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Macrodon atricauda (Günther, 1880) (Perciformes: Sciaenidae), a valid species from the southwestern Atlantic, with comments on its conservation

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Abstract

The American sciaenid genus *Macrodon* presently consists of only two species, the Atlantic *Macrodon ancylodon* (Bloch & Schneider, 1801), and the Pacific *Macrodon mordax* (Gilbert & Starks, 1904). The two species are distinguished mainly by the number of pored scales on the lateral line (66–78 in *M. ancylodon* vs. 45–55 in *M. mordax*). The present study revalidates a third species, the second from the Atlantic, *Macrodon atricauda* (Günther, 1880), which is genetically, morphologically, and geographically distinct from *M. ancylodon*, occurring between the Brazilian state of Espírito Santo and northern Argentina. It has significant economic importance in the area and thus considerations about its conservation are also presented.

Key words: King weakfish, geographic distribution, revalidation

Introduction

The Sciaenidae is among the World's most economically important fish families, especially in the western Atlantic. With about 78 genera and 282 species, this family is widely distributed in the tropical, subtropical and temperate seas, with some genera inhabiting freshwater habitats (Nelson, 2006).

Until the present study, the New World genus *Macrodon* was believed to contain only two species, the Atlantic *Macrodon ancylodon* (Bloch & Schneider, 1801) and the eastern Pacific *Macrodon mordax* (Gilbert & Starks, 1904). In addition to their distinct geographic ranges – *M. ancylodon* is found between Venezuela and Argentina, and *M. mordax* between Panama and Ecuador, occasionally to Peru (Chirichigno & Cornejo, 2001), in the tropical eastern Pacific – the two species are mainly distinguished by the number of pored scales on the lateral line (66–78 in *M. ancylodon vs.* 45–55 in *M. mordax*), and the posterior nostril, oblong and much larger than the anterior nostril in *M. ancylodon*, slit-like, very small, slightly larger than the anterior in *M. mordax* (Meek & Hildebrand, 1925; Chao, 1995; Velasco, 2002).

Along the Brazilian coast, *Macrodon ancylodon* (Block & Schneider 1801) is one of the most important fishes of the area in economic terms (FIG. 1). Recent studies using 16S ribosomal RNA and cytochrome b, both mitochondrial genes, have revealed two reciprocally monophyletic clades denominated tropical and subtropical, which show nucleotide divergences reaching 4.3% for the cytochrome b and 2.6% for the 16S RNA. These differences are of the same magnitude as the values detected for intrageneric comparisons in Perciformes (Santos *et al.*, 2003). Furthermore, AMOVA, using cytochrome b, showed that 93.09% ($P < 0.05$) of all variance is partitioned between the tropical and subtropical clades and fixation index (Fst > 0.9) indicates that no gene flow exist between the groups, suggesting the existence of two distinct species located to the north and south of a zone somewhere between 12º and 20º S (Santos *et al.*, 2006). These authors argue that the two species are adapted to distinct patterns of water temperature and currents, which have reinforced their genetic isolation.

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Despite the clear genetic differences, no morphometric differences were previously detected between the two populations. In this paper, we describe morphological differences and indicate that the southern form had previously been described as *Ancylodon atricauda* (Günther 1880), which is revalidated. This is the first time that the analysis of genetic data has lead to the revalidation of the taxonomic status of a sciaenid species native to Brazilian waters.

Material and methods

The main sample consists of 120 recently-collected specimens from three locations from the Brazilian coast: 50 from Pará, 40 from São Paulo, and 30 from Santa Catarina, obtained from the artisanal and commercial fisheries during biological surveys conducted by the authors. Additional, preserved specimens (listed below) include the specimen used by Günther (1880) to describe *Macrodon atricauda*. This revalidation of *Macrodon atricauda* (Günther, 1880) is based on the holotype, and 70 fresh and 39 preserved specimens from southern Brazil.

All specimens were measured with a digital caliper to the nearest tenth of a millimeter, following Santos *et al* (2006). Fin and scale counts follow Chao (1978). For practical purposes, we considered the dorsal fin as one, not two, so the spine counts are not separated. The height of the upper front canines was measured in a straight line from tip to base, rather than along the curvature. The teeth were extracted carefully and those damaged (2 from the northern and 5 from the southern population) were excluded from the analysis.

The type material and other preserved specimens were examined at the following institutions:

BMNH Natural History Museum, London.

Specimen: Holotype, BMNH 1879.5.14.258 (1: 94.2 mm SL), Rio de La Plata, Argentina. Label 1: *Ancylodon atricauda* no. 406, Stat.321, Rio de La Plata – Challenger, y9.5.111.258. Label 2: 32.495 *Macrodon ancylodon*.

MZUSP Museu de Zoologia da Universidade de São Paulo.

Macrodon atricauda:

MZUSP 69648 (2: 175.2 mm SL and 146.1 mm SL), Rio Grande do Sul, oceanographic research vessel W. Besnard, Station 1853 (30º14'S, 50º09'W), coll. G. Q. Benvegnú, 05 August 1972, 21 m. MZUSP 69640 (2: 193.4 mm SL and 174.8 mm SL), Rio Grande do Sul, oceanographic research vessel W. Besnard, Station 1886 (33º45'S, 53º16'W), coll. G. Q. Benvegnú, 16 August 1972, 16 m. MZUSP 69167 (1: 124.4 mm SL), Perequê, Guarujá, São Paulo, Brazil, coll. A. Carvalho-Filho, July 1981. MZUSP 69594 (4: 70.2 – 102.3 mm SL), Rio Grande do Sul, oceanographic research vessel W. Besnard, Station 1887 (33º20'S, 52º46'W), coll. G. Q. Benvegnú, 16 August 1972, 16 m. MZUSP 69596 (6: 57.3 – 126.2 mm SL) Rio Grande do Sul, oceanographic research vessel W. Besnard, Station 1912 (31º27'S, 51º04'W), coll. G. Q. Benvegnú, 22 August 1972, 21 m. MZUSP 69639 (5: 145.3 – 235.2 mm SL) Uruguay, oceanographic research vessel W. Besnard, Station 1915 (35º00'S, 54º50'W), coll. G. Q. Benvegnú, 29 October 1972, 24 m. MZUSP 69642 (4: 92.1 – 165.4 mm SL) Rio Grande do Sul, oceanographic research vessel W. Besnard, Station 1895 (32º28'S, 52º15'W), coll. G. Q. Benvegnú, 18 August 1972, 14 m. MZUSP 69655 (12: 98.3 – 132.4 mm SL), Baía de Jaguaré, Cananéia, São Paulo, Brazil, coll. A. E. Vazzoler, 16 April 1975.

Macrodon ancylodon:

MZUSP 69169 (1: 142.4 mm SL), Alegre, 15 km NE of Marapanim, Pará, Brazil, 9–12 September 1965. MZUSP 69606 (3: 223.2 – 233.0 mm SL), Northern Brazil, vessel Toko Maru (04º18'S, 50º51'W), coll. M. Fumya, 25 April, 1957. MZUSP 77639 (2: 15.1 mm SL and 27.3 mm SL), Tupinambá, Marajó Island, Pará, Brazil, 11 June 1984, coll. R.B. Barthem. MZUSP 77674 (1: 43 mm) Tupinambá, Marajó Island, Pará, Brazil, 20 July 1984, coll. R.B. Barthem.

ZUEC Museu de História Natural da Universidade Estadual de Campinas.

Macrodon atricauda:

ZUEC 5028 (3: 152.3, 143.0 and 142.9 mm SL), Enseada da Fortaleza, Ubatuba, São Paulo, Brazil, 23 November 2000, coll. J. Oliveira & M.L. Oliveira.

Results

The morphometric data are rather homogeneous across sites (Table 1). As in Santos *et al.* (2006), neither multi- nor univariate analyses of these data revealed any clear pattern of differentiation among geographical regions (data not presented).

TABLE 1. Selected morphometric characters of the Atlantic *Macrodon* collected during the present study.

	Mean (range) of specimens from:		
Character	Pará (n=50)	São Paulo (n=40)	Santa Catarina (n=30)
Head as % of SL	31.6 (30.3–33.6)	29.8 (27.8–30.7)	29.0 (27.5–30.9)
Snout as % of SL	6.2 (5.6–7.6)	6.3 (5.5–6.9)	5.8 (5.0–6.3)
Eye as % of SL	6.2 (5.3–6.7)	5.7 (4.9–6.7)	5.4 (4.7–6.3)
Snout as % of Head	6.2 (5.6–7.2)	6.3 (5.5–6.8)	5.8 (5.0–6.3)
Eye as % of Head	19.4 (16.8–20.8)	19.1 (16.5–23.1)	18.8 (16.5–21.0)
Eye as % of Snout	99.0 (82.3–112.2)	90.5 (75.1–100.2)	94.5 (80.0–107.1)

Considering that the genetic differentiation between the northern and southern populations is high (Santos *et al.*, 2003; Santos *et al.*, 2006), measurements were set aside and the more basic dorsal and anal fins rays and lateral lines pored scales counts were re-analyzed. Also the fish dentition, especially the large arrow-shaped front canines, seemed to differ, so they were measured and compared.

Published data for western Atlantic *Macrodon*.

We obtained the following meristic data (Table 2) from the literature: dorsal fin with X or XI spines and 27 to 30 soft rays; anal fin, II spines and 8 to 10 soft rays. There are virtually no data on the pectoral fins and few scales counts, which are probably due to methodological difficulties, since the scales are extremely small, and generally overlap without any clear pattern. A few authors nevertheless present counts of the pored lateral line scales and transversal scales.

We consider only six of the literature records of pored scales or scale rows to be original data:

1. While Jordan & Evermann's (1898) count of pored scales (75) differs considerably from the others available for specimens from southern Brazil, we presume that their count included the scales along the caudal fin (numbering 7 to 9 – see Table 2). When excluding these scales, the count is much closer to the values recorded in other studies, and in our own (49–63). On the other hand, these authors also compared their specimen with individuals from Panama, with which it "agrees in every respect. If any difference exists it must be sought in companion of specimens in good condition". This lead us to believe that specimens were either misidentified or of too poor condition for reliable comparisons. Ribeiro (1915) and Nomura (1984) apparently adopted the scale counts of Jordan & Evermann (1898) in their studies.

2. Schultz (1949) counted 120 rows of scales above the lateral line in a Venezuelan specimen.

3. Fischer *et al.* (2004) counted 68 to 73 lateral line pored scales between the operculum and the end of tail. These values were confirmed by the authors by personal communication. As we counted 7 to 9 pored scales from the hypural plate to the end of the caudal fin, their counts would be within our range (49–63 pored scales, see Table 2).

4. Cervigón (1993) counted only the transversal rows of scales above the lateral line to the base of the caudal fin of 17 specimens. His values are consistent with those of Schultz (1949).

5. Carvalho-Filho (1999) counted only the pored scales on the lateral line of 12 specimens, with values ranging from 49 to 53. These values are consistent with our data from southern Brazil.

6. Starks (1913), based on 3 specimens from Para, counted about 100 oblique series of scales above the lateral line in *Sagenichthys ancylodon* (not 85) and half as many scales on the lateral line (not 75), but this last remark is not corroborated by our data and somewhat vague.

TABLE 2. Meristic data available for Atlantic *Macrodon* species.

Reference	Collecting locality[1]	Dorsal Fin Elements	Anal Fin Elements	Pored Scales	Scale Rows
Northern form (*ancylodon*)					
Günther,1860	Suriname	X,28–29	I, 9–10	----	----
Starks, 1913	Pará	-------	------	?	± 100
Schultz, 1949	Venezuela	XI, 28	II, 9	-----	120
Cervigón,1993	Venezuela	XI,28-30	II, 9	----	112–120
Present Study[3]	Pará	XI, 27–29	II, 8–9	66–78	108–120
Southern form (*atricauda*)					
Günther, 1880	Mar del Plata	VIII,31	12	----	----
Jordan & Evermann,1898	RS	X, 27–28	II, 10	75	85
Ribeiro, 1915	NR	X, 27–28	II, 10	75	85
Vazzoler,1970	São Paulo	X, 28	II, 10	-----	----
Jardim, 1973	RS, SC	X, 28	II, 10	----	----
Nomura,1984	NR	XI, 27–28	II, 8–9	75	85
Menezes & Figueiredo, 1980	NR	XI,27–29	II, 8–9	----	----
Carvalho-Filho, 1999	São Paulo	XI, 27–29	II, 8–9	± 50	----
Chao, 2002	NR	XI, 27–29	II, 8–9	----	----
Fischer, 2004	RS	XI, 27–29	II, 8–9	49–63[2]	----
Present Study[3]	São Paulo	XI, 27–28	II, 8–10	49–63	77–87
Present Study[3]	Santa Catarina	XI, 27–29	II, 8–10	49–61	77–87

[1]Pará = Northern Brazil; RS = Rio Grande do Sul (southern Brazil); SC = Santa Catarina (southern Brazil); NR = Not Reported.

[2]See # 3, of the Published data for western Atlantic *Macrodon*

[3] The branched last ray of the dorsal and anal fins was counted as one.

Günther´s specimen was examined by Leopoldo Cavaleri Gerhardinger on May 7th of 2007 (FIG. 1). The specimen jar had two labels: Label 1: " *Ancylodon atricauda* no. 406 Stat.32, Rio de La Plata – Challenger y9.5.111.258"; and Label 2: "32.495 *Macrodon ancylodon*".

The second label refers to the correct name, prior to this study. Meristic data were obtained, but Dr. Gerhardinger made the following remarks on the condition of the specimen, which is almost 130 years old: "The fins are somewhat damaged and under the effect of a crust, the same also true for the lateral line pored scales". He recorded the following data: total length = 115.5 mm, standard length = 94.2 mm, dorsal fin 10 (or possibly 11) spines and 27 to 29 soft rays. Bad conditions of the specimen precludes precise counts here, although it would be possible to obtain exact values using X-ray photography. This same problem limited counts of the number of pored lateral line scales to between 55 and 60.

New data.

In the present study, standard length of the *Macrodon* fresh specimens ranged from 89 mm to 325 mm in the sample from Pará (n = 50), 71 to 305 mm in São Paulo (n = 40), and 262 to 343 mm in Santa Catarina (n =

30). Meristic data are presented in tables 2 and 3. As the values obtained from the preserved museum specimens were consistent with those recorded from these new specimens, they are not presented here.

***Macrodon atricauda* (Günther, 1880).**
Pescada-Foguete (Pt); Pescadilla Real (Sp); Southern King Weakfish (En)
(Figures 1 to 4)

Ancylodon atricauda Günther, 1880.
Sagenichthys ancylodon Berg, 1895; Ihering, 1897; Jordan & Evermann, 1898; Ribeiro, 1915; Devincenzi, 1924.
Perca mollis Larrañaga, 1923; in Divicenzi, 1925 (synonymized with *Sagenichthys ancylodon*).
Perca vigintoctoradiata Larrañaga, 1923; in Divicenzi, 1925 (synonymized with *Sagenichthys ancylodon*).

FIGURE 1. *Macrodon atricauda*, Holotype, BMNH 1879.5.14.258 (1: 94.2 mm SL), Rio de La Plata, Argentina.

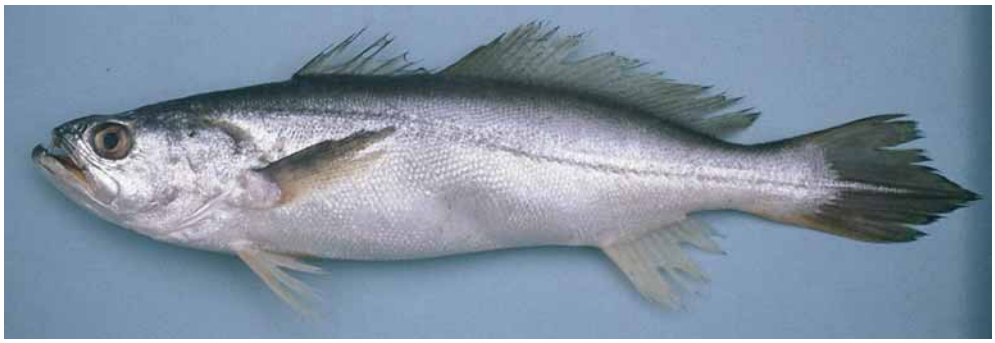

FIGURE 2. *M. atricauda*, 309 mm SL, recently collected from Guarujá, São Paulo.

FIGURE 3. Same-size specimens of *M. atricauda* (A) and *M. ancylodon* (B).

FIGURE 4. Same-size specimens of *M. atricauda* (A) *and M. ancylodon* (B), showing the front canines.

Holotype: BMNH 1879.5.14.258 (1, 94.2 mm SL), Mouth of the Rio de la Plata, Argentina, Station 321, 13 fathoms (Günther, 1880). Jar with two labels: label 1: *Ancylodon atricauda* no. 406, Stat.321, Rio de La Plata – Challenger, y9.5.111.258; label 2: 32.495, *Macrodon ancylodon*.

Diagnosis: a species of *Macrodon* as defined by Chao (1978) and Sasaki (1989), with the following character set: lateral line pored scales 49 to 63 (compared to 66–78 in *M. ancylodon*)*;* anal fin soft rays 9 or 10, rarely 8 (usually 8, occasionally 9 in *M. ancylodon*); dorsal fin soft rays 27 or 28, rarely 29 (28–29, rarely 27 in *M. ancylodon*); pectoral fin rays 16 or 17 (15–16 in *M. ancylodon*); largest front canines 2.5 to 3.2 in eye length, proportionally smaller and thinner when compared to *M. ancylodon* (1.8 to 2.2) .

Description (based on the holotype, 39 other museum specimens and the present sample of 70 fresh individuals): Dorsal fin XI, 27–29 (rarely 29); anal fin II, 8–10 (rarely 8); pectoral fins 16 or 17; pelvic fin I,5; lateral line pored scales 49–63; 9–12 gill rakers on upper limb of first arch (2 or 3) and on lower limb (7–9).

Body elongate, moderately compressed. Mouth large, strongly oblique, the lower jaw projecting; maxilla extending beyond eye; teeth very sharp, arrow-headed, set in narrow ridges in both jaws; upper jaw with a pair of large, elongated, fang-like, narrow, canines at tip, and an outer row of sharp teeth; lower jaws overlaying upper jaw with several canines at the tip, larger than the other mandibular teeth, but much smaller than the upper canines, and also with a widely spaced inner row of sharp teeth, the middle ones usually largest. Largest upper canine contained 2.5 to 3.2 (modally 2.7–2.9) times in eye horizontal diameter (*vs.* 1.8 to 2.2 – modally 1.8–2.0 in *M. ancylodon*), see Figure 6; this proportion does not vary with growth for specimens between 70 and 250 mm SL. Scales small, cycloid, often overlapping; soft dorsal fin and anal fin covered with small scales; lateral line in a smooth arch from upper operculum to below soft dorsal fin and straight from there

almost to the end of the caudal fin. Caudal fin with the central rays longer, more pointed in young, and rhombic in large adults.

Color silvery-gray to golden yellow, darker on back, paler ventrally, with an iridescent greenish cast on the sides of the body in very fresh specimens; pectoral fin with a dusky elongate blotch on its upper distal border, more evident in the young, and a dusky spot on its upper base; caudal fin yellowish to grayish, dusky to blackish distally; dorsal fin dusky-yellowish, anal and pelvic fin pale yellow to white.

Largest specimen analyzed: 343.0 mm SL, 420.3 mm TL.

Largest specimen reported in literature: 460 mm TL (Carneiro & Castro, 2005).

Comparisons: The most obvious difference between *M. ancylodon* and *M. atricauda* is the upper jaw canine size, which is larger in *M. ancylodon* (FIG. 6). This concurs with Günther's (1880) original description, that "the canine teeth are comparatively smaller than in *Ancylodon jaculidens* [= *Macrodon ancylodon*]".

While there is some overlap between *M. ancylodon* and *M. atricauda* in the number of soft rays, there are also strong regional divergences, and scale counts and canine length are quite distinct. Individuals from the northern population have more soft rays in the dorsal fin, and fewer in the anal and pectoral fins. In addition, whereas in the northern population all individuals had at least 66 pored lateral line scales, none of the specimens from the southern population had more than 63 (Table 3).

TABLE 3. Counts & Frequency.

	Frequency by Location		
Number of dorsal fin rays	Pará	São Paulo	Santa Catarina
27	3	6	5
28	15	23	24
29	12	1	1
Number of anal fin rays	Pará	São Paulo	Santa Catarina
8	27	1	1
9	3	8	20
10	0	21	9
Number of pectoral fin rays	Pará	São Paulo	Santa Catarina
15	16	0	0
16	14	8	6
17	0	22	24
Number of pored L.L. scales	Pará	São Paulo	Santa Catarina
49–55	0	16	14
56–63	0	14	16
64–65	0	0	0
66–71	17	0	0
72–78	13	0	0

Overall, then, these differences in the morphological features of the two populations clearly support their classification as distinct, albeit closely-related species, as suggested by the genetic data.

Distribution: *M. atricauda* occurs between the Brazilian state of Espírito Santo and northern Argentina. The closely related *M. ancylodon* occurs between Venezuela and the Brazilian state of Bahia (FIG. 5).

Conservation: At first glance, the fish fauna of the western Atlantic is relatively homogeneous, although a growing number of recent studies indicate that the southwestern Atlantic is home to a substantial number of endemic species. Over the past years several new species were described or revalidated, while at least another 40 species have been identified as unknown and are being described (e.g. Figueiredo *et al.*, 2002; Rocha,

2004; Bernardes *et al.*, 2005; Melo, 2007; Floeter *et al.*, 2008; Mincarone & Anderson, 2008; Sazima *et al.*, 2008; Carvalho-Filho & Floeter, in preparation).

FIGURE 5. Occurrence areas: Yellow, *M. ancylodon*; Green, *M. atricauda.*

The revalidation of *M. atricauda* represents one more study where genetics aids taxonomy. Both Atlantic species are important fishery resources. The main practical difference between them is the fact that the distribution of *M. atricauda* coincides with the most densely-populated stretch of coastline in South America, whereas *M. ancylodon* ranges over a much wider and sparsely populated area, especially in northern Brazil and the Guyanas. In addition, while *M. atricauda* is heavily exploited throughout its range, *M. ancylodon* is commercially important mainly in Venezuela (Cervigón, 1993) and the Brazilian states of Amapá, Maranhão and Pará (Fernandes, 1981/82; Haimovici et al., 1996; Haimovici, 1998; Piorsky *et al.*, 2004).

While there are few available data on the Brazilian population of *M. ancylodon*, *M. atricauda* is under intense pressure. Whereas 8,000 tons of this species were landed in 1986 (Carneiro and Castro, 2005, as *M. ancylodon*), the catch decreased to 4,000 tons in 2002, indicating a decline in commercial stocks of at least 50% over this 16-year period. Demersal resource stocks evaluation in southern Brazil obtained from 1975 to 1994 show a decreasing total biomass of *M. atricauda* since the beginning of exploitation and that the resource is heavily exploited in that region (Haimovici, 1998, as *M. ancylodon*). Similarly, stock evaluations of *M. ancylodon* based in recruitment yield model-based and Thompson and Bell's predictive models in the period from 1997 to 2000, in Pará and Maranhão, Brazil's north coast, indicate that the species is over-exploited or in the maximum limit of exploitation (Ikeda *et al.*, 2003).

Ultimately, an important question to be considered is whether and to what extent the presence of two different species of *Macrodon* in the southwestern Atlantic should redefine conservation and management strategies for these populations, especially considering that one species is clearly under much greater pressure than the other. Despite the relative morphological similarity between them, those species might have accumulated differences in physiological and behavioral features due to adaptations to local environmental characteristics, and should be managed as distinct units.

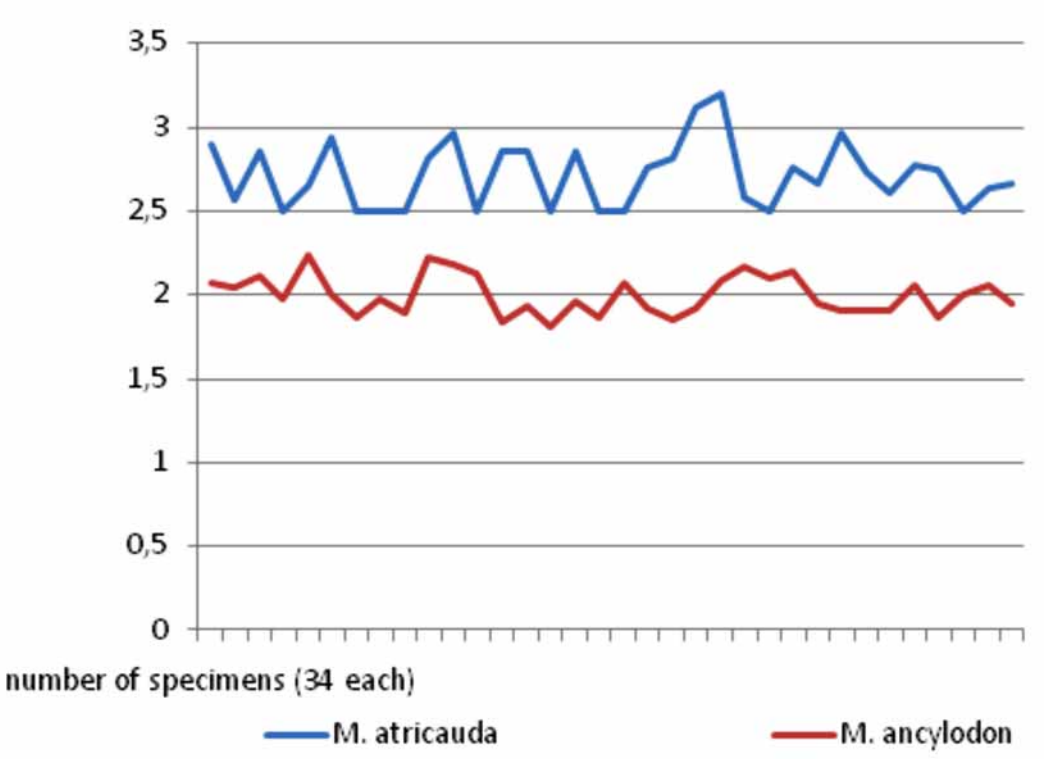

FIGURE 6. Number of times the largest front canine is contained in eye horizontal diameter.

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