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A MULTISPECIES AGGREGATION OF CIRRATE OCTOPODS TRAWLED FROM NORTH OF THE BAHAMAS

Michael Vecchione

ABSTRACT

Two cruises in the western North Atlantic collected 38 trawl samples between the Bahamas and New England. Of the 22 cirrate octopods taken in these samples, 17 came from the area north of the Bahamas. Pooled catch rate (specimens per hour of bottom trawling time) was significantly higher north of the Bahamas than in any other area sampled. Although the taxonomy of these gelatinous benthopelagic cephalopods is not yet settled, morphological characters from these specimens indicate that this aggregation includes at least four species. Only one species (*Cirrothauma murrayi*) was widely distributed in these samples.

Until recently, sampling of the deep sea with large bottom trawls has been limited, and as a result cirrate octopods have been quite rare in collections (Aldred et al., 1983). This problem is compounded by the fact that their delicate bodies are frequently damaged almost beyond recognition in trawl samples. Even specimens collected in good condition are easily deformed by preservatives. Thus, the taxonomy of suborder Cirrata is currently in disarray.

The only quantitative study of cirrate distribution to date (Roper and Brundage, 1972) was based on examination of a large number of deep benthic photographs from the western North Atlantic. They determined that cirrates are benthopelagic and are found at depths usually >1,000 m. Regional variability in abundance was noted based on the number of cirrates photographed per unit of calculated bottom area. Of the areas for which they had the most data, they found that abundance was highest in the Virgin Islands Basin, intermediate in the Blake Basin, and very low in the vicinity of Bermuda and the Northeast Channel off New England. This distribution may be based on increased abundance in enclosed basins, high productivity near islands, or a latitudinal gradient in abundance.

Identification of the specimens in their photographs was based on external morphology; they tentatively assigned their specimens to *Cirroteuthis* sp. However, G. L. Voss (pers. comms., University of Miami, 1984), who is preparing a monograph on the cirrates, has found that internal characters must be used for identification of these animals to genus and species.

I present data on specimens trawled from the western North Atlantic. These data allow examination of the distributional patterns inferred from Roper and Brundage's (1972) photographic study, including information on the taxonomic composition of the cirrate fauna. Observations on stomach contents and the possibility of bioluminescence by cirrates are also presented.

MATERIALS AND METHODS

All specimens reported here were collected with semi-balloon otter trawls (13.8 m headrope length). This gear was used on two cruises in the western North Atlantic. During March 1978, COLUMBUS ISELIN cruise 7802 sampled 19 stations including a transect between Miami and Bermuda and a cluster of stations off the Middle Atlantic Bight. COLUMBUS ISELIN cruise 8007 was conducted during September 1980 and sampled 6 stations within semi-enclosed basins in the Bahamas as well as 13 stations between the Bahamas and the southern part of the Hatteras Abyssal Plain (Fig. 1).

Trawling time was measured as the amount of time the gear was on the bottom from set to haul and varied from 20 min to 5.3 h, but most stations were trawled between 1.5–3.0 h. Trawling speed was generally 1.9–5.6 km/h, measured by timed changes in LORAN-C fix. Bottom depths were

Figure 1. Locations of trawling stations. Square symbols: Columbus Iselin cruise 7802, March 1978; round symbols: Columbus Iselin cruise 8007, September 1980. Filled symbols indicate stations at which cirrates were collected, numbers indicate standardized catch rate (cirrates/hour). Boundaries separate geographic areas presented in Table 2.

measured by precision depth recorder. All but two stations (220 and 918 m) were at depths >1,000 m and thus were within the depth range of cirrate octopods.

Because many of the specimens were fragmented, counts are based on the number of buccal/arm assemblages in the sample. Internal taxonomic characters which I examined included the structure of the gills, the eyes, optic lobes, and nerve bundles, and the cartilaginous fin support or shell vestige.

Differences in capture rate among areas were tested by analysis of variance. Because homogeneity of variances could not be assumed, I first used the non-parametric Kruskal-Wallis test. Since this conservative test allowed me to reject the null hypothesis that differences among the areas could be explained by random variability, a more powerful parametric test, the Student-Newman-Keuls multiple range procedure, was used for *a posteriori* comparisons to determine the pattern of differences among areas.

RESULTS

Distribution.—Cirrate octopods were collected at 8 of the 38 stations sampled on these cruises. In all, 22 specimens were collected, as many as 8 from a single station. When standardized to specimens per hour of trawling time, numbers at positive stations ranged from 0.3 to 3.3 cirrates per hour (Fig. 1). Depths at which cirrates were collected ranged from 1,093 to 5,043 m.

At three stations clustered north of the Bahamas, standardized capture rates were >2/h; these were the only stations where standardized abundance was >1/h. Two of these stations accounted for 15 of the 22 cirrates collected on these cruises. In all, 17 cirrates were taken at four of six stations located just north of the Bahamas.

A single specimen was collected in the Tongue of the Ocean. This was the only cirrate taken in the six stations from within the semi-enclosed basins in the Bahamas. Furthermore, no cirrates were collected from the Bermuda Pedestal or from the Caryn Seamount.

The remaining four specimens came from relatively close to the continental margin. Three were taken in the vicinity of the Blake Escarpment (one specimen on the Blake Plateau and two in the Blake-Bahamas Basin), and one on the continental rise off New England. None of the other samples from the Hatteras Abyssal Plain, Bermuda Rise, and continental rise included cirrates.

Taxonomic Composition.—Two specimens were identified without dissection as the blind octopod, *Cirrothauma murrayi.* They included the only cirrate collected from the Middle Atlantic Continental Rise and one of the three cirrates from the area of the Blake Escarpment. G. L. Voss identified three specimens from north of the Bahamas and one from the Blake-Bahama Basin. Those in the former group included one specimen of the presently monotypic genus *Cirroteuthis,* although *C. muelleri* has heretofore been recorded only from northern latitudes. The remaining specimens were all assigned to the genus *Grimpoteuthis.* The Blake-Bahamas specimen was not identified to species, but the other two specimens were identified as *G. grimaldii* and *G.* (*megaptera*?).

Eleven specimens were dissected to examine the internal taxonomic characters mentioned above. Four types of optic assemblages (eye, optic nerve, optic lobe, and white body) were found (Table 1). Similarly, four types of cartilaginous fin support were also found. Gills included both the "half-orange" type (Voss, 1982) and the sepioid type characteristic of *Cirroteuthis* and *Cirrothauma.* The group of cirrates trawled from north of the Bahamas included three of the fin-support types, both of the gill types, and all four of the optic morphotypes.

Notes on Cirrate Biology.—A freshly collected *Cirrothauma murrayi* was examined and photographed in full light, in the dark, and under ultraviolet light; no evidence of bioluminescence was noted. The Ektachrome transparencies taken under ultraviolet light have subsequently been reexamined, paying particular attention to the bases of the suckers where organs presumed to be photophores have been described (Chun, 1910; Aldred et al., 1983; but also see contradictory evidence by Aldred et al., 1984), but again, no bioluminescence was evident.

The stomachs of five specimens were opened. Two were empty and two contained a few crustacean fragments. One stomach, including the esophagus all the way to the buccal mass, was packed with crustacean fragments. All identifiable fragments were from large, presumably benthopelagic, copepods. No other identifiable food types were found.

Table 1. Morphotypes of cirrates examined, based on internal characteristics

Type	Fin support	Eye	Optic nerve	Optic lobe	White body	Gills	Probable ID*
1	Narrow U	Large	Multiple	Kidney	Off-center	½ Orange	*Opisthoteuthis* sp.
2	Narrow U	Large	Multiple	Large	Centered	½ Orange	*Grimpoteuthis* sp.
3	Long-wing	Regressed	Double	Very small	Large, by eye	Sepioid	*Cirrothauma murrayi*
4	Short-wing	Small†	Single	Small	Small, by eye	Sepioid	*Cirroteuthis* (?*muelleri*)
5	Open U	unknown	unknown	unknown	unknown	unknown	(*Grimpoteuthis* or *Opisthoteuthis*)

* G. L. Voss, pers. comm., University of Miami, 1984.

† Eyes were damaged on all specimens of this type, but presumably had lenses and were functional, in contrast to the regressed eye type.

Table 2. Summary of trawling effort and capture rate (specimens per hour) pooled by geographic area

Area*	Description	Stations	Hours trawled	Specimens	Rate
I	Miami Terrace	1	0.5	0	0.00
II	Bahamas†	6	9.5	1	0.11
III	North of Bahamas	6	18.4	17	0.92
IV	Blake Escarpment‡	7	13.5	3	0.22
V	Southern Oceanic§	7	15.7	0	0.00
VI	Bermuda Pedestal	1	0.5	0	0.00
VII	Middle Atlantic Continental Rise	7	9.0	1	0.11
VIII	Caryn Seamount	3	5.0	0	0.00

* See Figure 1.
† Includes Tongue of the Ocean, Exuma Sound and Crooked Passage.
‡ Includes Outer Blake Plateau and Blake-Bahama Basin.
§ Includes Outer Ridge, Hatteras Abyssal Plain and Bermuda Rise.

DISCUSSION

Problems of cephalopod sampling are notorious (Wormuth and Roper, 1983). Thus, interpretation of distributional patterns based on relatively few collections should be approached with caution. However, these cirrate distributional patterns appear to be sufficiently distinct to warrant statistical testing.

To test statistically for differences in cirrate capture rate among the areas sampled, it was necessary to set boundaries subjectively around the areas. The resulting groups of stations are detailed in Figure 1 and Table 2. Based on the Kruskal-Wallis test, differences among the six areas with three or more samples could not be explained by random variability (Chi-square = 10.9; $P = 0.05$). The Student-Newman-Keuls multiple range procedure demonstrated that the area north of the Bahamas was characterized by significantly ($P < 0.05$) greater capture rates than any other area sampled. All of the other areas combined to form a homogeneous subset in which the mean capture rates did not differ by more than the shortest significant range.

It is worth noting, however, that capture rate in the vicinity of the Blake Escarpment was twice as high as that of either the enclosed basins of the Bahamas or the Middle Atlantic Continental Rise. The Blake-Bahama Basin extends from the Escarpment to the area north of the Bahamas, and is separated from the Hatteras Abyssal Plain by the Blake-Bahama Outer Ridge (Emery and Uchupi, 1972). Some evidence exists indicating a distinct deep-circulation cell in the Blake-Bahama Basin (Riser et al., 1978). Thus, the cirrates collected near the Escarpment may conceivably represent an extension of the aggregation found north of the Bahamas.

The absence of cirrates from trawl samples in some areas investigated here is not proof that none exist in these areas. For instance, G. L. Voss (pers. comm.) collected three cirrates in two tows midway between Bermuda and the Puerto Rico Trench. Whereas I collected no cirrates near Bermuda, Roper and Brundage (1972) found one cirrate in 10,300 deep benthic photographs covering approximately 0.9 km^2 of bottom near Bermuda. Given random variability, though, these studies agree on low relative abundance of cirrates in these areas.

The present study also agrees with Roper and Brundage (1972) on low relative abundance of cirrates off New England. This low abundance may be a result of unsuitable physical conditions in the deep benthopelagic environment between Cape Hatteras and Nova Scotia. This is an area with a high-energy benthic boundary layer (Hollister and McCave, 1984) caused by the high-velocity core of the Western Boundary Undercurrent (Bulfinch et al., 1982). This area is characterized by a permanent nephaloid layer (Eittreim et al., 1969; Eittreim et al., 1975), marked short-term variability (Greenewalt and Gordon, 1978), and frequent erosion-and-sedimentation events associated with "abyssal storms" (Hollister and McCave, 1984). Since cirrate octopods are typically photographed drifting in a "drogue-like" posture (Roper and Brundage, 1972), such an environment may be too rigorous for them; cirrates may be swept out of areas with high bottom-current velocities.

The deep sea off New England does support a benthopelagic fauna dominated by large fishes (Haedrich and Rowe, 1977). These fishes, however, are primarily macrourids, which are quite mobile and probably subsist on large "food falls" (J. A. Musick, cited in Marshall, 1979, pp. 281–282). This contrasts with the ecology of cirrates, which appear often to drift passively, presumably feeding on planktonic copepods which are concentrated very near the bottom at least in some areas of the deep sea (Wishner, 1980). The Western Boundary Undercurrent is deflected eastward by the Blake-Bahama Outer Ridge (Amos et al., 1971). Thus, the Blake-Bahama Basin is presumably protected from these disturbances.

Because of the sampling design, I cannot dismiss the possibility that the distribution reported here reflects interannual variability rather than spatial variability. However, these two cruises overlapped in the area of the Blake Escarpment and cirrate capture rates were similar in this area for both cruises. My low capture rates off New England concur with the much earlier observations of Roper and Brundage (1972), as do my results for the Blake-Bahama Basin and Bermuda.

In summary, analyses of internal taxonomic characters indicate that at least four and perhaps five or more species are sympatric in the southern waters of the western North Atlantic. These species are found to have abundances higher in the area north of the Bahamas than in the other areas sampled, perhaps because of deep circulation patterns. The only species which I found to be widely distributed in my samples was *Cirrothauma murrayi*, a species which has been documented in discrete-depth midwater collections (Aldred et al., 1983; Roper and Brundage, 1972). These observations support those of Roper and Brundage (1972) that a latitudinal gradient in cirrate abundance exists in the western North Atlantic. This gradient may result from physical interaction between the inferred drifting lifestyle of the benthopelagic cirrates and near-bottom currents.

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