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Anguilla rostrata leptocephali in the Sargasso Sea during February and March 1981

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Abstract

A survey cruise was conducted in the southern Sargasso Sea between 13 February and 5 March 1981 to determine the horizontal distribution and size frequency of 0-group *Anguilla rostrata* leptocephali. At 29 stations a single standardized oblique tow was taken using a 3 m Isaacs-Kidd midwater trawl. A total of 341 *A. rostrata* leptocephali, identified by myomere counts, and ranging from 3.9 to 17.0 mm in total length (TL), were collected. Specimens ≦ 9.0 mm TL were taken between lat. 20-26° N and long. 63-76° W while specimens ≧ 9.1 mm TL were only found west of long. 69° W. The largest catches of specimens were also taken west of this meridian. Only six *A. anguilla* leptocephali, ranging from 4.8 mm to 40.3 mm TL, were collected. Data for *A. rostrata* leptocephali from this cruise was combined with data taken from two publications to develop linear regression statistics for specimen TL on Julian date of collection. The equation for the linear regression is: $y = 0.243x - 7.568$ where y = TL of leptocephalus and x = Julian date of collection.

Introduction

The spawning areas of the American eel, *Anguilla rostrata* (LeSueur), and the European eel, *A. anguilla* (Linnaeus), were outlined in the early part of this century by Schmidt (1922). By plotting the geographic position of leptocephali collected in the North Atlantic Ocean he concluded that the two species spawn in contiguous areas of the southern Sargasso Sea. However, Schmidt was primarily interested in the commercially important European eel and his data for the American eel are incomplete. Vladykov (1964) noted that the proposed spawning area of the American eel had never been adequately sampled and that its delineation was based on a small number of leptocephali of unknown age. Furthermore, few samples were taken during the late winter and early spring, the proposed time of spawning.

Subsequent studies further described the distribution of *A. rostrata* leptocephali but again sampling in the proposed spawning area during the spawning season was limited. Smith (1968) examined samples taken from April to August in the Florida Straits and off the Bahamas. Eldred (1968 & 1971) studied collections made in the Florida Straits in August and Yucatan Straits during July. Vladykov & March (1975) provided data on collections from the North Atlantic Ocean, but only five samples were taken from the western edge of the spawning area during January, February, and March. While sampling the adjacent spawning area of *A. anguilla* from mid-March to mid-April, Schoth & Tesch (1982) collected *A. rostrata* leptocephali at their westernmost stations.

Our laboratory conducted a survey cruise in the southern Sargasso Sea aboard the RV *Columbus Iselin*. Our overall objective was to determine the horizontal distribution and size frequency of 0-group *A. rostrata* in the proposed spawning area early in the spawning season. In addition we used data obtained on this cruise, data reported by Schoth & Tesch (1982), and historical data compiled by Kleckner & McCleave (1985) to develop a growth curve for *A. rostrata*.

Specimen and station data for both Atlantic species collected during the *Columbus Iselin* cruise in 1981 are listed in Kleckner *et al.*, 1985, pp. 127-128.

Material and methods

Sampling was conducted between 13 February and 5 March 1981. At 29 stations (Fig. 1) a single plankton sample was collected in a standardized oblique tow using a 3 m Isaacs-Kidd midwater trawl (IKMT) fully lined with 0.5 mm Nitex netting and having a mouth area of 8.7 m^2. Standard tow characteristics were (mean $\pm$ 1 standard error, range): maximum depth = 320 $\pm$ 11 m, 270-500 m; time to maximum depth = 26 $\pm$ 1 min, 19-40 min; fishing time = 94 $\pm$ 3 min, 38-126 min; ship's speed approximately 3.5 km/h. One transect was made across a thermal front (Fig. 1), an area where the horizontal temperature gradient is steep ($>$1 °C/10 km). Samples were taken across the front to determine if this oceanographic feature might represent a northern limit to the spawning area. This aspect of the cruise is discussed elsewhere (Kleckner *et al.* 1983).

Plankton samples were immediately preserved in 5% (v/v) formalin buffered with $CaCO_3$. Sorting was conducted in the laboratory. *Anguilla* sp. were separated from other leptocephali by the criteria of Smith (1979). Myomere counts, including the five incomplete pharyngeal segments and excluding the extreme caudal segments with fibers not paralleling the main body axes, totaling 102-111 and 112-119 were used to distinguish *A. rostrata* and *A. anguilla*, respectively. Total length (TL) was measured from the anterior tip of the teeth to the tip of the caudal fin rays. The total length was not adjusted for shrinkage due to preservation. Following the convention of Jespersen (1942) the position of the third vertical blood vessel was determined by counting the number of myomeres anterior to the vessel where it joins the dorsal aorta.

Volume of water strained was estimated from calibrated flow meters suspended in the mouth of the net except for stations 20, 48, and 50 where the meters failed. For these three stations the regression equation of flow meter reading on tow duration was used to estimate a meter reading from tow duration. The computed reading was then multiplied by the mean calibration value. In order to compare abundances the catch in numbers of specimens/10^5 m^3 of water strained was computed for each station.

The general linear models procedure was used to compute linear regression statistics of specimen TL on Julian date of collection for 0-group *A. rostrata* leptocephali collected during this cruise combined with specimens reported by Schoth & Tesch (1982) and Kleckner & McCleave (this volume). Following the method of Kleckner & McCleave (1985) 0-group leptocephali were defined as those

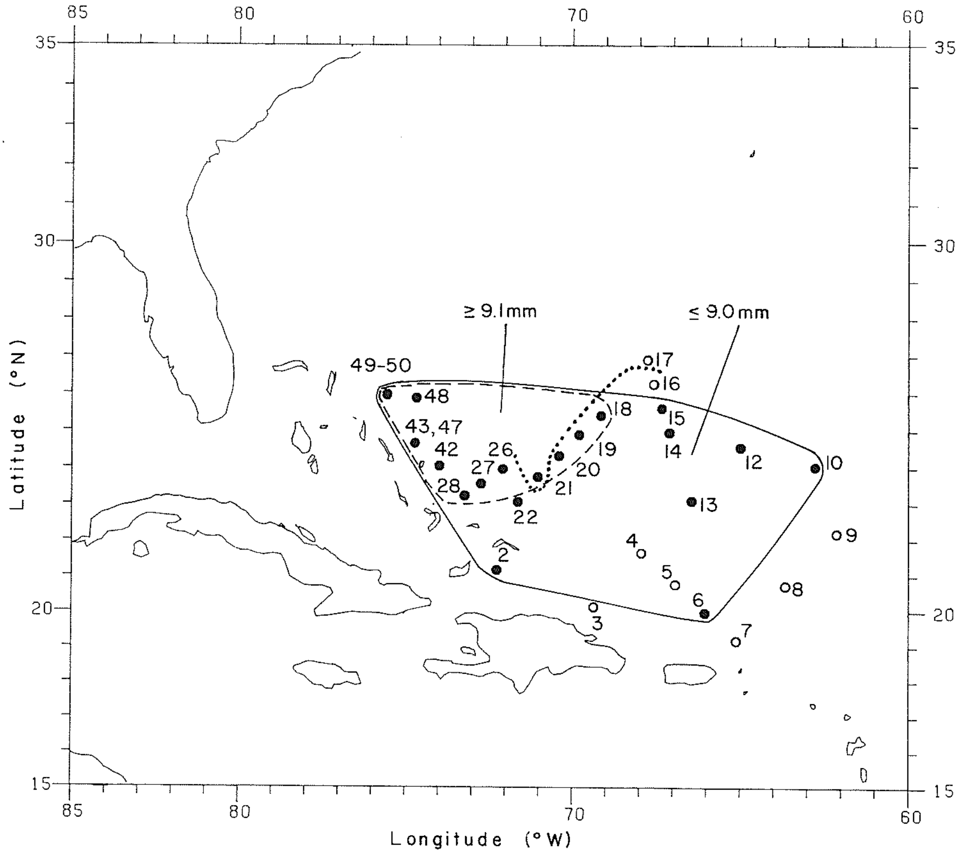

Fig. 1. Horizontal distribution of *Anguilla rostrata* leptocephali. Limits of specimens ≦ 9.0 mm TL indicated by solid line. Dashed line indicates limits of specimens ≧ 9.1 mm TL. Solid circles represent stations positive for leptocephali. Open circles are negative stations. IKMT station numbers are adjacent to circles. Approximate position of thermal front indicated by dotted line.

collected between 1 January (day 1) and 15 October (day 287). Specimen shrinkage due to fixation and preservation would underestimate the slope and intercept of the linear regression equation.

Results

A total of 341 *A. rostrata* leptocephali, ranging from 3.9 to 17.0 mm TL, was collected. The mean TL for all specimens was 7.8 mm. Only six *A. anguilla* leptocephali, ranging from 4.8 to 40.3 mm TL were collected.

Eight of the 29 stations sampled were negative for *A. rostrata* leptocephali (Table 1; Fig. 1). Six of the negative stations (3-5, 7-9) were located south of lat. 23°N and east of long. 70°W. Only one station (6) within this area was positive for

Table 1. Station, number of *Anguilla rostrata* leptocephali/$10^5 m^3$ water strained and specimen TL data. Numbers in parentheses are actual numbers of leptocephali caught.

Station	Number specimens per $10^5 m^3$	Mean TL (mm)	SD	Range (mm)	Station	Number specimens per $10^5 m^3$	Mean TL (mm)	SD	Range (mm)
2	7(2)	4.4	0.0	4.4	18	29(11)	8.7	2.6	4.9-13.2
3	0(0)	–	–	–	19	61(32)	7.9	2.1	4.7-12.2
4	0(0)	–	–	–	20	176(65)	8.4	2.1	5.0-17.0
5	0(0)	–	–	–	21	2(1)	6.0	–	6.0
6	12(5)	7.3	0.9	6.0-8.5	22	16(6)	6.3	1.6	4.3- 7.8
7	0(0)	–	–	–	26	51(22)	5.8	1.7	3.9-10.8
8	0(0)	–	–	–	27	68(36)	9.0	2.0	4.5-13.8
9	0(0)	–	–	–	28	78(39)	8.9	2.2	4.6-12.6
10	2(1)	7.4	0.0	7.4	42	31(13)	6.2	1.7	4.0- 9.0
12	11(7)	6.4	1.2	5.2-7.8	43	10(5)	8.6	1.7	6.3-11.1
13	5(2)	6.7	2.5	4.9-8.4	47	20(10)	11.1	2.1	8.8-15.7
14	6(3)	8.2	0.7	7.5-8.8	48	87(42)	6.8	1.9	4.5-11.7
15	5(3)	8.0	0.4	7.6-8.3	49	6(2)	6.3	2.3	4.6- 7.9
16	0(0)	–	–	–	50	16(7)	7.9	2.7	4.4-12.3
17	0(0)	–	–	–					

A. rostrata. Two negative stations (16-17) were also taken on opposite sides of a thermal front near long. 67°40′ W. A single *A. anguilla* leptocephalus was found at each of stations 14, 17, and 42. These specimens were 39.0 mm, 40.3 mm and 4.8 mm TL, respectively. The three leptocephali collected at station 20 were 6.2 mm, 8.1 mm and 10.2 mm TL.

A. rostrata leptocephali $\leqq$ 9.0 mm were more widely distributed than leptocephali with a TL $\geqq$ 9.1 mm (Fig. 1). Specimens belonging to the smaller size range were taken from the area bounded by lat. 20-26°N and long. 63-76°W. Specimens in the larger size class were only found west of long. 69°W.

Stations west of long. 69°W and north of lat. 23°N yielded catches of *A. rostrata* >20 specimens/$10^5 m^3$. To the east and south of this area catches contained $\leqq$ 20 specimens/$10^5 m^3$ (Table 1).

Combining data from our specimens with data reported by Schoth & Tesch (1982) and Kleckner & McCleave (1985) the equation for the linear regression of specimen TL on date of collection is:

$$y = 0.243x - 7.568 \qquad (1)$$

where y = TL of leptocephalus (mm) and x = date of collection (N = 5990; r^2 = 0.88). The linear regression coefficient has 95 % confidence limits of 0.241 to 0.245.

Myomere counts for *A. rostrata* leptocephali ranged from 104-111 with the mean being 107.320 (Table 2). In 83 % of the leptocephali the third vertical blood vessel was found at or just posterior to myomere 45 or 46. The overall range of its position was from myomere 42-48.

Table 2. Frequency and per cent frequency distribution of myomere counts for *Anguilla rostrata* leptocephali.

Number of myomeres	Frequency	Per cent
104	5	1.5
105	18	5.3
106	56	16.4
107	112	32.8
108	95	27.9
109	45	13.2
110	9	2.6
111	1	0.3

Discussion

The size at hatching of *A. rostrata* leptocephali is unknown. However, the leptocephali of a closely related species, *A. japonica* (Ege, 1939), are 2.9 mm long upon hatching (Yamamoto *et al.* 1975). Assuming that *A. rostrata* leptocephali are 2.9 mm at hatching and that they grow at a rate of 0.243 mm/day (from equation (1)) the smallest leptocephali we collected (3.9 mm TL) would be approximately four days old. This rate of growth may be conservative for newly-hatched leptocephali. *A. japonica* attained a length of about 6 mm five days after hatching (Yamamoto & Yamauchi, 1974).

Peak spawning by the American eel is assumed to occur during February (Schmidt, 1922; Harden Jones, 1968). Equation (1) predicts that newly-hatched leptocephali, assumed to be 2.9 mm TL, are spawned on 12 February (day 43).

The largest catches of small leptocephali occurred in the northwest just south of a thermal front separating the surface water mass of the northern Sargasso Sea from that of the southern Sargasso Sea. We have hypothesized (Kleckner *et al.* 1983) that some features of this southern water mass serves as a cue for adult *A. rostrata* swimming south to cease migration and begin spawning. The thermal front would form the northern limit of the spawning area. Similarly, adult eels from the Greater Antilles Islands may migrate north until they leave shelf water and encounter the surface water mass of the southern Sargasso Sea. The small leptocephali taken at stations 2 and 6 may be the offspring of these eels.

Schoth & Tesch (1982) reported collecting 20 *A. rostrata* leptocephali <7 mm long at their westernmost stations during 1979. These leptocephali were taken between lat. 24-27°N and long. 60-70°W. Their largest collection of specimens <7 mm were made in the vicinity of our stations 14, 15, 18, and 19. Samples taken east of long. 60°W and those taken north of lat. 27°N on a transect along long. 66°W were negative for *A. rostrata* <7 mm. Samples south of lat. 24°N from long. 57-65°W were also negative. Three of our stations (7-9) were within this area and were negative for *A. rostrata.*

The per cent frequency distribution of myomere counts for *A. rostrata* leptocephali collected on this cruise (Table 1) was similar to the distribution obtained by Kleckner & McCleave (1985; Table 1) for 1932 specimens; the range of 102-111 myomeres they listed has a mean myomere frequency of 106.885. Myomere counts for specimens from this cruise range from 104-111 with a mean of 107.320. The mean position of the third vertical blood vessel for our specimens was myomere 46. Schoth (1982) obtained the same value for 731 *A. rostrata* leptocephali collected in 1979.

In summary this cruise represents the largest sampling effort in the proposed spawning area of *A. rostrata* during the late winter. The resulting collections produced the smallest leptocephali ever reported and expanded the data base of small specimens. The larger number of specimens of all sizes in the northwest may be the result of intensive spawning in the area or concentration by surface currents.

Acknowledgments

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