



Occurrence of the pugnose pipefish *Bryx dunckeri* in the Sargasso Sea

Josefin Sundin¹  | Marko Freese²  | Lasse Marohn² | Tina Blancke² | Reinhold Hanel²

¹Department of Aquatic Resources, Swedish University of Agricultural Sciences, Drottningholm, Sweden

²Thünen Institute of Fisheries Ecology, Federal Research Institute for Rural Areas, Forestry and Fisheries, Bremerhaven, Germany

Correspondence

Josefin Sundin, Institute of Freshwater Research, Department of Aquatic Resources (SLU Aqua), Swedish University of Agricultural Sciences, Stångholmsvägen 2, 178 93 Drottningholm, Sweden.
Email: josefin.sundin@slu.se; josefin@teamsundin.se

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Abstract

Juvenile specimens of the pugnose pipefish, *Bryx dunckeri*, were collected during a multipurpose research survey conducted within the Sargasso Sea Subtropical Convergence Zone, extending the known distribution range of this species to include open ocean areas of the Western North Atlantic. Novel spatial data are of scientific interest as information on the distribution, population structure, and population size of this species is limited. Additionally, we present detailed photographs and morphological data on the collected specimens. The results are discussed in relation to the dispersal abilities and population structure in syngnathids.

KEYWORDS

Isaacs-Kidd midwater trawl, sargassum, species distribution, syngnathids

The Syngnathidae is a family of the order Syngnathiformes and is represented by more than 300 species of pipefishes, seahorses, pygmy pipefishes, and seadragons (Kuitert, 2000, Froese & Pauly, 2023). Members of the family are characterized by tubular snouts, fused jaws, rigid dermal plates covering their bodies, and the absence of pelvic fins (Dawson, 1982). One of the most striking features of this family is their extensive parental care, sometimes referred to as male pregnancy, wherein the males gestate the fertilized eggs in a brood pouch or attached to a specific surface on the body, providing the eggs with protection and, in some species, nutrients (Dawson, 1982; Paczolt & Jones, 2010; Rosenqvist & Berglund, 2011; Sagebakken et al., 2010). Due to this unique trait, syngnathid fishes have served as model species in behavioral and evolutionary biology, specifically to investigate aspects within the theories of parental care and sexual selection (e.g., Aronsen et al., 2013; Berglund et al., 1989; Paczolt & Jones, 2010; Roth et al., 2014). Despite their importance in these research fields, basic knowledge on the biology and distribution of many species remains incomplete.

Syngnathids occur in marine, brackish, and freshwater habitats. Most of the marine species primarily reside in shallow coastal waters, where their distribution is relatively well described (Dawson, 1977; Dawson, 1982; Kuitert, 2000). Their distribution in offshore areas is, however, less well documented, and information on pelagic spatial occurrence is scarcer and often even anecdotal (Dawson, 1982; Kloppmann & Ulleweit, 2007). The distribution of juveniles and adults coincides in most species, because all syngnathids produce free-living juveniles within their respective habitats (Hasse, 1974; Mi et al., 1998; Monteiro et al., 2003) with short (Planas et al., 2012; Wilson & Vincent, 2000) or absent pelagic dispersal phases (Silva, Monteiro, Almada, & Vieira, 2006; Silva, Monteiro, Vieira, & Almada, 2006). When the young are released from the brooding male, they are typically referred to as “larvae,” with the term being used in a broader sense to describe “small juveniles,” as, in most species, the larvae have no or very little yolk sac and start feeding immediately after being released from the male (Dawson, 1982; Froese & Pauly, 2023; Kuitert, 2000).

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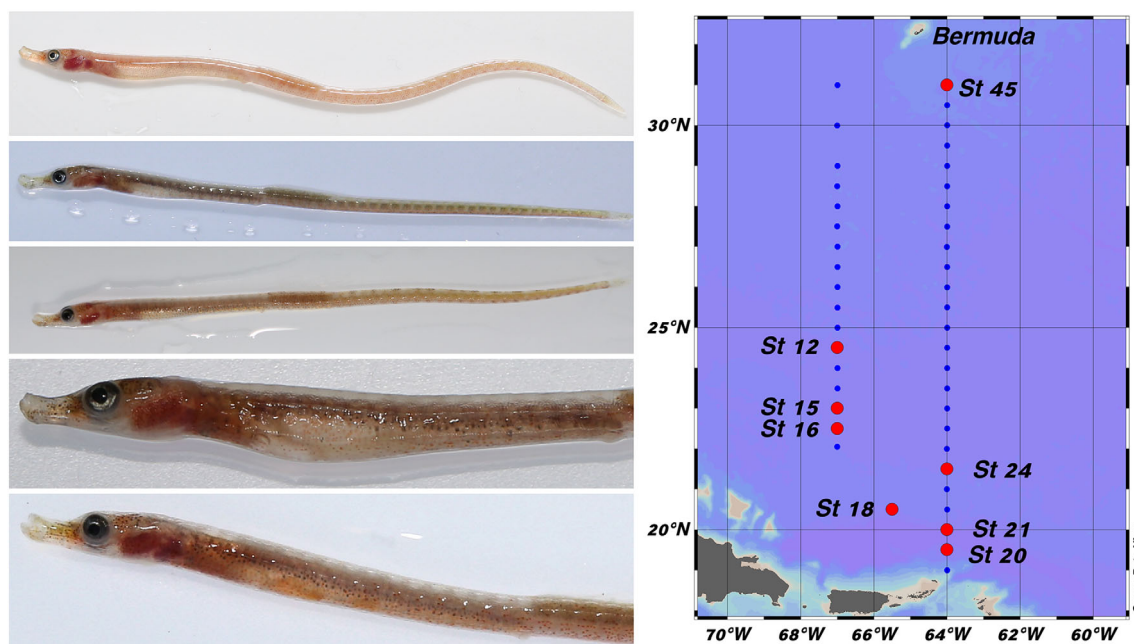


FIGURE 1 Samples of juvenile pugnose pipefish, *Bryx dunckeri*, collected in the Sargasso Sea using an Isaacs-Kidd midwater trawl during a multipurpose research survey carried out between March and April 2023. All locations (stations) visited during the cruise are indicated on the map; red circles (with respective station numbers) indicate the locations where the pipefish were collected.

This paper reports on the occurrence of juveniles of the pugnose pipefish *Bryx dunckeri* Metzelaar, 1919 in the Sargasso Sea Subtropical Convergence Zone, an area well known as the spawning ground of Atlantic anguillid eels (Miller et al., 2019; Schmidt, 1922). Our findings extend the known distribution range of *B. dunckeri* to include open ocean areas of the Western North Atlantic and establishes the inclusion of this species to the fauna of the Sargasso Sea. The previously known distribution range of *B. dunckeri* extends along the eastern coast of North America, from North Carolina to Florida, encompassing the Gulf of Mexico adjacent to the Florida Keys, as well as to the Bahamas, Bermuda, north-western Cuba, and Macau, Brazil (Froese & Pauly, 2023; Williams et al., 2015). Most records are reported from shallow coastal areas, but occurrences from some sites further off coast are registered in the online database Ocean Biogeographic Information System (OBIS <http://www.iobis.org>), which is mainly derived from FishNet2 Marine Data (Fishnet2 Portal, <http://www.fishnet2.net>). *B. dunckeri* is listed as Least Concern according to the 2015 IUCN Red List of Threatened Species assessment (Williams et al., 2015). There are, however, no dedicated population estimates, and the Red List assessment states that more research is needed to quantify population size, structure, and trends (Williams et al., 2015). The Red List assessment further concludes that more research is needed on life history and ecology, habitat trends, and threats (Williams et al., 2015).

B. dunckeri were collected during a multipurpose research survey on-board the German fishery research vessel Walther Herwig III, conducted from March to April 2023 (cruise number WH-465). The main purpose of the triennial survey was to investigate the distribution, abundance, and ecological aspects of early developmental stages of

the European eel (*Anguilla anguilla*) and American eel (*Anguilla rostrata*). The survey was designed to largely resemble the study of Kleckner and McCleave (1988), investigating the same research area and using similar collection methods. The general sampling has been described previously (e.g., Hanel et al., 2014) and is briefly described here. A total of 45 stations were sampled along two north-south transects, located between 31–19° N and 67–64° W (Figure 1). The stations were located at steps of 1 or 0.5° along the latitudinal transects, depending on larval eel catches. The distance between the transects was 3° longitude, with the first transect ending at 67° W 22° N, and the second transect starting at 64° W 19° N, with one intermediate station between the two transects (number 16) (Figure 1). Water depth in the sampled area ranged roughly from 5000 to 7000 m. Sampling was conducted using an Isaacs-Kidd midwater trawl (IKMT) (mesh size 500 µm, mouth opening 6.2 m², length 10 m, Hydro-Bios Apparatebau GmbH). The IKMT was deployed using double-oblique tows between the surface and a maximum depth of 300 m during night and day. At two stations (number 12 and 34), the regular IKMT-cod-end was replaced by a multi-net closing device (MultiNet-Midi). Plankton samples were manually sorted on-board immediately upon collection. In total, 14 pipefish specimens were collected at eight stations (Figure 1). The specimens were identified to the species level on-board according to a region-specific identification guide (Richards, 2005) by counting the number of trunk and tail rings and fin rays of the dorsal and pectoral fins. The specimens were subsequently photographed using a Canon EOS 5D Mark III camera with a Canon EF 100 mm/2.8 L Macro lens on a light board equipped with a millimeter scale, after which they were placed in ethanol (99%) and stored at room temperature. Morphometric measurements were

TABLE 1 Data for pugnose pipefish, *Brynx dunckeri*, samples: date collected, collection site number (station), latitude and longitude, total length (TL), standard length (SL), and snout length (from tip of snout to front edge of eye) measured from photos using ImageJ.

Date	Station	Lat (°N)	Long (°W)	TL (mm)	SL (mm)	Snout (mm)
March 27, 2023	12	24°30	66°59	51	49	2.1
March 29, 2023	15	23°00	67°00	49	47	2.1
March 29, 2023	16	22°30	66°59	51	49	2.2
March 30, 2023	18	20°29	65°26	33	33	1.8
March 31, 2023	20	19°29	63°59	40	39	2.0
March 31, 2023	21	20°00	64°00	56	54	2.5
March 31, 2023	21	20°00	64°00	47	45	2.1
March 31, 2023	21	20°00	64°00	46	45	2.2
March 31, 2023	21	20°00	64°00	46	44	2.1
March 31, 2023	21	20°00	64°00	49	47	2.0
March 31, 2023	21	20°00	64°00	38	36	1.7
March 31, 2023	24	21°30	63°59	53	51	2.1
March 31, 2023	24	21°30	63°59	52	51	2.2
April 6, 2023	45	31°00	63°59	47	45	2.0

subsequently conducted from the photos using the open-source software ImageJ (version 1.53) (Schneider et al., 2012) using the straight or segmented line tool with appropriate magnification. After the ship's arrival back at the Thünen Institute of Fisheries Ecology (Bremerhaven, Germany), species identification was verified with genetic analysis. The methods were similar to those described in Marohn et al. (2021). DNA was extracted using a Chelex-based method (Walsh et al., 1991) and amplified by PCR for DNA barcoding using the mitochondrial marker cytochrome c oxidase I (COI). The sequencing of the PCR products was carried out by a service lab (StarSEQ GmbH, Mainz, Germany), and forward and reverse DNA sequences were checked and trimmed before generating consensus COI sequences for each sample. To verify the species identification, all sequences were aligned and compared with BioEdit Sequence Alignment Editor (Copyright 1997–2013 Tom Hall) and verified by nucleotide BLAST against NCBI database (Altschul et al., 1990).

The 14 pipefish samples were identified on-board as the pugnose pipefish *B. dunckeri*. Meristic counts included 17 trunk rings (dermal plates, starting at the pectoral-fin base, ending at the anal), and 31–33 tail rings (starting behind the anal, ending at the caudal fin, excluding the plate bearing the caudal fin). These measurements are in accordance with Richards (2005) and within the range presented by Dawson (1982) (trunk: 15–18, with 16–17 being the most common, tail: 30–36, with 31–33 being the most common, Table XLVII in Dawson, 1982). Fin ray counts included 21–27 dorsal-fin rays, 10 pectoral-fin rays, and 10 caudal-fin rays (all pipefish genera have 10 rays in the caudal fin), which is in accordance to Richards (2005) and within the range presented in Dawson (1982) (dorsal fin: 21–27, with 23–25 being the most common, pectoral fin: 9–13, with 10–12 being the most common, Table XLVIII in Dawson, 1982). *B. dunckeri* does not possess an anal fin. The morphological species identification was later confirmed with 99.6%–100% certainty in the genetic analysis. The pipefish specimens exhibited orange to pink colouration, varying from light to relatively dark (Figure 1), but it should be noted that the

individuals were dead after collection from the trawl and hence colors could have already changed. Color was not used as a species identification trait. The snout is distinct, slightly curved, and round at the tip (Figure 1), explaining the common name “pugnose.” The average total length of the collected specimens was 47 mm (33–56 mm, min–max), with an average snout length of 2.1 mm (1.7–2.5 mm, min–max) (Table 1; Figure 1). Reports on the maximum recorded total length of this species varies between sources, maximum 95 mm is reported in Dawson (1982), with a note that the species probably does not exceed 100 mm. Maximum 100 mm is also reported in the Red List assessment (Williams et al., 2015). Other notes on maximum length include 80 mm in Sterrer and Schoepfer-Sterrer (1986), and 75 mm in Froese & Pauly (2023); Robins & Ray (1986). Most of the specimens collected during the survey fall within the length range classified as “young and subadults” (35–51.5 mm) according to Dawson (1982). Consequently, they were designated as juveniles based on this size range and their overall morphology, as well as the absence of distinct sex-specific characteristics. Developing brood pouches have, however, been observed in males as small as 42 mm, but brooding males are generally larger (Dawson, 1982). Brooding males have been recorded for all months except January and September (Böhlke & Chaplin, 1968; Dawson, 1982).

B. dunckeri was originally described as insular or “semi-pelagic” (Herald, 1942), but the species was later shown to occupy a variety of habitats from mainland estuaries to coral reefs (Dawson, 1982). Its association with drifting seaweed far offshore over deep waters was previously based only on anecdotal records of single individuals (Dawson, 1982). A study investigating species composition in floating sargassum in coastal waters versus open water, conducted off the coast of North Carolina, recorded eight individuals of *B. dunckeri* in sargassum and one in open water, when sampling the upper meter of the water column using a neuston and dip net (Casazza & Ross, 2008). Although that particular study was conducted comparably close to the coast (approximately 77–76° W, 33–35° N), in which most of the

specimens were smaller in size (reported standard length: 28–47 mm, min–max) compared to our collected specimens, the results indicate that *B. dunckeri* is likely associated with sargassum rather than found in open water. It is, therefore, likely that the pipefish caught in this study were also present in the upper water layers in the floating sargassum, but data on depth distribution and habitat were not assessed. The floating sargassum seaweed, mainly consisting of *Sargassum natans* and *Sargassum fluitans*, is the world's only self-sustaining community of holopelagic algae (Trott et al., 2011). The algal mats provide the only form of structure in the open ocean (Trott et al., 2011), and hence constitute the most likely habitat for a weak-swimming species such as *B. dunckeri*, providing shelter and feeding opportunities.

Another question that arises is whether our findings signify rare occurrences, or if the investigated area is indicative of a more consistent distribution, potentially even serving as a breeding site. The dispersal of juveniles in relatively close proximity to continental structures could be a strategic tactic that ensures genetic exchange and opportunities to colonize new areas. Although any such inference would be far beyond the scope of this paper, speculations are warranted. Based on our discovery of 14 specimens, these findings likely do not signify random occurrences. In addition, at least seven pipefish were collected during a previous fishery research cruise in approximately the same area (conducted from March to April 2017 with Walther Herwig III, cruise number WH-404, for methods, see e.g., Lüsckow et al., 2019). These pipefish samples were also identified as *B. dunckeri*. One of the samples was included in our genetic analysis for this study and was conclusively confirmed as *B. dunckeri*. The previous reports of this species relatively far offshore (OBIS <http://www.iobis.org>) also support the assumption that the occurrence of *B. dunckeri* in this area does not constitute random occurrences. Studies on the population structure of syngnathids have generally revealed high structuring and relatively high genetic diversity, indicating large effective population sizes and limited dispersal abilities (reviewed in Mobley et al., 2011). These findings are consistent with the apparent relationship between life-history traits and past and present geographical distributions of syngnathids (Mobley et al., 2011). The majority of species within Syngnathidae are poor swimming and habitat specialists that rely heavily on crypsis for their survival (Vincent et al., 1995). As mentioned earlier, all syngnathids produce free-living juveniles (Hasse, 1974; Mi et al., 1998; Monteiro et al., 2003) with short (Planas et al., 2012; Wilson & Vincent, 2000) or absent pelagic dispersal phases (Silva, Monteiro, Almada, & Vieira, 2006; Silva, Monteiro, Vieira, & Almada, 2006), which limits the potential for dispersal (Grantham et al., 2003). Exceptions to these established patterns exist, often interpreted as outcomes of recent colonization events. These events are believed to result from the drifting of juvenile individuals via floating vegetation along ocean currents. It is predominantly observed in seahorses (Fedrizzi et al., 2015; Nickel & Cursons, 2012; Teske et al., 2005). Pelagic dispersal has also been reported in pipefish. For example, the opossum pipefish *Micropis lineatus* spawns in low salinity areas of estuaries in the West Atlantic (Frias-Torres, 2002; Froese & Pauly, 2023). Juveniles of this species, generally described as migratory (Frias-Torres, 2002, Froese & Pauly, 2023), have also

been found in floating sargassum with a similar distribution to *B. dunckeri*. Similarly, the northern pipefish *Syngnathus fuscus* has been observed to undertake seasonal migration between estuaries and nearshore continental shelf waters (Lazzari & Able, 1990). Perhaps the most well-studied pipefish example is represented by the snake pipefish *Entelurus aequoreus* that has been reported to occur far offshore (Ehrenbaum, 1936; Holt & Byrne, 1906; Kloppmann & Ulleweit, 2007). Unlike most other syngnathids, *E. aequoreus* is primarily described as oceanic, displaying a pelagic lifestyle, found in both coastal and oceanic waters on depths up to 100 meters (Ehrenbaum, 1936, Holt & Byrne, 1906, Kloppmann & Ulleweit, 2007). It has been hypothesized that there could be self-sustained populations of snake pipefish occurring in the open ocean, exhibiting distinct phenotypes or ecotypes associated with different coastal and pelagic habitats (Kloppmann & Ulleweit, 2007; van Damme & Couperus, 2008). This hypothesis, however, appears unlikely, given the absence of significant population differentiation or genetic evidence supporting distinct coastal or pelagic ecotypes (Braga Goncalves et al., 2017). The lack of population structure was rather attributed to a pelagic lifestyle and long distance dispersal mechanisms aided by ocean currents (Braga Goncalves et al., 2017). Whether *B. dunckeri* should be designated as a migratory species or potentially maintains self-sustained oceanic populations remains to be answered, but it is unlikely based on insights derived from studies on other pipefish species (Braga Goncalves et al., 2017; Mobley et al., 2011). The identification of *B. dunckeri* in the Sargasso Sea reported here not only expands the recognized geographical range of this species but also presents an intriguing opportunity for future research into its population structure.

AUTHOR CONTRIBUTIONS

Conceptualization: J. Sundin. Methodology: J. Sundin, M. Freese, L. Marohn, T. Blancke, and R. Hanel. Formal analysis: J. Sundin, T. Blancke, and M. Freese. Resources: J. Sundin, M. Freese, L. Marohn, and R. Hanel. Data curation: J. Sundin, T. Blancke, M. Freese. Writing—original draft: J. Sundin. Writing—review and editing: J. Sundin, M. Freese, L. Marohn, T. Blancke, and R. Hanel. Visualization: J. Sundin and M. Freese.

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CONFLICT OF INTEREST STATEMENT

The authors have no conflict of interest to declare.

DATA AVAILABILITY STATEMENT

The data used for descriptive statistics are archived in the figshare repository, together with high-resolution images of all the pipefish samples (<https://figshare.com/s/62043c1b9a5680b15925>, DOI: 10.6084/m9.figshare.24293566), following best practices guidelines for public data archiving (Roche et al., 2015).

ORCID

Josefin Sundin  <https://orcid.org/0000-0003-1853-4046>

Marko Freese  <https://orcid.org/0000-0001-8919-6318>

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