Updating taxonomic and biometric knowledge of *Enchelyopus cimbrius* (Gadiformes, Gaidropsaridae) through morphology and DNA barcoding

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Abstract

A taxonomic characterisation of *Enchelyopus cimbrius* (Gadiformes, Gaidropsaridae) is presented on the basis of eleven specimens from the North Atlantic. Identification was carried out by integrative taxonomy, combining the examination of morphological and molecular characters. The former are consistent with previous descriptions, but new biometric and meristic data for the species are provided, showing ontogenetic changes with respect to post-larvae-pelagic juveniles. Length-weight relationships of 44 specimens showed isometric growth, while the length-length relationships of eight body parts of the species showed differential allometric growth. The molecular analysis resulted in the addition of 11 new sequences of cytochrome c oxidase subunit 1 (*COI*) to the molecular repositories. DNA barcoding supports the morphological identification of *Enchelyopus cimbrius* specimens and confirms the amphi-Atlantic distribution of the species. Updating the taxonomic data can be useful to confirm the current status or to identify divergences, and also to better characterise and delimit each species, contributing to a better understanding of intraspecific variability, both morphological and molecular.

Keywords *COI*, rocklings, barcoding, biogeography, mitochondrial DNA, allometric growth

Introduction

The family Gaidropsaridae Jordan & Evermann, 1898, as currently recognized, contains three genera: *Gaidropsarus* Rafinesque, 1810, *Ciliata* Couch, 1832, and *Enchelyopus* Bloch & Schneider 1801 and 17 species (Carnevale and Harzhauser 2013). Fishes of this family, commonly known as rocklings, are characterized by an elongated and relatively slender body, the presence of three barely separated dorsal fins (the first with a single thickened unsegmented ray; the second with small, unsegmented rays in a fleshy ridge rising in a groove; and the third with segmented rays in an elongated fin) and two to four prominent individual barbels on the snout, in addition to the one at the tip of the lower jaw (Nelson et al. 2016). The genus *Enchelyopus* is a monotypic genus containing a single species, the fourbeard rockling *Enchelyopus cimbrius* (Linnaeus, 1766). It is a demersal species found in the North Atlantic and adjacent Arctic, on muddy and sandy bottoms at depths from 20 to 900 m (Moore et al. 2003). The distribution extends from the Gulf of Mexico and Florida to Newfoundland and southwestern Greenland in the western Atlantic, around Iceland, and from the Barents Sea to the Bay of Biscay in the eastern Atlantic, with only one record from Mauritania (Cohen 1990; Mecklenburg et al. 2018). According to the Red List of the International Union for Conservation of Nature (IUCN), *E. cimbrius* is considered globally to be of least concern (Iwamoto et al., 2015).

The species has a carnivorous diet that varies depending on age and location. It has been reported to consist primarily of bivalve molluscs, polychaetes, crustaceans (amphipods, decapods, copepods, mysids and cumaceans) and fishes (Langton and Bowman 1980; Deree 1999)

According to Cohen (1990) the growth rate is relatively slow; the maximum age recorded in the Baltic Sea is 13 years and 37.8 cm of total length (TL) (Lampart-Kałużnicka and Heese 2015).

The spawning season is apparently protracted, lasting from January to August or even to September/October, in waters less than 140 m deep (Cohen 1990). First maturity is reached at three years of age (at about 15 cm total length) and females spawn between 5,000 and 45,000 planktonic eggs depending on their body size (Cohen 1990).

Molecular taxonomy has been successfully applied to the systematic study of fishes in conjunction with traditional morphological analysis. The use of mitochondrial cytochrome c oxidase subunit I (*COI*) in *E. cimbrius* for taxonomic or phylogenetic purposes has been described previously (Von der Heyden and Matthee 2008; McCusker et al. 2012; Knebelsberger et al. 2014).

The aims of this research are: (i) to combine the use of morphological data and the *COI* molecular marker to analyse specimens caught mainly in the eastern North Atlantic for taxonomic purposes, and (ii) to establish length-weight and length-length relationships for the species. The results are discussed in the context of the data available in the scientific literature.

Material and Methods

Sampling data and morphological analysis

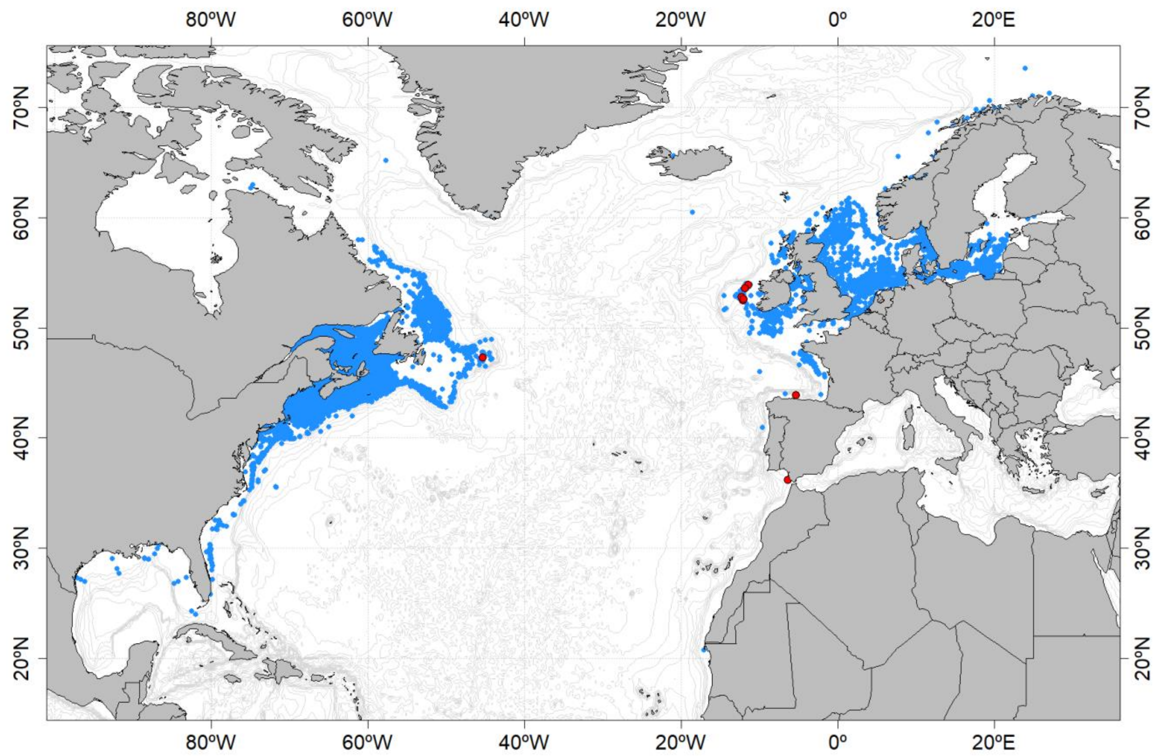

Fig. 1 Distribution of *Enchelyopus cimbrius* (light blue dots) and sampling locations of the analysed specimens in the current study (red dots). The distribution data were downloaded from Global Biodiversity Information Facility (GBIF, 2024) and Ocean Biogeographic Information System (OBIS, 2024).

Eleven specimens of *E. cimbrius* were caught by trawling during several scientific research surveys carried out in different areas of the North Atlantic Ocean: i) Flemish Cap 2016, carried out in the Flemish Cap (Northwest Atlantic); ii) PORCUPINE 2023, conducted off the west coast of Ireland, and iii) Demersales2022, in the Cantabrian Sea and Galician waters (north and northwestern Spain), and iv) ARSA 2019 in the Gulf of Cadiz (southern Spain) (Fig. 1).

The specimens were preserved frozen on board. Once in the laboratory, they were defrosted at room temperature, thoroughly examined, photographed and deposited in the fish collection of the Universidade de Santiago de Compostela, Museo de Historia Natural Luis

Iglesias, in Galicia, Spain, under the reference numbers from MHN USC 25221-1 to MHN USC 25221-11. Species identification was carried out following Cohen (1990), and morphological measurements were recorded to the nearest mm using a digital caliper. Vertebral counts were obtained from radiographs taken by a mammography computed radiography equipment (Fujifilm Capsula XL II, Japan- using exposure factors of 44 kVp x 35 mAs) and do not include the terminal ural element. Standard length (SL) and head length (HL) were used throughout.

The total length-weight relationship (TL-W, power relationship) (n=44) was explored using data from specimens captured during scientific surveys on Porcupine Bank between 2001 and 2023, and the allometric growth of each body measurement (n=11) for the 2023 specimens. Eight body characters were used to analyse the allometric growth: Interorbital length (IO), eye diameter (ED), pelvic fin length (VL), head length (HL), first dorsal height (D1H), pectoral fin length (PL), body depth (BD) and caudal peduncle depth (CPD). Models were fitted using linear regression after log-transformation all morphometric data according to the equation: $Y = a \times X^b$, where 'Y' represents TL or the morphological parameter; 'X' represents W o TL for the TL-W relationship and the allometric growth, respectively; 'a' was the intercept and 'b' was the growth coefficient (Lleonart et al. 2000; Froese 2006; Karachle and Stergiou 2012). Based on the b value, growth was classified as hypoallometric (negative allometric growth; b significantly >3 for TL-W relationship and > 1 for allometric growth), isometric (b not different from 3 for TL-W relationship and 1 for allometric growth) or hyperallometric (positive allometric growth; b significantly < 3 for TL-W relationship and < 1 for allometric growth) (Lleonart et al. 2000; Froese 2006). All relationships were tested by examining whether the slope estimates for 3 (TL-W relationship) or 1 (algometric growth) fell within the 95% confidence interval.

Molecular analysis

DNA was extracted from muscle, using the E.Z.N.A. Tissue DNA Kit (Omega BIO-TEK, Norcross, GA, USA) following to the manufacturer's instructions, with a single 200 µL elution step. The 5´end of *COI* gene was amplified using 2 µL of template DNA, the universal primer cocktail for fish DNA barcoding C_FishF1t1-C_FishR1t1 (Ivanova et al. 2007), and the Phire Green Hot Start II PCR Master Mix (Thermo Scientific, Waltham, MA, USA), in a final volume of 20 µL. The PCR cycling profile consisted of 30 s at 98 ºC, followed by 35 cycles at 98 ºC for 5 s, 52 ºC for 10 s and 72 ºC for 15 s, 72 ºC for 1 min and cooling to 12 ºC. The PCR products were purified by treatment with ExoSAP-IT, subjected to sequencing reactions using the BigDye v3.1 cycle sequencing kit. The sequencing was performed in both directions using the M13F (-21) and M13R (-27) primers (Messing 1983), using a SeqStudio Genetic Analyser (Applied Biosystems, Foster City, CA, USA) at the Centro de Apoyo Científico y Tecnológico a la Investigación of the Universidade de Vigo (CACTI) facilities. Sequence quality was verified using MEGA v11 (Tamura et al. 2021) and, for each individual, the direct and reverse sequences were assembled into a consensus sequence.

The DNA sequence data, specimen photographs and other metadata have been deposited in the Barcode of Life Database (BOLD Systems; www.boldsystems.org) as part of the projects entitled "Fishes of the Porcupine Bank" (code PORCU), with process IDs PORCU029-24 to PORCU36-24, "Fishes of the Western Atlantic Ocean" (code FIWA), with process ID FIWA020-24 and "Unusual Atlantic Fishes" (code UNAFI) with process IDs UNAFI 011-24 and UNAFI 012-24. The barcode sequences have also been deposited in GenBank (https://www.ncbi.nlm.nih.gov/genbank/) under accession numbers PP131287-PP131297.

The *COI* data were utilised for two purposes: (a) double-check the morphological identification of voucher specimens through DNA barcoding and (b) to evaluate potential genetic structure among individuals from different sampling sites. To achieve this, a Median Joining Network (Bandelt et al. 1999) was constructed using PopART 1.7 (Leigh and Bryant 2015), with ε = 0.

The sequences used to elaboration of the haplotype network, including those contributed by the present research, were obtained from the BOLD database, selecting those with a length of more than 600 nucleotides. The set of 51 sequences was collapsed into 12 haplotypes using FaBox 1.61 (Vilesen, 2007).

Results

Taxonomic account

Enchelyopus cimbrius (Linnaeus, 1766) Fig. 2 and 3

Gadus cimbrius Linnaeus [C.] (ex Strussenfelt) 1766: 440. Bigelow and Schroeder (1953): 234-238 (description); Cohen and Russo (1979): description; Demir et al. (1985); Cohen (1990): description; Deree (1999): feeding, age and growth; Lampart-Kałużnicka and Heese (2015): biology; Iwamoto and Cohen (2016): keys.

Material examined

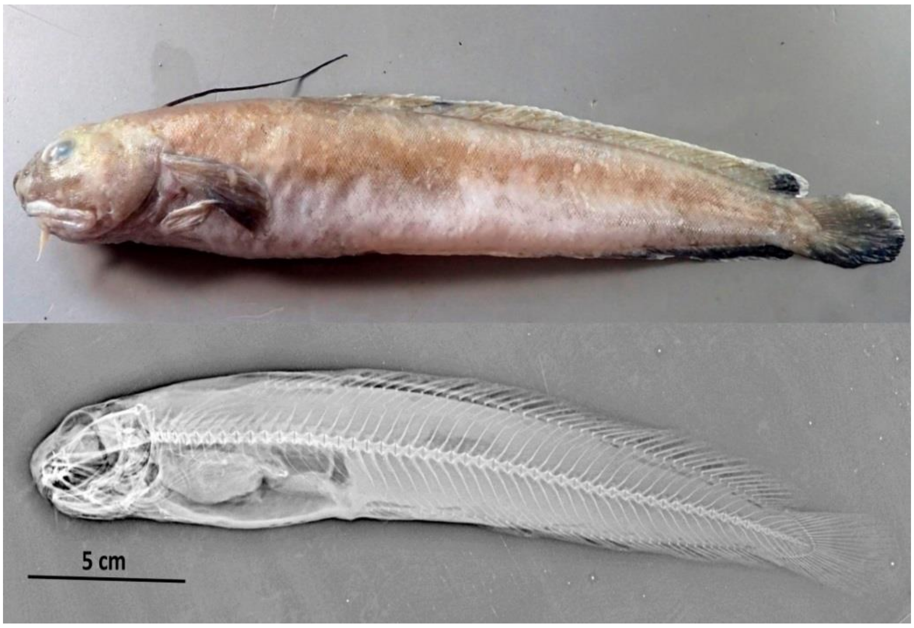

Fig. 2 *Enchelyopus cimbrius* MHN USC 25221-5, 281.5 mm TL (top) and the corresponding radiograph of the specimen (below).

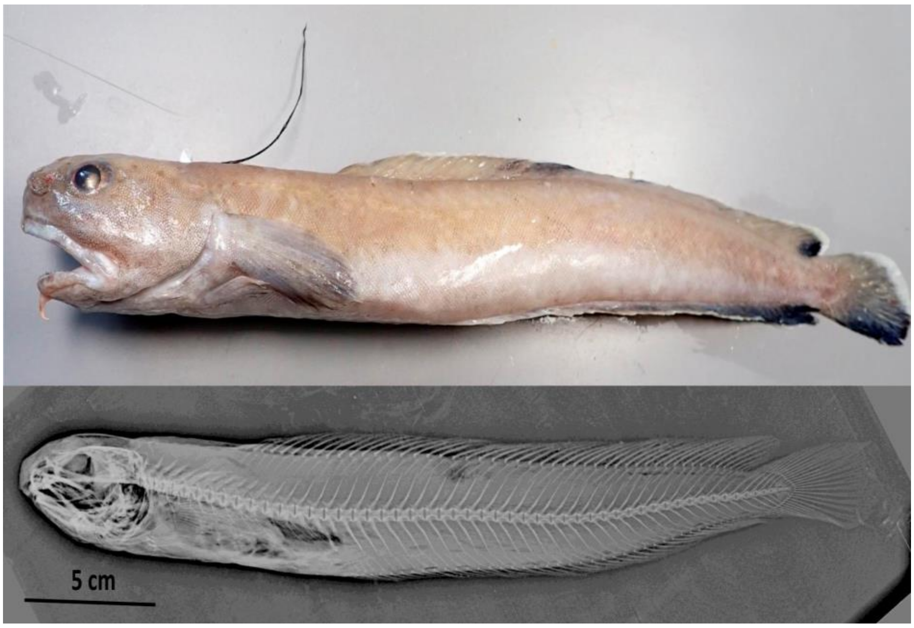

Fig. 3 *Enchelyopus cimbrius* MHN USC 25221-10, 325.1 mm TL (top) and the corresponding radiograph of the specimen (below).

Eleven specimens were caught in the North Atlantic, one specimen from the western and ten from the eastern North Atlantic (Fig. 1): MHN USC 25221-1, Cantabrian Sea, 245.3 mm TL, 10 October 2022, 43.873 ºN, 5.379 ºW, 300 m depth, 11.6 ºC, salinity (S)=35.5; MHN USC

25221-2, 211.5 mm TL, 5 July 2016; 47.261ºN, 45.294ºW, 261 m depth; MHN USC 25221-3, 81 mm TL, 24 February 2019; 36.198 ºN, 6.396 ºW, 294 m depth, 14.7 ºC, S=36.5; MHN USC 25221-4, Porcupine Bank, 234.7 mm TL, 26 September 2023; 52.781 ºN, 12.293 ºW, 344 m depth, 11.3 ºC, S=35.5; MHN USC 25221-5, Porcupine Bank, 281.5 mm TL (Fig. 2), 27 September 2023, 53.571 ºN, 11.841 ºW, 270 m depth, 11.7 ºC, S=35.5; MHN USC 25221-6, Porcupine Bank, 314.2 mm TL, 26 September 2023, 52.781 ºN, 12.293 ºW, 344 m depth, 11.3 ºC, S=35.5; MHN USC 25221-7, Porcupine Bank, 281.7 mm TL, 26 September 2023, 52.467 ºN, 12.080 ºW; 327 m depth, 11.3 ºC, 35.5; MHN USC 25221-8, Porcupine Bank, 317.3 mm TL, 18 September 2023, 53.858 ºN, 11.395 ºW; 258 m depth, 11.5 ºC, S=35.5; MHN USC 25221-9, Porcupine Bank, 277.4 mm TL, 26 September 2023, 52.619 ºN, 12.056 ºW; 267 m depth, 11.1 ºC, 35.4; MHN USC 25221-10, Porcupine Bank, 325.1 mm TL (Fig. 3), 18 September 2023, 53.858 ºN, 11.395 ºW; 258 m depth, 11.5 ºC, S=35.5; MHN USC 25221-11, Porcupine Bank, 358.2 mm TL, 27 September 2023, 53.571 ºN, 11.841 ºW, 270 m depth, 11.7 ºC, 35.5.

Description

Elongated body, cylindrical anteriorly and compressed posteriorly (Figs. 2 and 3), body depth 5.8-9 times in SL; the head above is flattened posteriorly and rounded anterior to the eyes, head length 4.5-5.8 in SL; snout short and blunted, 3.5-5.1 times in HL; eyes horizontally oblong, horizontal eye diameter 4.4-5.4 in HL; four barbels, one on the chin, one on at the tip of the snout, and one on each nostril; small chin barbel 5.8-10.8 times in HL; mouth large, inferior; upper jaw prominent, extending beyond the posterior margin of the eye, upper jaw length 1.7-2.3 in HL; first dorsal fin with a single elongated ray, 4-4.7 times in SL; second dorsal fin with a series of short filaments in a groove, its base 1.6-3.2 times in HL; third dorsal fin longer with normal soft rays, its base 1.5-2 times in SL; pelvic fin jugular, anterior to the base of the pectoral fin; the lateral line is interrupted along its entire length; the colour is brownish on the back, lighter on the sides, dirty white on the belly, dark oval spot on the posterior end of the third dorsal and anal fins and on the lower part of the caudal fin. The inside of the mouth, the gill cavities and the first dorsal fin ray are blackish. Table 1 shows the morphological results while Tables 2 and 3 provide a comparison of the morphometric and meristic data, respectively.

Genetic features

Considering all mitochondrial *COI* sequences, 12 haplotypes were recognized, of which four (H3 to H6) were obtained for the first time for this species (Fig. 4). As can be seen, the two main haplotypes, H1 and H2, which account for 78% of the sequences, are present in 7 of the 9 locations, on both sides of the Atlantic Ocean.

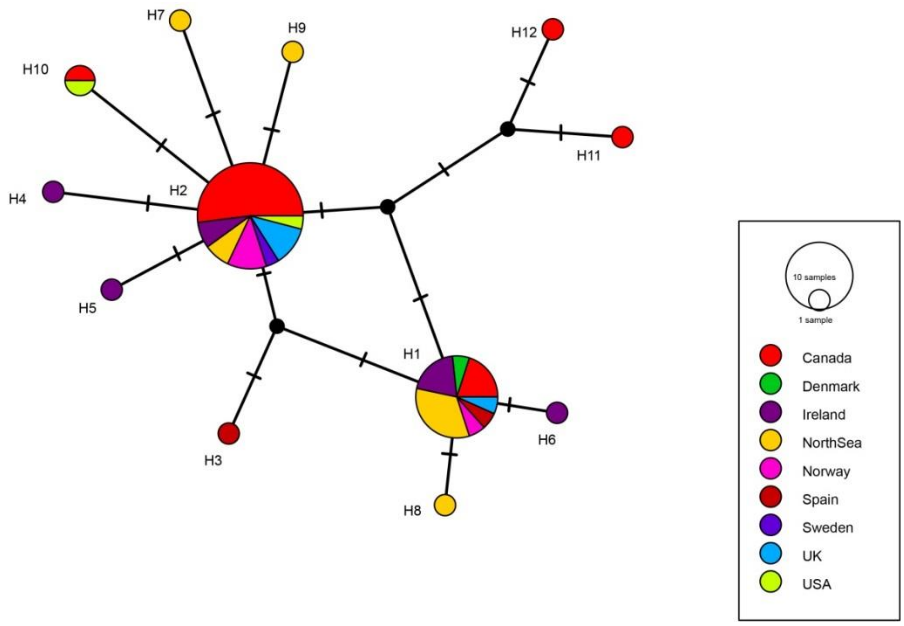

Fig. 4 Haplotype network of *COI* sequences (623 nucleotides) from *Enchelyopus cimbrius* (n = 51). Median Joining Network (ε = 0) created in PopART v1.7. Each circle represents a

haplotype; the size of the circles corresponds to the number of individuals with that haplotype. Colours indicate sampling locations. Bars indicate the number of mutations between two haplotypes. Small black circles indicate hypothetical haplotypes, predicted by the model.

Weight-length relationships

The TL-W results of the manuscript along with results from other areas are shown in Table 4. The individuals showed equal growth in weight and length ($b = 3.049$; CI $b = 2.797$- 3.303; $p < 0.001$). Only in one other published case is this relationship provided, also isometric, while in all other cases this information is missing.

Allometric morphological growth

The linear regression relationship between total body length (TL) and different morphometric characters for *E. cimbrius* are presented in Table 5. The findings showed strong and significant correlations ($r > 0.974$; $p < 0.001$) between TL and morphometric characters, indicating a direct relationship between total body length and growth of various body parts of this species. However, there are differences in allometric growth between characters. IO and D1H showed positive allometry with TL, while ED, VL, HL, and PL exhibited negative allometry with respect to TL. BD and CPD, on the other hand, showed isometry.

Discussion

The under-description of many fish species is mainly due to a current lack of interest in fish taxonomic studies at institutional, individual and editorial levels. This limited knowledge of intraspecific variation makes it difficult to recognise species boundaries and thus to assess the actual diversity and distribution of species (Frutos et al. 2022). Integrative taxonomic studies combining morphology and molecular tools should be increasingly applied in fishes. These studies can support the current taxonomic status or reveal the presence of cryptic and synonymous species, indicating hidden biodiversity (Bañón et al. 2023).

In the eastern Atlantic, although *E. cimbrius* occupies a considerable area, only a small sample has been taxonomically studied, mainly from Denmark and Norway (Cohen and Russo 1979). Additionally, there is a significant knowledge gap between the southernmost documented record in the eastern Atlantic, at Cape Blanc, Mauritania and the more common distribution northwards from the northern part of the Bay of Biscay (Mecklenburg et al. 2018). The present study partially fills this gap, although the southern occurrence of this species in the eastern Atlantic is too sparse to provide valuable information. This species has previously been reported in the northern part of the Bay of Biscay, in the Grande Vasière and Quiberon Bay (Quéro et al. 1989) with only one specimen found in the southern part, specifically, in the Cantabrian Sea (Sánchez et al. 1995).

The morphological description of *E. cimbrius* is mainly based on meristic characters (Bigelow and Schroeder 1953; Cohen and Ruso 1979), as biometrics characters are poorly described. Exceptions are found in Demir et al. (1985) for post-larvae and juveniles, and Svetovidov (1948) for adults. In the latter case, however, relative measurements were obtained with respect to TL rather than the more commonly used SL, making taxonomic comparisons difficult.

The TL-W relationship estimated in the study showed an isometric growth, suggesting that the specimens maintain the same shape during the growth process, without changing their density (Lleonart et al. 2000). Even with the limited data, the growth allometry of the species showed similar patterns to other studies. Considerable ontogenetic changes have been described in *E. cimbrius*, including a progressive increase in the length of the elongated first dorsal fin ray during development (Demir et al. 1985). These authors reported a range of 1.2-32.4% HL in specimens between 8 and 29.9 mm TL, prior to the 118.3-138.8% HL obtained in this study. Other morphological characters, such as pelvic fin length, showed differences between post-larval pelagic juveniles and adults. Although Demir et al. (1985) reported a range of 15.8-32.1% SL, the present study obtains lower values for this character (6.9-15.8% SL). A comparison of the relative biometric ranges between post-larval pelagic juveniles and adults showed an increase in the first dorsal fin length, the interorbital width and the peduncle height with growth. Conversely, there is a decrease in body depth, head length, eye diameter and pelvic fin length. Body depth and caudal peduncle length followed an isometric growth pattern. This suggests a growth strategy that prioritises the development of certain body parts over others. In *E. cimbrius* there is a greater development of some body features in the anterior part of the body as individuals become longer.

Ontogenetic growth in fishes is a complex and multifaceted process, influenced by multiple factors (Sibly et al. 2015). Most fishes undergo dramatic changes in body size as they grow, because they occupy multiple niches throughout their ontogenetic development, and may experience different selective pressures within each sequential niche (Searle et al. 2021). In general, juveniles have larger eyes and heads relative to body size, while adults have smaller eyes and heads relative to body size (Searle et al. 2021), as it was observed in the current study. Younger gadiforms often have relatively more expanded and elongated pelvic fins than adults, which seems to assist with buoyancy (Fahay and Marckle 1984).

Several differences from Svetovidov (1948) were identified. For instance, the length of the first dorsal fin ray was 13.2-14.2%TL, which is lower than the 19-22%TL found in this study. The interorbital space was narrower in our samples (1.9-4.7% TL) compared to 7.9-8.9% TL in Svetovidov (1948). In addition, the lateral line is interrupted along its entire length (Cohen 1990), with about 29 pores in Svetovidov (1948) and 29-36 pores in this study. Svetovidov did not provide information on the number, size, or origin of the specimens examined. Therefore, it is possible that the differences found are related to any of these variables. Additionally, transcription errors cannot be ruled out. Svetovidov (1948) reported lower values for the length of the upper jaw (43.9-48 %HL) compared to the lower jaw (48.7-55.8%HL). However, since the mouth of *E. cimbrius* is inferior, it is likely that these values were erroneously interchanged. The interorbital space also seems to be an error, as this author state that "the interorbital space is very narrow", but the reported range (7.9-8.9%TL) suggests otherwise and it is far from our values and from the theoretical values based on the calculated linear regression.

The sample size (n=11) used for allometric growth analysis is a limitation of this study, reflecting the scarcity of *E. cimbrius* in the sampling areas. Despite this, the consistent patterns observed provide valuable preliminary insights into the morphological development of the species, although future studies with larger samples would help to confirm these findings.

Integrative studies are particularly recommended for species with high intraspecific variability in order to find taxonomic divergences. Geographical and morphological differences have been noted previously (Cohen and Russo 1979), which, together with allometric growth, accounts for the high intraspecific variability of this species. Despite this, the species can be easily distinguished from other gadiformes by several taxonomic characters, such as the presence of four barbels and the blackish colouration of the posterior end of the third dorsal and the anal fins as well as the lower part of the caudal fin. Molecular analysis also confirms the amphiatlantic distribution of the species.

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Declarations

Conflict of interest The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Ethics approval No animal testing was performed during this study.

Sampling and field studies All necessary permits for sampling and observational field studies have been obtained by the authors from the competent authorities and are mentioned in the acknowledgements. The study is compliant with CBD and Nagoya protocols.

Data availability The sequences employed in the current study are available in the BOLD systems (https://www.boldsystems.org/, accessed on 21 December 2023) and GenBank (https://www.ncbi.nlm.nih.gov/genbank/, accessed on 21 December 2023) repositories. All specimens used in this study for taxonomical purposes are deposited in the fish collection of the Universidade de Santiago de Compostela, Museo de Historia Natural Luis Iglesias, in Santiago de Compostela, Spain (see methods). All other data are included in this article.

Author contribution RB conceived the study. ADC and ASC conducted molecular analyses. FB and JCA compiled the specimens. JDBV make the X-ray photographs. RB and CGF conducted morphological analysis. RB, FB, CGF and ADC wrote the manuscript and all authors critically reviewed and approved the manuscript.

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Figure

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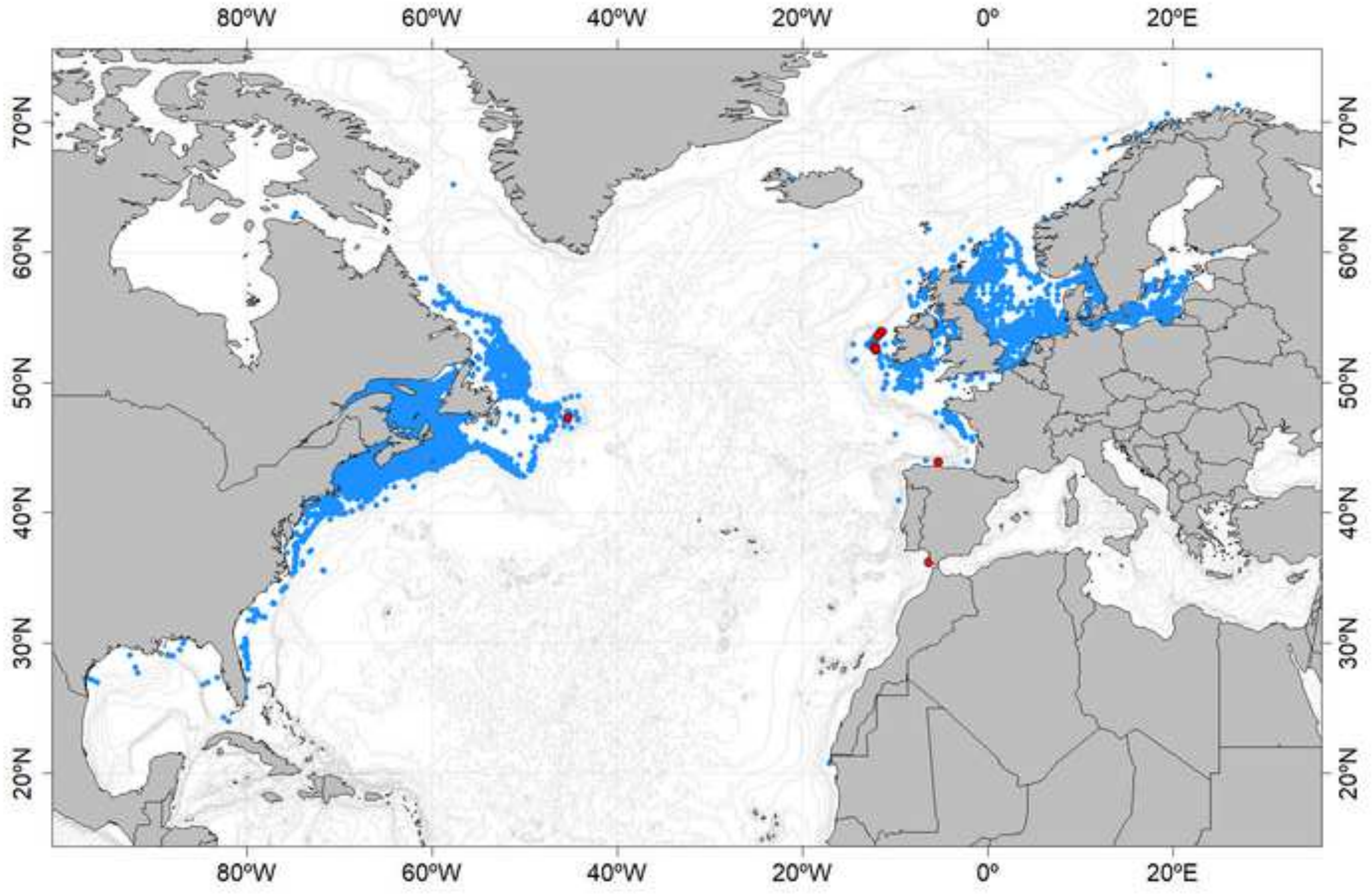

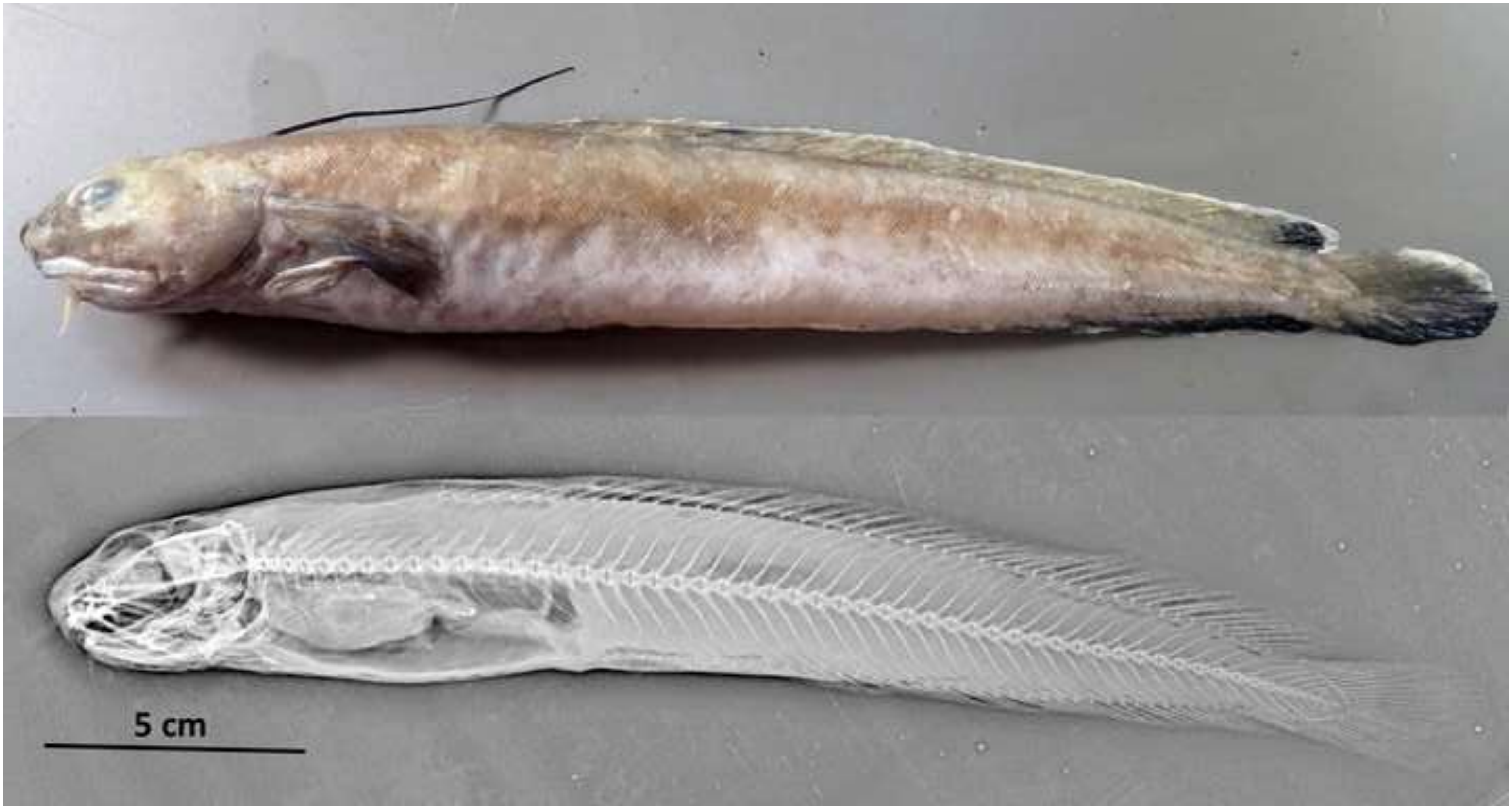
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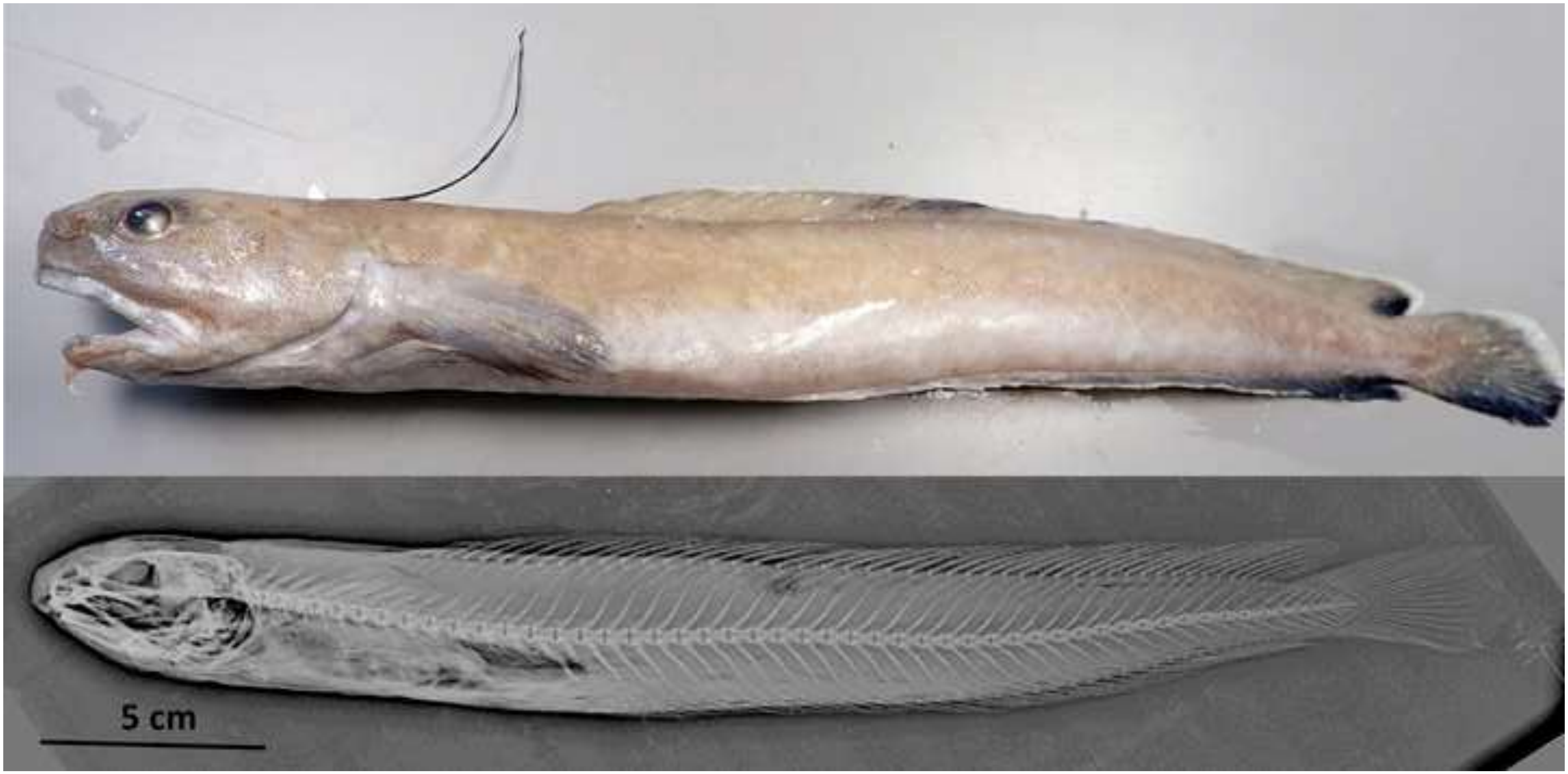

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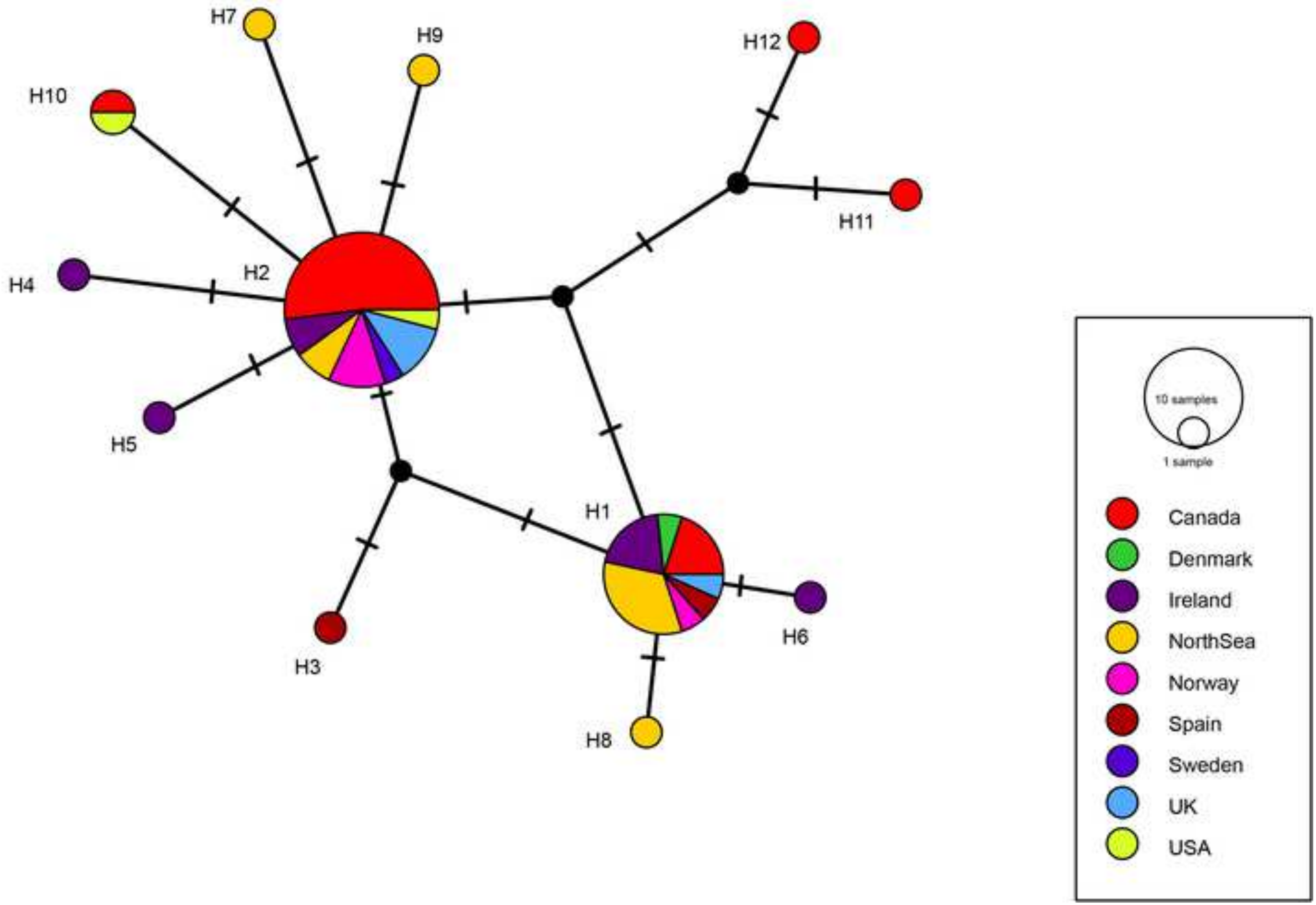

Table

Table 1 Morphometric and meristic data of Enchelyopus cimbrius based on the examination of 11 specimens from the North Atlantic. The number of specimens is indicated in brackets.

	Range (n)	Mean±SD
Total length (mm)	81-358.2(11)	
Standard length (mm)	73-319(11)	
As % SL		
Head length	17.2-22.2(11)	18.7±1.5
Pre-dorsal 1-fin length	12.2-21.1(11)	16.5±2.1
Pre-dorsal 3-fin length	27-32.9 (11)	29.3±1.4
Pre-anal-fin length	39.6-48.2 (11)	43.9±2.4
Pre-pectoral-fin length	18-23.6 (11)	19.6±1.5
Pre-pelvic-fin length	16.3-19.3 (11)	17.7±0.9
Pectoral-fin length	12.1-14.7 (11)	13±0.7
Pelvic-fin length	6.9-15.8 (11)	9.2±2.3
Dorsal 3-fin base	49.3-66.9 (11)	63.8±4.9
Anal-fin base	43.6-53.6 (11)	50.8±2.8
Body depth (maximum)	11.1-17.2 (11)	24.3±0.4
Dorsal 1-fin height	19.3-24.8 (5)	22.8±2.5
Caudal-peduncle depth	4.6-5.3 (11)	5±0.3
As % HL		
Pre-orbital length	19.8-28.9 (11)	24.5±2.5
Post-orbital length	52.5-63.4 (11)	55.6±3
Eye diameter	18.4-22.6 (11)	20.7±1.4
Interorbital width	9.3-30.8 (11)	23.7±6.1
Upper jaw length	43.2-60.5 (11)	53.4±5.1
Lower jaw length	35.4-47.6 (11)	42.7±3.8
Barbel length	9.3-16.7 (11)	14.2±2.6
Meristic		
Dorsal fin rays	48 (1), 49 (4), 50 (4), 51 (2)	49.6±0.9
Anal fin rays	42 (3), 43 (4), 44 (4)	43.1±0.8
Pectoral fin rays	15 (3), 16 (4), 17 (3),18 (1)	16.2±1
Pelvic fin rays	5 (1), 6 (10)	5.9± 0.3
Branchiostegal rays	7 (11)	
Gill rakers	1+8 (2), 1+9 (7), 1+10 (2)	10± 0.6
Pores in lateral line	29-36 (10)	32.1±2.6
Vertebrae	52 (1), 53 (1)	

Table

Table 2 Comparative in relative percentages of *Enchelyopus cimbrius* morphometric data.

	As %SL		As % TL		As %HL		
	This study	Demir et al. 1985	This study	Svetovidov (1948)	This study	Svetovidov (1948)	Demir et al. 1985
Head length	17.2-22.2	22.9-32.6	15.3-20	16-17.2	—	—	—
Pre-dorsal 1-fin length	—	—	10.8-19	14.4-15.1	—	—	—
Pre-anal-fin length	—	—	35.2-42.3	37.4-43	—	—	—
Pre-orbital length	—	—	—	—	19.8-28.9	24.4-27.1	—
Eye diameter	—	—	—	—	18.4-22.6	22.2-24.4	27.7-50
Interorbital width	—	—	1.9-4.7	7.9-8.9	—	—	—
Upper jaw length	—	—	—	—	43.2-60.5	43.9-48	—
Lower jaw length	—	—	—	—	35.4-47.6	48.7-55.8	—
Barbel length	—	—	—	—	9.3-16.7	—	6-23.1
Dorsal 2-fin base	—	—	6.3-10.3	10.5-11.8	—	—	—
Dorsal 3-fin base	—	—	44.4-59.4	58.3-59.2	—	—	—
Anal-fin base	—	—	39.3-47.6	41.7-45.3	—	—	—
First dorsal fin length	—	—	19-22	13.2-14.2	118.3-138.8	—	1.2-32.4
Pectoral-fin length	12.1-14.7	5.6-16.7	10.7-13.2	13.4-14.9	—	—	—
Pelvic-fin length	6.9-15.8	15.8-32.1	6.1-14.2	7.4-8.9	—	—	—
Body depth	11.1-17.2	18.9-30.2	—	—	—	—	—
Caudal-peduncle depth	—	—	4.1-4.9	3.3-3.7	—	—	—

Table

Table 3 Comparative of meristic data of *Enchelyopus cimbrius*. The number of vertebrae obtained in this study corresponds to only two radiographed specimens.

	This study	Svetovidov (1948)	Cohen and Russo (1979)	Demir et al. (1985)
Third dorsal fin rays	48-51	45-50	45-55	38-40
Anal fin rays	42-44	37-41	36-49	38-40
Pectoral fin rays	15-18	15-16	15-19	14-17
Pelvic fin rays	5-6	5	–	5-6
Branchiostegal rays	7	–	–	–
Gill rakers	9-11	9-10	5-13	–
Pores in lateral line	29-36	29	–	–
Vertebrae	52-53	54	–	51-55

Table 4 Parameters of allometric relationships between total length (TL, mm) and total weight (TW, g) of *Enchelyopuys cimbrius* in this study and in the literature fitted to a potential equation $Y = a \times X^b$ (where b is the growth coefficient and a is the intercept). n: number of measurements for each study; r^2: adjusted R-squared; Allo: allometry (I, isometric)

N	Min. length (cm)	Max. length (cm)	a	b	r^2	Allo	Source
44	11	31	0.0043	3.0496	0.93	I	This manuscript
43	3.4	22	0.0044	3.003	0.99	I	Froese and Pauly (2023)
63	11	29	0.0035	3.106	0.70	–	Froese and Pauly (2023)
448	4.7	28.5	0.0032	3.144	0.95	–	Froese and Pauly 2023)
334	6	31	0.0080	2.8377	0.966	–	Silva et al. 2013
174	–	29	0.00335	3.095	0.95	–	Noble and Clark (2019)
529	–	38	0.00254	3.188	0.97	–	Noble and Clark (2019)
27	–	–	0.0016	3.37	–	–	Alpoim et al. (2002)

Table

Table 5 Parameters of allometric relationships between total body length (TL) and different morphometric characters for *Enchelyopus cimbrius* fitted to a potential equation $Y = a \times X^b$ (where b is the growth coefficient and a is the intercept). CI b: coefficient interval of the growth coefficient; n: number of measurements of each morphometric character; Allo: allometry (+ indicates positive allometry, − indicates negative allometry and I indicates isometry); Abbreviations as follow: Interorbital length (IO), eye diameter (ED), pelvic fin length (VL), head length (HL), first dorsal height (D1H), pectoral fin length (PL), body depth (BD), caudal peduncle depth (CPD).

Total length	Morphometric character	Regression coefficients						
X	Y	a	b	CI b	r^2	n	p-value	Allo
TL	IO	0.001	1.621	1.417-1.826	0.969	11	<0.001	+
TL	ED	0.095	0.814	0.703-0.925	0.965	11	<0.001	-
TL	VL	1.213	0.507	0.375-0.640	0.881	11	<0.001	-
TL	HL	0.421	0.831	0.759-0.904	0.985	11	<0.001	-
TL	D1H	0.0002	2.190	1.829-2.552	0.983	6	<0.001	+
TL	PL	0.198	0.903	0.825-0.981	0.986	11	<0.001	-
TL	BD	0.057	1.138	0.906-1.369	0.924	11	<0.001	I
TL	CPD	0.033	1.056	0.945-1.167	0.979	11	<0.001	I