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JUVENILE PLANKTONIC CEPHALOPODS SAMPLED OFF THE COASTS OF CENTRAL GREECE (EASTERN MEDITERRANEAN) DURING WINTER

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ABSTRACT: Cephalopod early life stages were identified from plankton samples taken with bongo-nets (500 µm mesh size) off the coasts of central Greece (N: 39º 18´–37º 25´, E: 20º 15´–24º 33´) in December 2000–February 2001. The sampling was not directed at cephalopods but provided valuable information on the distribution of cephalopod planktonic stages in Greek waters. Oblique tows were carried out over a grid of 100 stations from a depth of 200 m to the surface on a 24 hour basis. At each station vertical profiles of temperature and salinity were also taken using a SBE-25 CTD profiler. A total of 9 taxa belonging to five families were caught at 21 stations. Among these, the Ommastrephidae was the most numerically abundant (75.7%) family followed by the Octopodidae (15.7%), Loliginidae (4.3%), Sepiolidae (2.9%) and Enoploteuthidae (1.4%). Frequency of occurrence (number of positive tows/total number of tows) of cephalopods was highest during evening tows and in waters with surface temperature >18°C. Most positive tows yielded less than 3 specimens.

INTRODUCTION

Knowledge of the early life and recruitment processes is very important for understanding of population dynamics and of managing of commercial species, especially those with a short life-span like cephalopods.

Although several cephalopod species are commercially important in Greece and the monitoring of their abundance and distribution in Greek waters has progressed during the last decade (Stergiou *et al.*, 1997), information on their early life stages is still very limited (Degner, 1926; Lefkaditou *et al.*, 1999); most of the published studies are related to the adults of demersal species caught by bottom trawl (D'Onghia *et al.*, 1996; Lefkaditou *et al.*, 2003; Lefkaditou and Kaspiris, 2004).

In the present paper, cephalopod paralarvae collected by bongo-nets off the coasts of central Greece during a sardine egg production survey during December 2000–February 2001 are reported and their occurrence in relation to hydrological regimes is discussed.

MATERIALS AND METHODS

The ichthyoplankton survey of the R/V PHILIA in December 2000–February 2001 sampled along the continental coast of the central Aegean and Ionian Seas in a series of separate basins connected by a number of narrow passages (Fig. 1).

We sampled 54 stations in the Aegean Sea during 3–15 December 2000 and 46 in the Ionian Sea during 27 January–9 February 2001. Plankton samples were collected on a 24 hour basis using a pair of 60 cm Bongo nets with 500 ìm and 250 ìm mesh sizes. Tows were double oblique from the surface to 200 m depth or to within 5 m of the bottom at stations where the bottom depth was less than 200 m. A stopwatch was used to monitor the duration of each tow. All tows consisted of a wire release to desired depth and retrieval to the surface at standard speeds (40 and 20 m/min for release and retrieval respectively), and the net depth was monitored on board using a depth meter attached to the sampler. The volume of filtered water was determined from a calibrated flowmeter

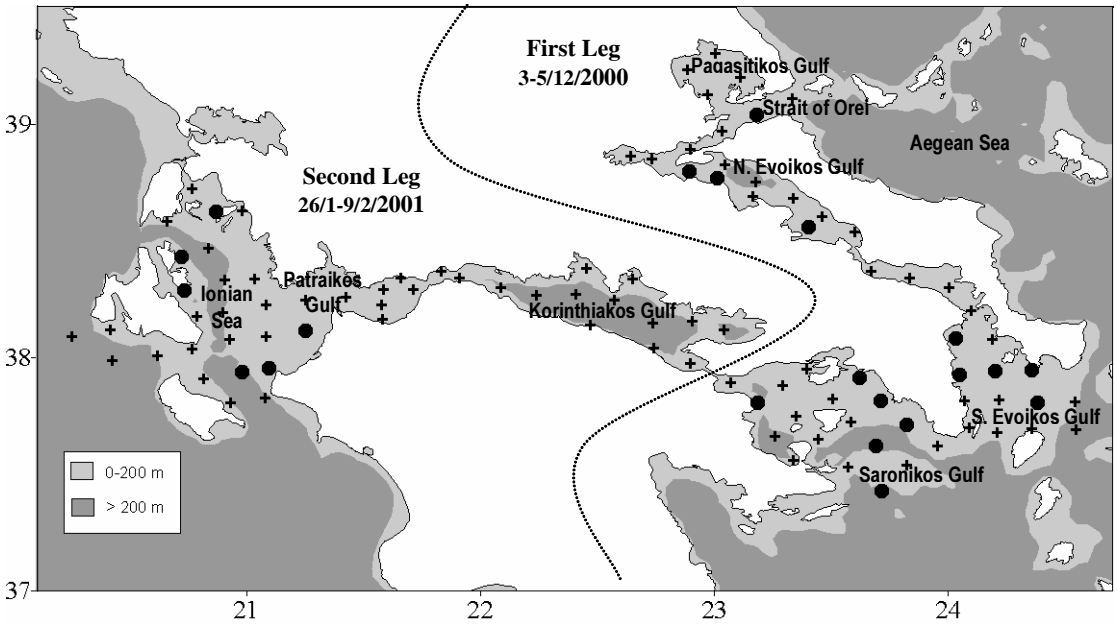

Figure 1. Map of the Central Greece showing the location of Bongo-net stations (December 2000–February 2001). ●: stations positive for cephalopods. ✚: stations without cephalopods.

in the mouth of each net. At each station, vertical profiles of temperature and salinity were also taken using a SBE-25 CTD system.

Immediately after collection, samples from the 250 ìm net were preserved in 10% borax-buffered formalin solution, and those from the 500 ìm net were preserved in 85% ethanol solution. Cephalopod paralarvae were sorted from the samples of the 500 ìm net under a dissecting microscope and the species were identified following the keys in Sweeney *et al*. (1992), Mangold and Boletzky (1987) and (Bello, 1995). The mantle length (ML) of each specimen was measured to the nearest 0.01 mm using an image analysis system. All cephalopod specimens were subsequently stored in the National Centre for Marine Research, Athens, Greece, where additional studies on statolith microstructure are in progress.

RESULTS

Hydrography

The horizontal distribution of the surface (5 m) and the mean vertical profiles of temperature and salinity are shown in Figs. 2 and 3 respectively.

Temperature and salinity varied between the eastern (Pagasitikos, N. Evoikos, S. Evoikos and Saronikos Gulfs) and the western part (Ionian Sea, Patraikos and Korinthiakos Gulfs) of the survey area (Figs. 2 and 3).

In the eastern part of the survey area, surface temperature ranged from 15.4 to 19.8 ºC, with the highest values recorded in Saronikos and the lowest in the N. Evoikos Gulf. In the western regions, considerably lower temperature values (13.9–16.5 ºC) were recorded, which was due to the time interval between the two parts of the survey coupled with the seasonal changes. Surface salinity (Fig. 2b) varied between 36.7 and 38.8 psu, and was lowest in the Pagasitikos Gulf, northern Evoikos Gulf and near river mouths due to fresh water discharge.

The water column (Fig. 3) appeared to be stratified in the earlier sampled (December 2000) eastern regions, showing a marked vertical stratification between 50 and 90 m with a thick thermally homogeneous surface layer. In the north Evoikos Gulf, the coldest temperatures (<12 ºC) were recorded below the thermocline, whereas low salinity values (<38 psu) were observed throughout the water column. In the western part (sampled

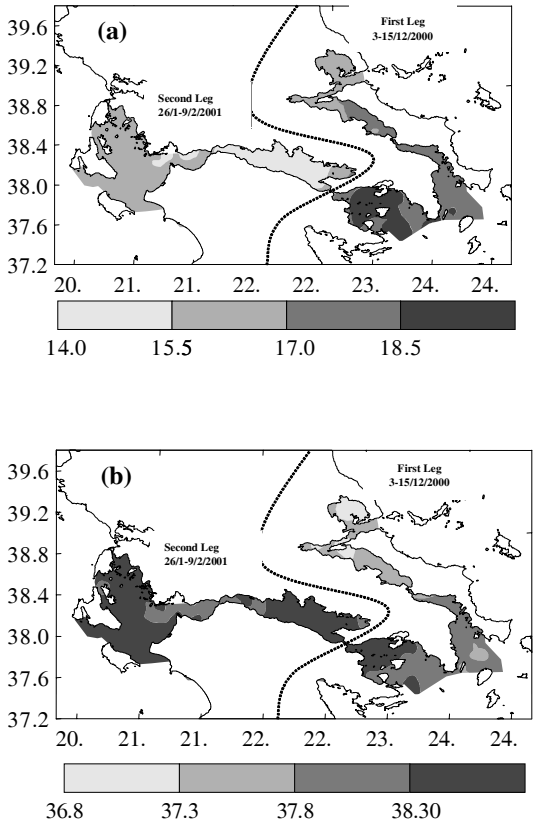

Figure 2. Contour maps of surface temperature and salinity (5 m) during the survey of December 2000–February 2001.

during January–February 2001), the vertical profiles of temperature and salinity were more homogeneous.

Composition and distribution of cephalopod paralarvae

A total of 70 cephalopod paralarvae were caught at 21 stations (Fig. 1). They were identified to 9 taxa, including one myopsid squid, two oegopsid squids, two sepiolids and four octopods. Remarks on each species are given below following the systematic order of Mangold and Boletzky (1988).

Order: Teuthoidea
Suborder: Myopsida
Family: Loliginidae
Loligo forbesi (Steenstrup, 1856)
Three paralarvae were collected at 3 stations in the Ionian Sea. Their mantle lengths ranged between 2.2 and 3.2 mm.

Order: Teuthoidea
Suborder: Oegopsida
Family: Ommastrephidae
Subfamily: Illicinae
Illex coindetii (Verany, 1839)
It was the dominant species represented by rhynchoteuthion larvae (ML: 1.2–9.0 mm), as well as by larger juveniles (ML: 9.0–17.0 mm) with separated tentacles, bearing suckers with the typical dentition for the species. Fifty-three individuals were caught at 9 stations in the eastern regions and 1 station from the Ionian Sea.

Abundance was highest in the northern part of the Evoikos Gulf where 43 specimens were caught in a single tow between 56 m and the surface, whereas each of the other tows yielded fewer than 2 specimens.

Family: Enoploteuthidae
Subfamily: Pyroteuthinae
Pyroteuthis margaritifera (Rüppell, 1848)
One specimen (4.8 mm ML) was collected from the Saronikos Gulf.

Order: Sepioidea
Family: Sepiolidae
Subfamily: Heteroteuthinae
Heteroteuthis dispar (Rüppell, 1844)
A juvenile (2.4 mm ML) bearing the species' characteristic light organ (Bello, 1995) in its mantle cavity was found in the Ionian Sea.

Subfamily: Rossinae
Neorossia caroli (Joubin, 1902)
One paralarva (1.4 mm ML) was caught in the north Ionian Sea.

Order: Octopoda
Suborder: Incirrata
Family: Octopodidae
Subfamily: Octopodinae
Octopus vulgaris (Cuvier, 1797)
A total of 8 paralarvae was collected from 4 stations in the south Evoikos Gulf, 2 stations in

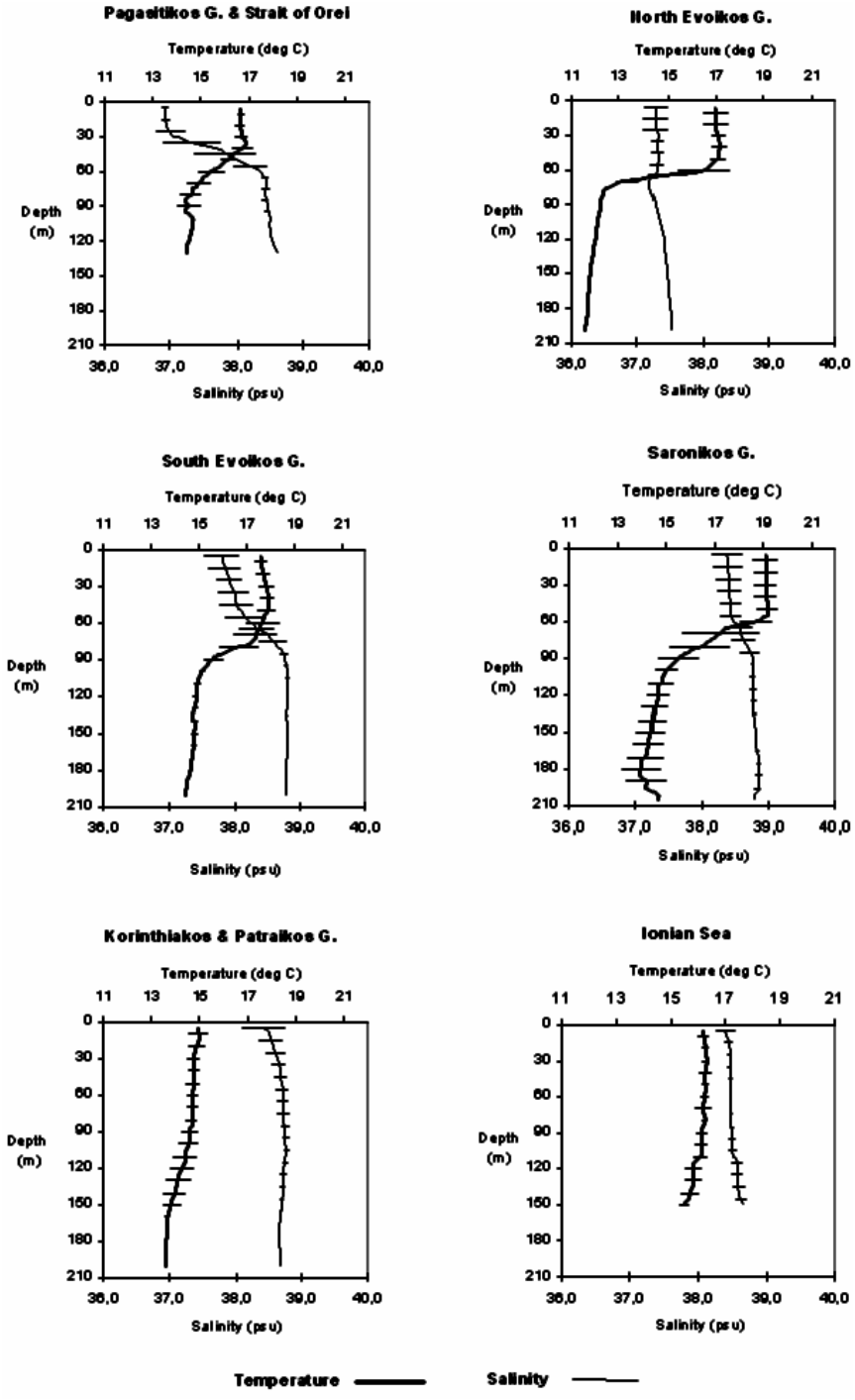

Figure 3. Mean vertical profiles of temperature (ºC) and salinity (psu) in different regions of the surveyed area during the cruise of R/V Philia in December 2000/February 2001.The standard deviations are indicated as horizontal bars.

the Saronikos Gulf and 1 station in the Ionian Sea with maximum tow depth ranging between 22 and 161 m. They consisted of seven hatchlings with the typical pattern of large chromatophores on head, ventral mantle and dorsal digestive gland surface (Sweeney *et al.,* 1992), ranging from 1.2 to 1.9 mm ML, and one advanced planktonic octopod with smaller chromatophores and two rows of suckers in the arms, measuring 4.5 mm in ML. *O. vulgaris* was the most common octopod and the second most abundant species collected.

Scaeurgus unicirrus (Orbigny, 1840)
A single paralarva with an ML of 2.4 mm was found in the north Evoikos Gulf.

Eledone cirrhosa (Lamarck, 1798)
A hatchling (1.7 mm ML) was caught over the shelf break of the Saronikos Gulf.

Pteroctopus tetracirrhus (Delle Chiaje, 1830) probably.
Neither hatchlings nor planktonic paralarvae of this species have been illustrated or described before. The baggy mantle and the relatively long (shallow) web between the arms appearing in a paralarva (1.8 mm ML) collected in the Saronikos Gulf (Fig. 4), as well as in some other specimens collected over the shelf break of the north Aegean Sea during previous surveys (unpublished data), suggest that this is probably an early life stage of *P. tetracirrhus.*

The frequency of cephalopod occurrence (number of positive tows/total number of tows) with respect to sampling hour, bottom depth and surface temperature is shown in Fig 5. Cephalopods were found in waters with surface temperature >16 ºC, and they were most frequently caught during evening tows and over depths of 50–200 m .

DISCUSSION

The generally low occurrence of cephalopod species in the samples examined may be due to the inadequacy of conventional ichthyoplankton sampling for these species (Piatkowski, 1998), as well as to the high dispersion of cephalopod paralarvae. The exceptionally large number of

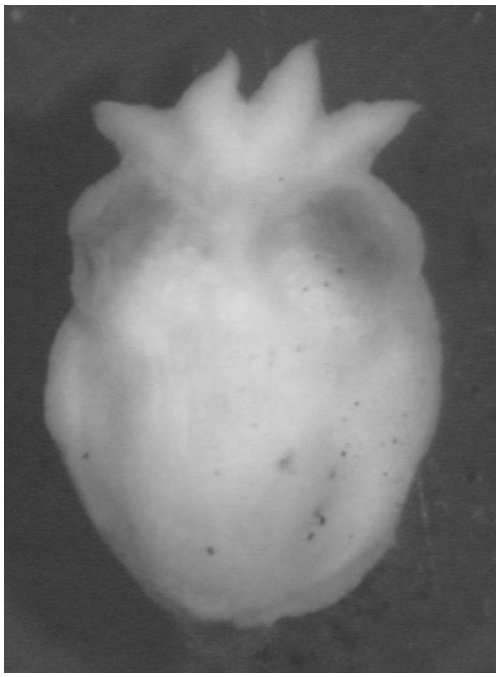

Figure 4. An octopod paralarva (1.8 mm ML) most likely belonging to *Pteroctopus tetracirhus*, caught by a bongo-net (0.500 mm mesh size) in the Saronikos Gulf during December 2000.

I. coindetii juveniles caught in the northern part of the Evoikos Gulf indicates that Bongo nets might sample paralarvae and larger cephalopod individuals efficiently, up to a size of 17 mm ML, when they are abundant. This record is probably related to the hydrology of the deep-water basin formed at this specific area. The upwelling of less saline waters from the bottom (Balopoulos *et al*., 1986) and the high concentration of nutrient salts (Psilidou-Giouranovits *et al.*, 1993) result in high phytoplankton and zooplankton productivity in this area (Stergiou *et al*., 1997), making it an ideal nursery area for cephalopods and fishes. Moreover, this exceptional record raises question about aggregation of ommastrephid paralarvae due to convergence of currents in the vicinity of upwelling regimes, as also noted by Vecchione (1999) in the Pacific ocean, off the coasts of Central America.

Although oblique tows do not give information on the species vertical distribution in the water column, the scarcity of cephalopods in tows to

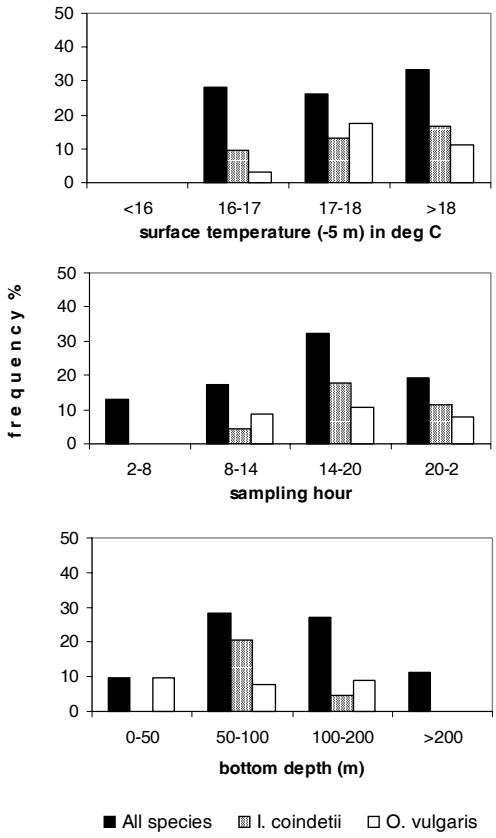

Figure 5. Frequency of occurrence (number of positive tows/total number of tows) of cephalopods in bongo-net collections with regard to sampling hour, bottom depth and surface temperature.

depths shallower than 50 m suggests that they are predominantly found below the mixed layer, as has been observed in other areas (Röpke *et al.*, 1993). The frequency of occurrence was low over depths greater than 200 m and at stations distant from the coast (Fig. 1). Similar distribution patterns have also been demonstrated for octopod, loliginid and ommastrephid paralarvae collected in Iberian Atlantic waters (Moreno and Pereira, 1998; Rocha *et al.*, 1999).

Studies on the vertical distribution of cephalopod paralarvae have shown that they ascend at night (Röpke *et al.*, 1993), which could explain why the frequency of occurrence was higher during evening hours than during the day.

By comparing the different regions and sampling times of the surveyed area some differences in species occurrence were observed. No cephalopods were collected in the Pagasitikos and Patraikos-Korinthiakos regions, where the lowest salinity and temperature values, respectively, were recorded in the upper layers (Fig. 3). Octopods and ommastrephids were mostly found in the Evoikos Gulf and the Saronikos Gulf during December, where the highest surface temperatures were observed, whereas loliginids and sepiolids were collected only in the Ionian Sea (January–February) with relatively colder surface waters. Since analogous differences have not been observed in adult distributions (Lefkaditou *et al.*, 2003a; 2003b), temperature seems to be an important factor associated with the occurrence of cephalopod early life stages. This is further supported by the results of plankton surveys in Portugese waters, which show that paralarvae of ommastrephids and *O. vulgaris* are associated with warmer waters than those of loliginids and sepiolids (Moreno and Pereira, 1998).

The present collection of planktonic cephalopods is relatively restricted, comprising only 9 of the 48 cephalopod species occurring in the Greek seas (Lefkaditou *et al.*, 2003a; 2003b). However, it provides valuable information on the distribution of cephalopod planktonic stages in Greek waters.

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