Unexpected deep-sea fish species on the Porcupine Bank (NE Atlantic): Biogeographical implications

R. BAÑÓN[1,2]†, A. DE CARLOS[3], S. RUIZ-PICO[4], AND F. BALDÓ[5]

[1]*Servizo de Planificación, Consellería do Mar, Xunta de Galicia, Rúa dos Irmandiños s/n, 15701 Santiago de Compostela, Spain,* [2]*Grupo de Estudos do Medio Mariño (GEMM), Edif. Club Naútico bajo, 15960 Ribeira, Spain,* [3]*Departamento de Bioquímica, Xenética e Inmunoloxía, Facultade de Bioloxía, Universidade de Vigo, Campus Universitario Lagoas-Marcosende s/n, 36310 Vigo, Spain,* [4]*Instituto Español de Oceanografía (IEO), Centro Oceanográfico de Santander, Promontorio de San Martín s/n, 39004 Santander, Spain,* [5]*Instituto Español de Oceanografía (IEO), Centro Oceanográfico de Cádiz, Puerto Pesquero, Muelle de Levante s/n, 11006 Cádiz, Spain.*

Ethical statement

The fish specimens that are the subject of this manuscript were captured by fishing methods and were already dead when they were analysed. Therefore, we consider that the ethical information is not applicable in this case.

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† Author to whom correspondence should be addressed. Tel.:+ +34986231930; e-mail: anoplogaster@yahoo.es

ORCID: Rafael Bañón http://orcid.org/0000-0001-6038-9335

ABSTRACT

Four specimens corresponding to three rare deep-water fish species were caught on the Porcupine Bank (Northeast Atlantic) in September 2019. These catches include the new northernmost records of Azores rockling *Gaidropsarus granti* and Deep water dab *Poecilopsetta beanii* in the Atlantic Ocean and the second record of the latter species in its eastern zone. Three of the specimens were retained and their molecular identification also allowed the first time to obtain the *Cataetyx alleni* DNA barcode. The appearance of *P. beanii*, a West Atlantic species, in its eastern zone is discussed in relation to a possible phenomenon of transoceanic drift in the larval stage.

Keywords: NE Atlantic; Distribution; Northernmost record; Transatlantic drift; DNA barcoding.

Observation of new species in a given area allows us to substantially expand its known distribution range or to refine information on the morphological variation of the species (Prokofiev, 2017). These findings increase knowledge of the composition and distribution of fishes, and are an important source of information to understand mechanisms involved in the connectivity between distant areas (Barros-García *et al*., 2019).

The Porcupine Bank is located in the north-eastern Atlantic, 200 km off the west coast of Ireland, forming a seamount-like structure, with its related anticyclonic structures. The fish fauna of this bank and the adjacent areas are well known (O'Riordan, 1984; Johnston *et al*., 2010). However, some singular fishes such as *Gadella maraldi* (Risso, 1810), *Bellottia apoda* Giglioli, 1883 and *Neoscopelus macrolepidotus* Johnson, 1863 were also reported in the bank (Ruiz-Pico *et al*., 2012; Fernández-Zapico *et al*., 2013; Ordines *et al*., 2017).

In September 2019, four fish specimens were caught by bottom trawl using a Baca-GAV 39/52 with a cod-end mesh size of 20 mm during the Spanish Bottom Trawl Survey on the Porcupine Bank (SP-PORC-Q3). Sampling was carried out onboard the R/V Vizconde de Eza, a stern trawler of 53 m and 1800 Kw. The covered area extended from 12 ºW to 15 ºW and from 51 ºN to 54 ºN. After removing tissue samples for molecular analysis, which were stored at -28ºC, the specimens were preserved in 70% ethanol and deposited in the fish collection of the Museo Luis Iglesias de Ciencias Naturais in Santiago de Compostela (MHNUSC).

An unpreserved specimen of *Gaidropsarus granti* (Regan, 1903) of 253 mm L_T (Figure 1a) and 130 g weight was recorded on September 11, 2019 at 51.0316 ºN, 14.4061 ºW and 751 m depth. This species is distributed in the eastern Atlantic, in the Canary and Azores Islands, Seine Seamount and Galicia Bank and the Mediterranean Sea (García, 2015). Two specimens of *Cataetyx alleni* (Byrne, 1906) of 147 mm and

150 mm L_T (Figure 1b) and 41 g and 34.3 g respectively, were caught on September 11, 2019 at 51.0316 ºN, 14.4061 ºW and 751 m depth. This species is distributed in the eastern Atlantic, from Portugal and Spain along the northern Bay of Biscay and northwest Mediterranean Sea and Adriatic Sea (Uiblein *et al.*, 2015). Finally, a specimen of *Poecilopsetta beanii* (Goode, 1881) of 172 mm L_T (Figure 1c) and 37.2 g weight was recorded on September 15, 2019 at 52.2247 ºN, 14.2007 ºW and 333 m depth. This is a western Atlantic species, distributed from the New England waters to Colombia and northern Brazil (Cobián-Rojas *et al*. 2019); the only previous record in the east Atlantic is from southern Ireland waters (Nielsen and Casey, 2008). Table 1 shows the main morphometric and meristic characters determined. The new locations of the species along with the historical georeferenced records (Bello, 2018; GBIF, 2020a,b,c; OBIS, 2020; Spinelli and Castriota, 2019) are shown in Figure 2.

The identity of the specimens was verified by barcoding DNA analysis of muscle tissue samples, amplifying part of the sequence of the mitochondrial gene COI as previously described in Bañón *et al*. (2019). 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 project entitled "Unusual fish from the north eastern Atlantic Ocean" (code UNAFI). The barcode sequences have been also deposited in GenBank under accession numbers MN992052-MN992054. Sequences similar to that of *C. alleni* and *P. beanii* were sought through an analysis carried out with BLAST (Altschul *et al*., 1990). The closest match to the COI sequence of *C. alleni* was a sequence of *Cataetyx rubirostris* Gilbert, 1890, with a similarity value in the congeneric range (93%). The two DNA barcodes of *C. alleni* provided by this research are therefore the first of this species to be deposited in international databases. The *P. beanii* COI sequence submitted to BLAST analysis produced alignments with similarity higher than 98% with sequences from *P. beanii* (99.69%), *P. colorata* (98.63%) and *P. natalensis* (98.62%) (Table 2).

The coloration of *G. granti*, with numerous irregular brown creamy blotches and spots and a whitish longitudinal sinuous band from the end of the head to the caudal peduncle identifies this specimen as *G. granti*. This pattern of coloration makes this species unmistakable (Orsi Relini and Relini, 2013) and is a quick and useful diagnostic character for the species. Following this criterion, we analysed a digital frame recorded by landers in the Belgica Mounds Province (Linley *et al*., 2017). This species was erroneously identified by the authors as cf *Gaidropsarus argentatus* (Reinhardt, 1837), but according to its coloration pattern it should be now reassigned to *G. granti*.

The *G. granti* specimen of the Porcupine bank caught at 51ºN constitutes a new northernmost record in the eastern Atlantic Ocean, previously established in the Galician Bank (Bañón *et al*., 2002). This species has a patchy distribution in the Atlantic and the Mediterranean Sea, probably related to the occurrence of suitable habitats, mainly coral banks in offshore banks and deep-seamounts, and to the difficulties of sampling these ecosystems. In fact, cold-water coral banks are frequently mentioned in the catches of *G. granti* in the Mediterranean (Bello, 2018). This species was only previously seen in cold-water coral areas of *Lophelia pertusa* (Linnaeus, 1758) and *Madeprora aculeta* Linnaeus, 1758 at the Belgica Mounds Province (Linley *et al*.,

2017) and a large amount of live and dead of *L. pertusa* has been caught along with the specimen captured in the Porcupine Bank, which reinforces this hypothesis.

Although *C. alleni* is reported in the North Atlantic to the northern part of the Bay of Biscay (Uiblein *et al*., 2015), this species was also found northwards, in the Porcupine Seabight and Porcupine Abyssal Plain (Merrett *et al*., 1991; Priede *et al*., 2011). The current records on the Porcupine Bank confirm its presence further north of the Bay of Biscay.

The occurrence of *P. beanii*, a western Atlantic species, in the eastern part is very striking. The morphological identification of this specimen is reinforced by the sequence similarity between its DNA barcode COI sequence and others from the same species found in both databases. However, other sequences described from *Poecilopsetta* species from different geographical origins showed genetic distance values less than 2%, which is the cut-off criterion to consider conspecificity among fishes (Ward, 2009). The low congeneric distances observed could be an indicator of misidentifications, recent divergence, hybridization or synonymy (Bañón *et al*., 2019). The molecular results of *Poecilopsetta* invite further study of the genetic diversity of this genus.

Nielsen and Casey (2008) recorded *P. beanii* in the eastern Atlantic but suggested it's occurrence there was due to transportation through ships' ballast water, as transatlantic travel seemed unlikely. However, transatlantic transport could also be possible. The pelagic larvae of *Poecilopsetta* grow to rather larger size than those of other pleuronectids and other fish groups (Nielsen and Casey, 2008). Deep-water flatfish species, such as *P. beanii*, tend to have larger larvae, a longer period of time as plankton and metamorphose at a larger size, all of which aid in dispersal of the individuals (Kyle, 1913). The length at transformation in *P. beanii* is ca. 36 mm L_S (Evseenko and Suntsov, 1994). Larvae of flatfishes with a metamorphic size greater than 25 mm may spend more than 3 months as plankton and, in some species, over a year (Duffy-Anderson *et al*., 2015). Moreover, there are expatriate larvae with an unusually large pre-transitional size having undergone delayed metamorphosis (Munroe and Krabbenhoft, 2010). In addition, a transatlantic drift of flatfish larvae from North America eastwards has been observed in gradually cooling currents, leading to an increase in the duration and extent of their passive migrations (Evseenko, 2008). All these arguments support the hypothesis of a possible transoceanic migration in the pelagic phase of *P. beanii*.

Considering that the northernmost records of adult specimens in the western Atlantic are found in the eastern Block Canyon (Moore *et al*., 2003), the distance separating this point from the Porcupine Bank is approximately 4500 km, in range with larval shift of American flatfishes *Bothus* spp found in the Azores islands (Evseenko, 2008). Taking into account that the average speed of the Gulf Stream is 6.4 km/h (NOAA, 2020), it is likely that viable eggs and larvae of *P. beanii* born in the western Atlantic reached the eastern Atlantic via current-carried plankton, but more sampling would be needed to better understand this potential transoceanic connectivity.

The size of the specimen of *P. beanii* should also be highlighted. The 143 mm L_S is longer than previous documented values, which establish a new larger size for the species. The maximum reported size for this species was 90 mm L_S (Munroe, 2002), although larger sizes have been previously documented, up to 106.7 mm L_S (Hoshino, 2000) or 111 mm L_S (Goode and Bean, 1895), all of them being smaller than the specimen here described.

Due to the latitudinal trend in environmental food conditions, the maximum body size increases with latitude, both within and among flatfish species (Van der Veer *et al*., 2003). Therefore, this maximum body size in *P. beanii* could be related to the latitude in which it was found, as far as we know, the northernmost record for the species. Since hatching, larval and metamorphosis sizes scale directly with maximum body size, similar trends with latitude related to these variables are expected (Van der Veer *et al*., 2003), which also reinforces the hypothesis that longer pelagic phases enable a transoceanic drift scenario.

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CONTRIBUTIONS

RB and F.B. developed the research idea; R.B., S.R.P. and F.B. collected, identified and provided data on the specimens; R.B., A.D.C. and F.B. analyse the specimens and wrote the manuscript with significant contributions from S.R.P.

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Table 1 Measurements and counts carried out on specimens of *C. alleni* and *P. beanii*

	C.alleni MHNUSC 25174-1	*C. alleni* MHNUSC 25174-2	*P. beanii* MHNUSC 25166-1
BIOMETRIC (mm)			
Total length (L_T)	147	150	172
Standard length (L_S)	143	136	143
% L_S			
Head length	29.0	27.9	18.9
Preorbital length	5.4	5.6	2.1
Eye diameter	4.2	4.4	7.5
Postorbital length	18.5	18.8	9.0
Interorbital distance	5.5	4.8	0.6
Predorsal length	37.1	33.1	6.3
Dorsal fin base length	64.3	69.9	85.3
Preanal length	54.5	51.5	22.4
Anal fin base length	45.5	51.5	68.5
Preventral length	21.0	18.4	14.0
Prepectoral length	26.6	26.5	18.8
Pectoral length	14.5	14.2	7.4
Ventral length	12.2	11.8	9.0
Body depth	25.7	22.1	36.7
Caudal peduncle length			4.6
Caudal peduncle depth			10.1
MERISTIC			
No. of dorsal fin rays	110	112	64
No. of anal fin rays	82	85	54
No. of pectoral fin rays	30	32	8
No. of caudal fin rays	2	2	6
Gill rakers	4+1+13	3+1+12	7+10

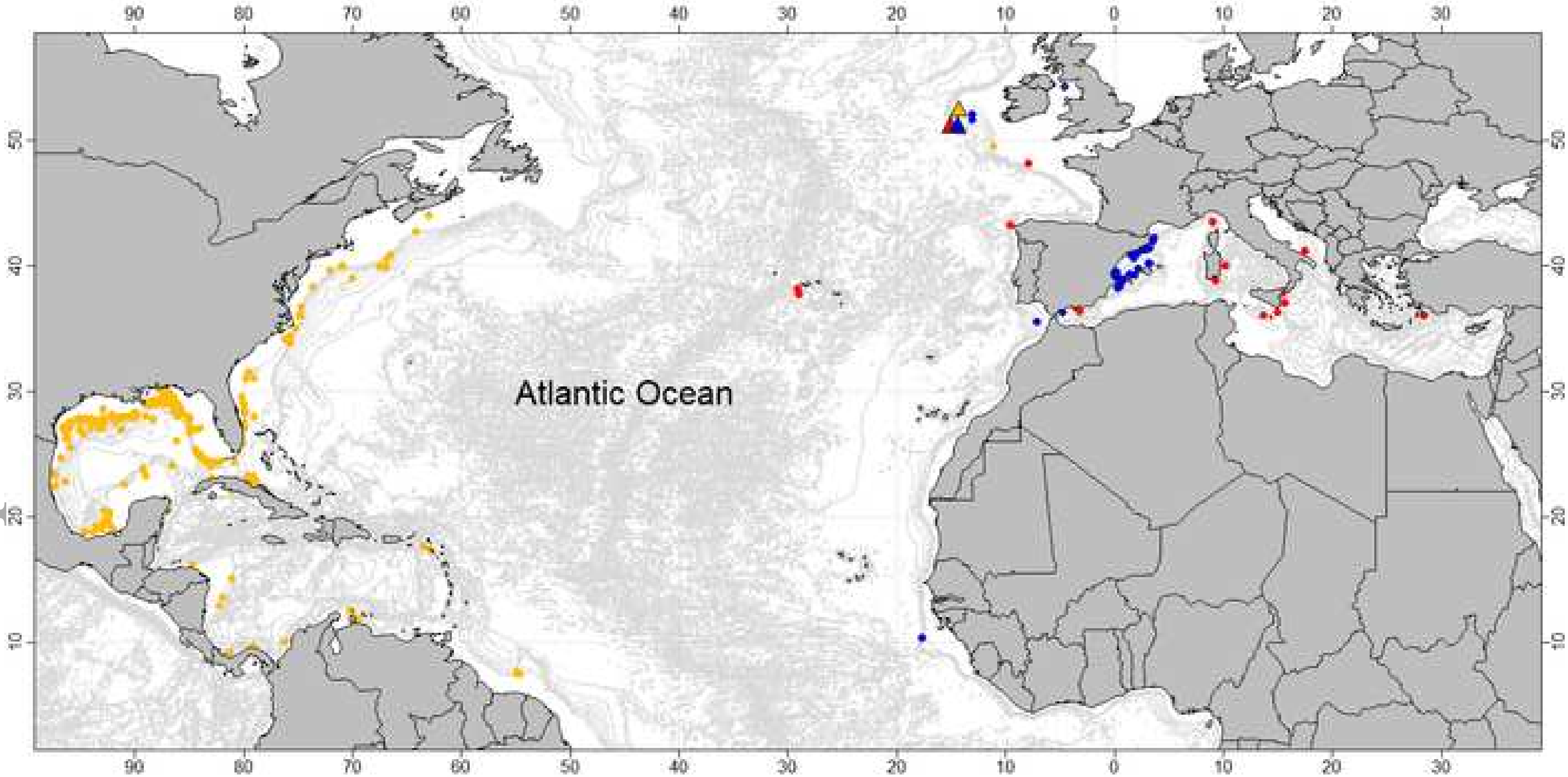
Table 2 Sequences producing significant alignments (BLAST) with the *P. beanii* COI barcode of Porcupine Bank

Description	Query cover (%)	E-value	Identity (%)	Accession
P. beanii	98	0.0	99.69	MK617167
P. colorata	100	0.0	98.63	MH638801
P. colorata	100	0.0	98.63	MH638802
P. natalensis	99	0.0	98.62	GU804911
P. natalensis	99	0.0	98.47	JN312199
P. natalensis	99	0.0	98.47	GU804926
P. colorata	97	0.0	98.12	KX611099
P. natalensis	91	0.0	98.67	JN312200
P. natalensis	91	0.0	98.49	JN312197
P. natalensis	86	0.0	98.42	JN312198

FIGURE 1 Deep-water fishes caught on the Porcupine Bank: a: *Gaidropsarus granti* 253 mm TL; b: *Cataetyx alleni*, 150 mm TL; c: *Poecilopsetta beanii* 172 mm TL. (Photos: Francisco Baldó)

FIGURE 2 Distribution map showing the records of *Poecilopsetta beanii* (yellow dots), *Gaidropsarus granti* (red dots) and *Cataetyx alleni* (blue dots) reported by GBIF and OBIS and the literature reviewed. The triangle marks represent the new locations reported in this research.

Figure



Figure