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Coastal-Oceanic planktonic distribution of natantia shrimps in the Florida Keys, U. S. A.

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Resumen: Veinte y un taxones de larvas de carideos y peneideos, y camarones micronectónicos fueron identificados del plancton recolectado en Looe Key National Marine Sanctuary, Florida, U.S.A., (28 mayo-2 junio, 1989). Un análisis estadístico de componentes principales no confirmó cuales son los factores ambientales que controlan la distribución de las especies pero sí detectó consistencia en las distribuciones de los taxones con un supuesto gradiente ambiental costero-oceánico y con los ciclos de vida de las especies.

Key words: Distribution, planktonic natantia, Florida Keys.

The heterogeneity of the marine pelagic environment makes it difficult to describe faunal associations and their interrelationships with the environment. Detailed studies of horizontal and vertical distribution of pelagic and mesopelagic species of decapod crustaceans in light of ocean circulation features may help to improve understanding of the multispecies assemblage (Fasham & Foxton 1979). As part of the Southeast Florida and Caribbean Recruitment Project (SEFCAR) the taxonomic composition and horizontal distribution of the larval natantia decapods and micronektonic shrimps from the coastal shelf water near Looe Key, Florida was quantitatively described. Plankton samples were collected May 28 and June 1-2, 1989, during cruise CA8906 of the R/V *Calanus* (Lee *et al.* 1992). The transect off Looe Key was repeated on both legs of the cruise (Yeung and McGowan 1991). The stations were placed across the shelf between 1.7 and 30.6 km from the coast (Fig. 1). Stations 38-40 were made at the same location during a single 24 h period. A multiple opening-closing net, MOCNESS, sampled from the surface to near the bottom with discrete oblique tows at 25 m depth intervals. Five 25 ml aliquots of the total sample were analyzed and the mean of these standardized to n/m^2. Natantia larvae and micronektonic shrimps were identified to genus or species using several keys and original descriptions (*e.g.*, Gurney 1938, Gurney and Lebour 1940, Williamson 1963, Cook 1966). It was possible to identify 21 taxa of planktonic natantia plus Anomura and Brachyura larvae for a total of 23 taxa (Table 1). Adults and juveniles, and larvae of the micronektonic shrimps *Lucifer typus*, *L. faxoni*, and *Sergestes* spp. were treated separately as individual taxa.

Ordination of taxa was done with principal component analysis (PCA) using the statistical package SYSTAT (Wilkinson 1990). The standardized abundance (n/m^2) for each taxa was transformed by ln $(x+1)$ as is the usual practice for species abundance data. The correlation matrix of the standardized, log-transformed abundance values was used for the ordination. Most of the variance (74%) was explained by the first two principal components so a plot against these two axes displays much of the information of the multidimensional data in two dimensions. This plot of the PCA among taxa on two dimensions described an arch (Fig. 2). A strongly arched plot can cause problems of interpretation (Green and Vascotto 1978)

TABLE 1

Abundance (n/m^2) of decapod larvae and micronektonic shrimp recorded at 9 station at Looe Key, Florida, on SEFCAR cruise CA8906. Numbers in parentheses indicate the ordination of taxa for the Principal Component Analysis (PCA)

	Stations								
	11	13	15	16	30	33	38	39	40
Distance offshore (km)	1.73	10.62	21.02	30.59	1.83	11.9	15.5	15.5	15.5
Depth sampled (m)	0-25	0-150	0-175	0-200	0-25	0-150	0-125	0-125	0-125
Infraorders									
PENAEIDEA									
(1) *Solenocera* sp. Mysis I-IV	0.0	35.9	0.0	2.9	0.0	0.0	1.2	1.1	0.5
(2) *Penaeus duorarum* Mysis III, post I-III	0.7	2.5	0.0	0.5	1.8	0.0	0.0	0.0	0.0
(3) *Parapenaeus* spp. Mysis I-IV	0.0	7.1	0.5	2.6	0.0	1.5	0.8	0.7	1.4
(4) *Sicyonia* spp. Mysis I-II	0.0	2.0	0.0	2.0	2.1	0.0	0.0	0.0	0.0
(5) *Trachypenaeus* sp. Mysis II-III	0.0	2.3	1.6	1.3	2.5	2.3	1.3	0.6	0.0
(7) *Sargastes* spp. Protozoeae, Zoeae	0.5	5.1	16.6	33.0	1.8	17.8	10.2	14.7	17.8
(8) *Lucifer* spp. Protozoeae, Zoeae, Mysis	6.6	155.7	6.2	15.3	0.0	3.6	1.7	0.0	0.5
(9) *Lucifer faxoni* Juveniles, adults	34.5	21.0	3.5	27.9	55.5	0.0	0.0	0.0	0.0
(10) *Lucifer typus* Juveniles, adults	1.4	5.4	4.5	13.8	1.1	12.4	8.5	10.4	5.6
CARIDEA									
(11) *Leptochela bermudensis* Late zoeae	5.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
(12) *Palaemonetes* spp. Zoea I-II	146.2	0.0	0.0	2.7	106.4	0.0	0.0	0.3	0.0
(13) *Periclimenes* sp1 Zoeae	21.6	5.7	0.0	0.0	14.4	0.0	0.0	0.0	0.0
(14) *Periclimenes* sp2 Zoeae	2.3	9.1	0.0	0.6	16.8	0.5	3.6	0.0	0.5
(15) *Alpheus* sp1 Zoeae I-V	38.7	27.5	0.0	1.1	27.4	0.3	0.0	0.6	0.0
(16) *Alpheus* sp2 Zoea II	0.0	0.4	0.0	0.6	2.8	1.7	0.,0	0.0	0.0
(17) *Latreutes* sp. Zoea I-V	207.7	3.8	0.5	2.6	294.8	2.3	3.5	3.8	0.0
(18) *Lysmata* sp. Late Zoea	3.8	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
(19) *Thor* spp. Zoea I-V	9.6	52.8	1.3	0.0	38.3	1.9	1.2	5.0	0.0
(20) *Tozeuma carolinense* Zoea I-VI	12.0	0.6	0.0	0.0	8.4	0.0	0.0	0.3	0.0
(21) *Acanthephyra* sp. Zoea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.5
ANOMURA (22) Zoeae, Megalopae	31.5	112.4	6.7	6.8	136.2	10.2	1.7	6.7	0.9
BRACHYURA (23) Zoeae, Megalopae	57.5	78.1	6.3	7.7	363.3	9.4	4.3	7.8	6.0

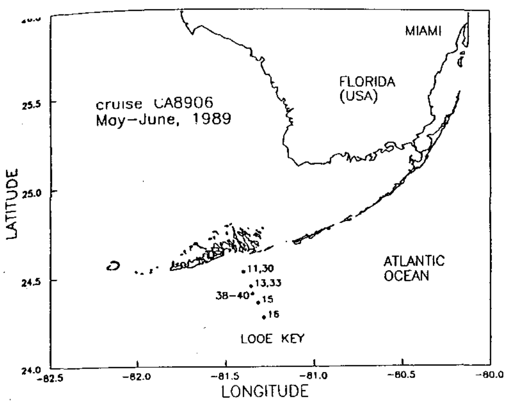

Fig. 1. Sampling stations at Looe Key, Florida, U.S.A., SEFCAR cruise CA8906, May-June 1989.

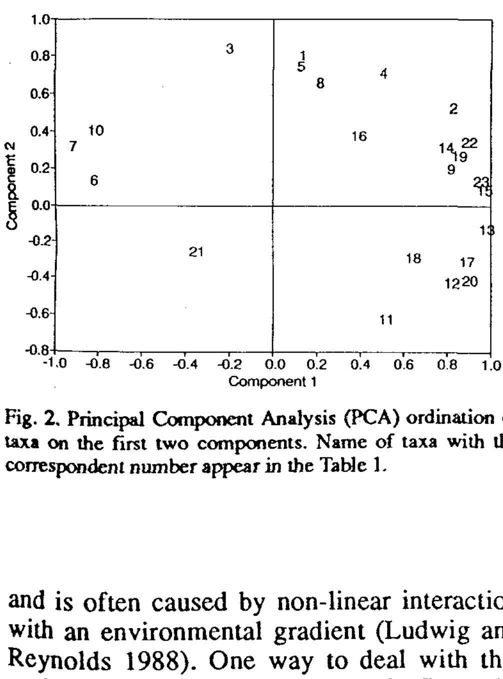

Fig. 2. Principal Component Analysis (PCA) ordination of taxa on the first two components. Name of taxa with the correspondent number appear in the Table 1.

and is often caused by non-linear interaction with an environmental gradient (Ludwig and Reynolds 1988). One way to deal with this problem is to evaluate a quadratic fit to the arched data: so-called detrended PCA. Larval fish from the same SEFCAR samples as these natantia fit a detrended PCA model very well (McGowan, unpublished data), so we expected the natantia larvae to follow the same pattern. And, in fact, the PCA ordination of taxa along the first axis shows a progression from coastal species to those with oceanic affinities. For example, *Leptochela bermudensis* (11) is at the coastal end of the arch (Fig. 2) and the deepwater *Acanthephyra* (21) is at the opposite extreme (Fig. 2). Other taxa group together consistently with this pattern. For example, a mix of larval stages from nearshore and shallow-water caridean taxa of the superfamilies palaemonoidea and alpheoidea: *Palemonetes* spp.(12), *Periclimenes* (13, 14), *Latreutes* sp.(17), *Lysmata* sp. (18), Thor spp. (19), *Tozeuma carolinense* (20), *Alpheus* (15, 16) are plotted close together. The sergestoid *Lucifer faxoni* (9), the phasiphaeid *Leptochela bermudensis* (11), brachyuran (22), and anomuran larvae (23) were also included in this first group. A less well defined assemblage was comprised mainly from mysis stages of penaeoids with both deep-water and coastal species: *Penaeus duorarum* (2) *Parapenaeus* spp. (3), *Solenocera* sp. (1), *Trachypenaeus* sp. (5), *Sicyonia* sp. (4), and *Penaeus duoraru m* (2), as well as the sergestoid *Lucifer* larvae of both species (8). This group predominated on the middle continental shelf. Together at the "oceanic" end of the ordination were oceanic deep-water taxa of the superfamily sergestoidea *Sergestes* spp. larvae and juveniles (6,7), *Lucifer typus* adults (10) and the deep-water oplophorid *Acanthephyra* sp. larvae (21). These different coastal-offshore distributions of the PCA are consistent with the reproductive strategies and life histories of these planktonic natantia. For example, larval stages of most shallow-water carideans do not disperse very far from their parents (Knowlton and Keller 1986). *Penaeus duorarum* (4), which has an estuarine-dependent juvenile stage, was situated closest to the coastal group. *Parapenaeus* (3), which spawns in deeper and oceanic waters, was located closest to the oceanic group. The oceanic sergestoid *Lucifer typus* (10) plotted with other oceanic species which were located in the negative quadrant. The coastal species *Lucifer faxoni* (9) grouped with other coastal species in the positive quadrant. This preliminary multivariate description does not confirm which environmental factors control these distributions but likely candidates are: water depth, distance from spawning areas, salinity gradient, and water mass type. These will be investigated in subsequent work now that the objective statistical ordination detected distributions of these species consistent both with the presumed coastal-oceanic environmental gradient, and with life histories and dispersal strategies of the natantia.

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