, Berlin) generously photographed and measured the types of *Batrachus didactylus* Bloch and *Batrachus tau* Bloch (= *Halobatrachus conspicillum*). Dr. Sven O. Kullander (Swedish Museum of Natural History) kindly borrowed the type of *Batrachus borealis* Nilsson from the Lund University Zoological Museum, photographed it, sent us a copy of the pertinent pages of Nilsson's 1832 paper, and clarified the type locality of this nominal species.

Material of *Halobatrachus* was borrowed from the Museum of Comparative Zoology through Karsten Hartel and from the University of Florida through George Burgess and Robert Robins. This paper is one result of the participation of the first two authors in the FAO Workshop to revise the Species Identification Sheets for the East Central Atlantic organized by Kent Carpenter (Old Dominion University) and Michel Lamboeuf (FAO, Rome). The drawing of *Halobatrachus didactylus* (Fig. 3) was rendered by Manuela D'Antoni and is used with her permission and that of Michel Lamboeuf. An earlier draft of the manuscript was read by Dr. William N. Eschmeyer.

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