

## Vertical distribution and abundance of juvenile cephalopods in the Aegean Sea\*

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**SUMMARY:** This study was carried out in northern (Saros Bay) and southern (Gökova Bay) parts of the Aegean Sea. In pelagic samplings, Hamburg Plankton Net (HPN) was used. Samplings were done out at four different periods of a 24 hour day; sunrise, noon, sunset and midnight. Horizontal hauls were carried out at depths of 100, 350 and 650 m. As the result of 24 hauls in both parts of the Aegean Sea, one hundred juvenile specimens were sampled and 14 species were determined. Juvenile cephalopods were mostly frequent at 350 m. Among the determined species, *Ctenopteryx sicula* (Verany, 1851), *Brachioteuthis riisei* (Steenstrup, 1882), *Illex coindetii* (Verany, 1839), *Thysanoteuthis rhombus* Trochel, 1857 and *Argonauta argo* Linnaeus, 1798 juveniles are being reported for the first time in the Aegean Sea. 28% of the catches were from the northern Aegean and the remaining 72% were from the southern Aegean. *Heteroteuthis dispar* (Rüppell, 1844) was the most common species.

**Key words:** Cephalopoda, juvenile, vertical distribution, Aegean Sea.

**RESUMEN:** DISTRIBUCIÓN VERTICAL Y ABUNDANCIA DE JUVENILES DE CEFALÓPODOS DEL MAR EGEO. – El presente estudio se llevó a cabo en la zona norte del Mar Egeo (Bahía de Saros) y en la zona sur (Bahía de Gökova) de dicho mar. Para los muestreos pelágicos se usó la red de plancton Hamburg Plankton Net (HPN). Los muestreos se llevaron a cabo en cuatro momentos diferentes en un periodo de 24 horas: amanecer, mediodía, atardecer y medianoche. Se realizaron arrastres horizontales a profundidades de 100, 350 y 650 m. Se capturaron cien cefalópodos juveniles pertenecientes a 14 especies como resultado de los 24 arrastres realizados en ambas áreas del mar Egeo. Los cefalópodos juveniles fueron mas frecuentes a 350 m de profundidad. Entre las especies determinadas fueron citadas por primera vez en el mar Egeo los juveniles de: *Ctenopteryx sicula* (Verany, 1851), *Brachioteuthis riisei* (Steenstrup, 1882), *Illex coindetii* (Verany, 1839), *Thysanoteuthis rhombus* Trochel, 1857 y *Argonauta argo* Linnaeus, 1798. El 28 % de las capturas provinieron del Egeo septentrional y el resto, 72%, del Egeo meridional. *Heteroteuthis dispar* (Rüppell, 1844) fue la especie más común.

**Palabras clave:** Cephalopoda, juveniles, distribución vertical, mar Egeo.

### INTRODUCTION

Because of its differing ecologic characteristics, which are reflected in its biological characteristics, the Aegean Sea is divided into northern and southern subsections. There are trenches with depths of more then 3150 m in the south but the deepest

trench in the study basin was no deeper than 1000 m. The average depth is around 350 m (Kocatas and Bilecik, 1992).

In the life cycle of the pelagic ecosystem, juveniles of benthic cephalopods play as important a role in food-predator relationships as the juveniles of pelagic cephalopods (Amaratunga, 1983). Studies on the distribution of pelagic cephalopods in the Mediterranean have been carried out by Naef

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(1923), Degner (1925), Mangold-Wirz (1963), Roper (1974), Sánchez and Molí (1985), Bello (1986, 1990) and Orsi-Relini *et al.* (1994).

In the Aegean Sea, a mesopelagic young fish trawl was used for the first time by the Danish Oceanographical Expedition to the Mediterranean and adjacent seas. At that time, Degner (1925) sampled some species of juvenile cephalopods. Nine other juvenile cephalopod species have more recently been reported by Lefkaditou *et al.* (1999), who studied the mesopelagic fauna in the northern Aegean.

In contrast with the inadequacy of studies on juvenile cephalopods, there have been several studies on the distribution and biology of adults by Katagan and Kocatas (1990), D'Onghia *et al.* (1991, 1996), Katagan *et al.* (1992), Salman *et al.* (1997, 2000), Stergiou *et al.* (1997).

When the information above is considered, it is observed that there are not many studies on juvenile cephalopods in the Aegean Sea. With this study we aimed to investigate the vertical distribution and abundance of juvenile cephalopods according to different periods of the 24-hour day.

## MATERIAL AND METHODS

This study was carried out in the Aegean Sea in the period May 10-24 2001 by the R/V K. Piri Reis. For pelagic sampling a 0.5 mm mesh size Hamburg Plankton Net (HPN; Isaac-Kid, modified from mid-water trawl, Hydrobios) was used. Sampling was done down to a depth of 850 m in the Saros Bay region (north) and down to a depth of 714 m in the Gökova Bay region (south) (Fig. 1). In order to determine the vertical distribution of cephalopods according to the amount of light, samplings in both directions were performed during four different periods of day time (dawn, noon, dusk, midnight) and at depths of 100, 350 and 650 m.

A total of 24 hauls were carried out as one set of 12 at each station. Depths at which hauls were carried out were recorded by a Scanmar depth sensor. A fifteen-minute horizontal haul was carried out at each depth. The hauling speed was stabilized at 3.5 knots. Samples were preserved in 4% formalin in seawater.

Dorsal mantle lengths (ML) of preserved specimens were measured. To identify specimens, a stereomicroscope (Olympus model SZ-60) was used for

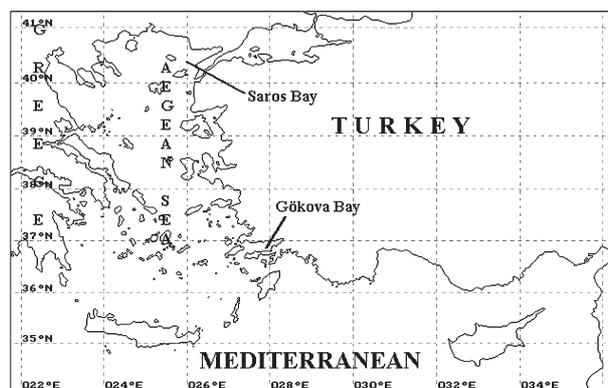


FIG. 1. – Sampling area.

photographing and a camera lucida was used for drawings. For statistical calculation Tukey one way variance analysis (Sokal and Rohlf, 1980) was used. The juvenile cephalopods were identified according to keys of Chun (1910), Naef (1923), and Sweeney *et al.* (1992).

## RESULTS

One hundred juvenile cephalopod specimens were collected from 21 of 24 hauls. Among this catch 14 species, 13 genera and 13 families were included. The number of species recorded was 10 in the north and 8 in south (Table 1). Species of which juveniles are reported in the Aegean Sea for the first time are marked with an asterisk (Table 1).

Remarks on each species are given below following the systematic order of Sweeney and Roper (1998).

### Order SEPIOLIDA

#### Subfamily HETEROTEUTHIDINAE

#### *Heteroteuthis dispar* (Rüppell, 1844)

This was the most abundant species in both parts of the study area (Aegean Sea), comprising 50% of total cephalopod species in the northern Aegean and 41.7% in the southern Aegean. It was observed at all depths and time periods all over the Aegean Sea. (Table 1, 2). ML of 44 specimens from *H. dispar* varied between 0.9-9.1 mm. When their sizes were examined in groups of catch depths as the result of Tukey one-way variance analysis [ $F_{\text{calc}} = 3.35$  critical  $F_{0.05} (2.41) = 3.22$ ] it was found that longer specimens were spread within 100-350 metres and smaller specimens were spread within 350-650 metres (Fig. 2).

TABLE 1. – List of cephalopod juveniles caught at different depth levels

Species	100 m		350 m		650 m		Total	
	N	%	N	%	N	%	N	%
<b>NORTH AEGEAN</b>								
<i>Heteroteuthis dispar</i>	3	42.8	8	80.0	3	27.3	14	50.0
<i>Pyroteuthis margaritifera</i>			1	10.0	3	27.3	4	14.3
Onychoteuthidae sp.					1	9.1	1	3.6
<i>Histioteuthis bonnellii</i>	1	14.3					1	3.6
<i>Histioteuthis reversa</i>	2	28.6					2	7.1
* <i>Ctenopteryx sicula</i>	1	14.3					1	3.6
* <i>Illex coindetii</i>					2	18.2	2	7.1
* <i>Thysanoteuthis rhombus</i>			1	10.0			1	3.6
<i>Octopus vulgaris</i>					1	9.1	1	3.6
<i>Eledone cirrhosa</i>					1	9.1	1	3.6
Total	7	25	10	35	11	40	28	100
<b>SOUTH AEGEAN</b>								
<i>Heteroteuthis dispar</i>	3	21.4	17	54.8	10	37.1	30	41.7
<i>Ancistrocheirus lesueurii</i>			1	3.2			1	1.4
<i>Pyroteuthis margaritifera</i>	2	14.3	5	16.1	4	14.8	11	15.3
* <i>Brachioteuthis riisei</i>			1	3.2			1	1.4
* <i>Illex coindetii</i>	2	14.3			4	14.8	6	8.3
<i>Chiroteuthis veranii</i>					1	3.7	1	1.4
<i>Octopus vulgaris</i>	6	42.9	7	22.6	8	29.6	21	29.2
* <i>Argonauta argo</i>	1	7.1					1	1.4
Total	14	19	31	43	27	38	72	100
TOTAL (Aegean Sea)	21	21	41	41	38	38	100	100

TABLE 2. – Distribution of cephalopod juveniles caught in Aegean Sea considering period of light, depth and regions

Time Period Depth (m)	Dawn			Noon			Dusk			Midnight		
	100	350	650	100	350	650	100	350	650	100	350	650
<b>NORTH AEGEAN</b>												
<i>Heteroteuthis dispar</i>					2		2	5		1	1	3
<i>Pyroteuthis margaritifera</i>								1				3
Onychoteuthidae sp.						1						
<i>Histioteuthis bonnellii</i>							1					
<i>Histioteuthis reversa</i>	1						1					
<i>Ctenopteryx sicula</i>				1								
<i>Illex coindetii</i>						1						1
<i>Thysanoteuthis rhombus</i>								1				
<i>Octopus vulgaris</i>												1
<i>Eledone cirrhosa</i>											1	
Total	1			1	2	2	4	7	1	1	1	8
<b>SOUTH AEGEAN</b>												
<i>Heteroteuthis dispar</i>		5	1	3	6	3		2	2		4	4
<i>Ancistrocheirus lesueurii</i>											1	
<i>Pyroteuthis margaritifera</i>	2	1				1			1		4	2
<i>Brachioteuthis riisei</i>											1	
<i>Illex coindetii</i>			2	2								2
<i>Chiroteuthis veranii</i>			1									
<i>Octopus vulgaris</i>	1			2	1	3	3	1	2		5	3
<i>Argonauta argo</i>	1											
Total	4	6	4	7	7	7	3	3	5		15	11
TOTAL (Aegean Sea)	5	6	4	8	9	9	7	10	6	1	16	19

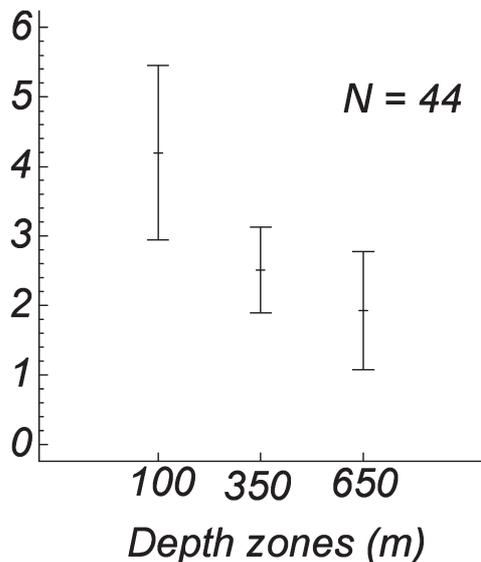


FIG. 2. – Size distribution of *Heteroteuthis dispar* according to depth by Tukey one-way variance analysis

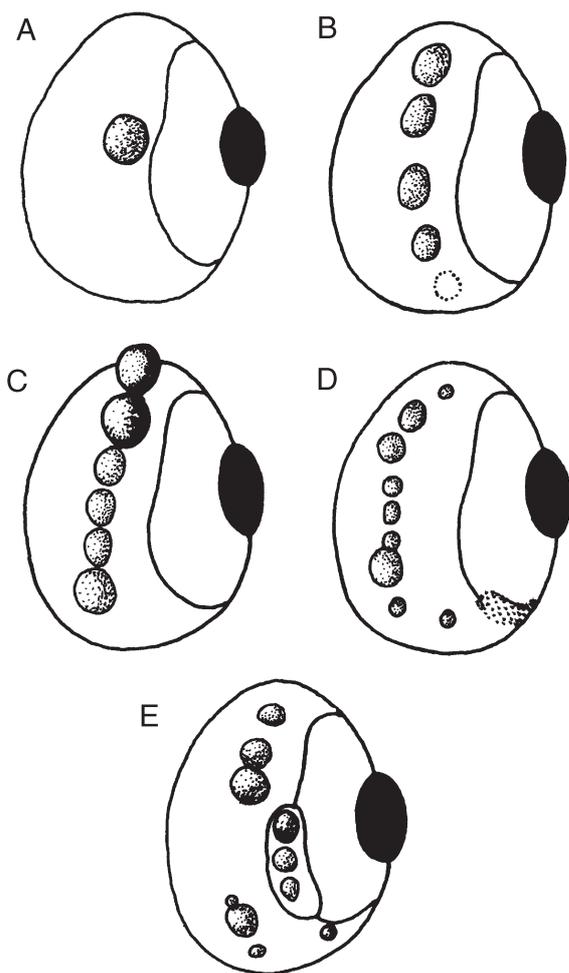


FIG. 3. – Ontogenic variances of eye photophores of *Pyroteuthis margaritifera* (A: 1.8 mm ML; B: 2.8-3.1 mm ML; C: 3.8-4.6 mm ML; D: 6.6 mm ML; E: 8.3 mm ML).

Order TEUTHIDA  
Suborder OEGOPSINA  
Family ANCISTROCHEIRIDAE  
*Ancistrocheirus lesueurii* (Orbigny, 1842)

One specimen (2.5 mm ML) was retrieved from 350 m in the southern region (Table 1).

Family PYROTEUTHIDAE  
*Pyroteuthis margaritifera* (Rüppell, 1844)

15 specimens of this species were sampled. Four individuals were collected from the northern Aegean at 350-650 m, measuring 3.5-6.6 mm ML; the other eleven with 1.8-16.6 mm ML were from the southern Aegean.

Within the specimens examined, anal photophores in the dorsal cavity were observed on ones larger than 2.8 mm ML but gill photophores were observed only on ones larger than 4.6 mm ML.

When eye photophores were examined on the smallest specimens (1.5 mm ML) a photophore was seen in the ventral eye. On the specimens of 2.8-3.1 mm ML four photophores of the same size in a linear fashion were observed. On specimens of 3.8-4.6 mm ML six with the same characteristic were observed. On specimens with 6.6 mm ML nine photophores with different sizes on a line were observed. However on ones with 8.3 mm ML, ten photophores with various sizes and similar lining characteristics as adults have were observed (Fig. 3).

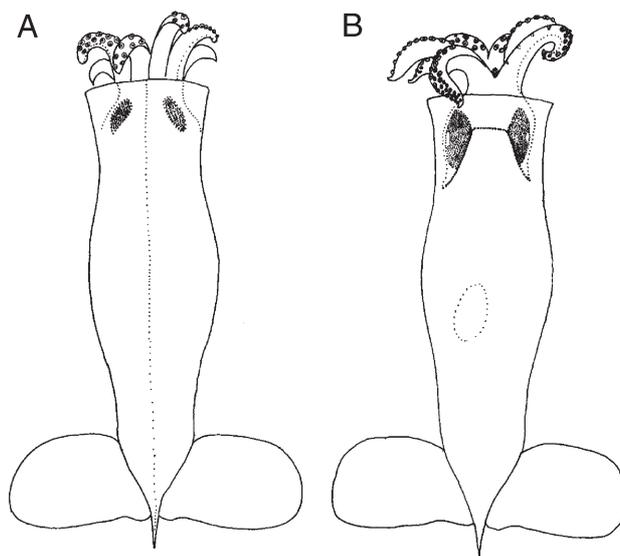


FIG. 4. – *Onychoteuthis banksii* ML= 5.0 mm (A: dorsal view, B: ventral view).

Family ONYCHOTEUTHIDAE  
**Unidentified larvae**

One specimen with a 5 mm ML was collected from 650 m in the northern Aegean (Table 1, Fig. 4).

There are two recognised *Onychoteuthidae* specimens in the Mediterranean, *Ancistroteuthis lichtensteinii* and *Onychoteuthis banksii* (Mangold and Boletzky, 1987). According to Sweeney *et al.* (1992) these two are indistinguishable at a size smaller than 11 mm ML. Lefkaditou *et al.* (1999) reported a specimen with a 7.5 mm ML at 1000 m in the northern Aegean as an unidentified larva of the Onychoteuthidae family. In addition, Lefkaditou *et al.* (1999) stated the possibility that this larva may be a member of the *O. banksii* species referring to the reports made by Degner (1925) and Roper (1974) from the eastern Mediterranean (east of 23°), in agreement with our findings.



FIG. 5. – *Ctenopteryx sicula* ML= 9.0 mm ventral view.

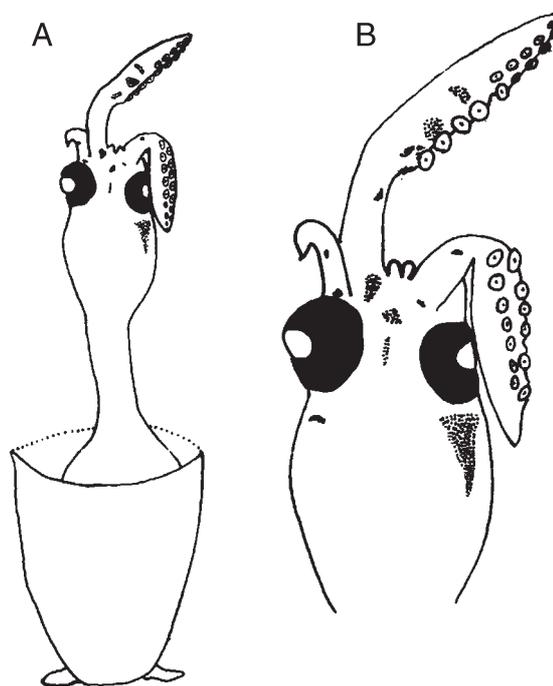


FIG. 6. – *Brachioteuthis risei* ML= 3.5 mm (A: general view, B: view of the head and arms).

Family HISTIOTEUTHIDAE  
*Histioteuthis bonnellii* (Férussac, 1834)

One specimen (10 mm ML) was found at 100 m in the northern Aegean (Table 1).

*Histioteuthis reversa* (Verrill, 1880)

Two specimens (1.6-5.0 mm ML) were found at 100 m in the northern Aegean (Table 1)

Family CTENOPTERYGIDAE  
*Ctenopteryx sicula* (Verany, 1851)

A specimen of this species with 9.0 mm ML was collected in the northern Aegean at 100 m (Table 1, Fig. 5). A juvenile specimen of this species is being reported for the first time from the Aegean Sea.

Family BRACHIOTEUTHIDAE  
*Brachioteuthis riisei* (Steenstrup, 1882)

One specimen (3.5 mm ML) was found at 500 m in the northern Aegean (Table 1, Fig. 6). A juvenile specimen of this species is being reported for the first time from the Aegean Sea.

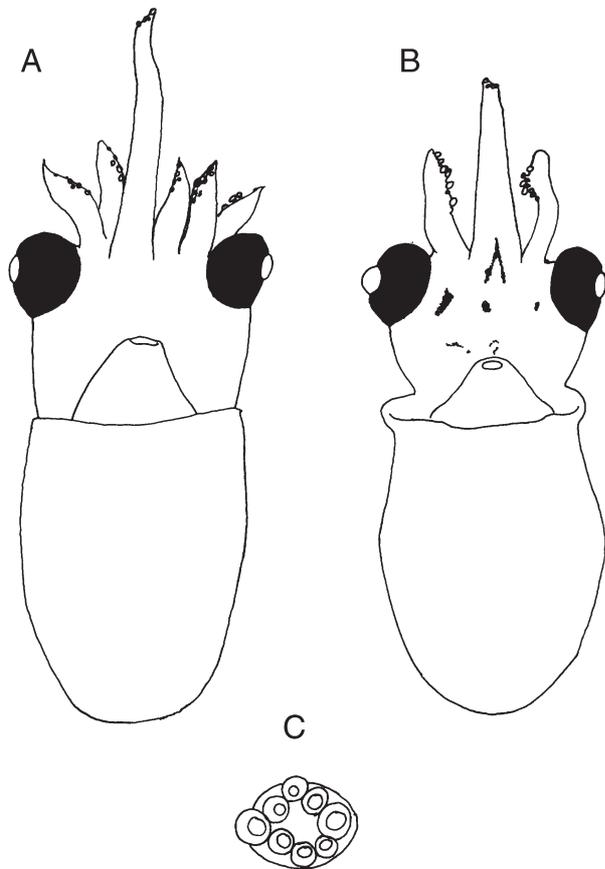


FIG. 7. – *Illex coindetii* A: 2.5 mm ML; B: 5.3 mm ML; C: view of proboscis suckers.

Family OMMASTREPHIDAE  
*Illex coindetii* (Verany, 1839)

Eight specimens of this species, two from the northern Aegean and six from the southern Aegean, were obtained. Samples from the northern Aegean of 2.5 mm ML were gathered from 650 m. From the southern Aegean, two samples with 2.1-3.3 mm ML were collected from 100 m and four with 1.6-5.3 mm ML were collected from 650 m. It was observed that the lengths of proboscis suckers were almost the same (Fig. 7).

Juveniles of this species are being reported for the first time from the Aegean Sea.

Family THYSANOTEUTHIDAE  
*Thysanoteuthis rhombus* Troschel, 1857

One specimen with a ML of 2.5 mm was collected from a depth of 350 m in the northern Aegean (Table 1, Fig. 8). A juvenile specimen of this species is being reported for the first time from the Aegean Sea.

Family CHIROTEUTHIDAE  
*Chiroteuthis veranii* (Férussac, 1835)

A specimen of this species was collected from 650 m in the southern Aegean (Table 1). The mantle length of this specimen was measured as 54.0 mm ML.

Order OCTOPODIDA  
Suborder INCIRRINA  
Family OCTOPODIDAE  
Subfamily OCTOPODINAE  
*Octopus vulgaris* Cuvier, 1797

Twenty-two specimens of this species were collected, which proves it to be the second most abundant species. One of the specimens with 3.0 mm ML was collected from 650 m in the northern Aegean and the remaining of 21 with ML's varying between 1.2-5.1 mm were collected from all contours of depths in both parts (Table 1, Fig. 9).

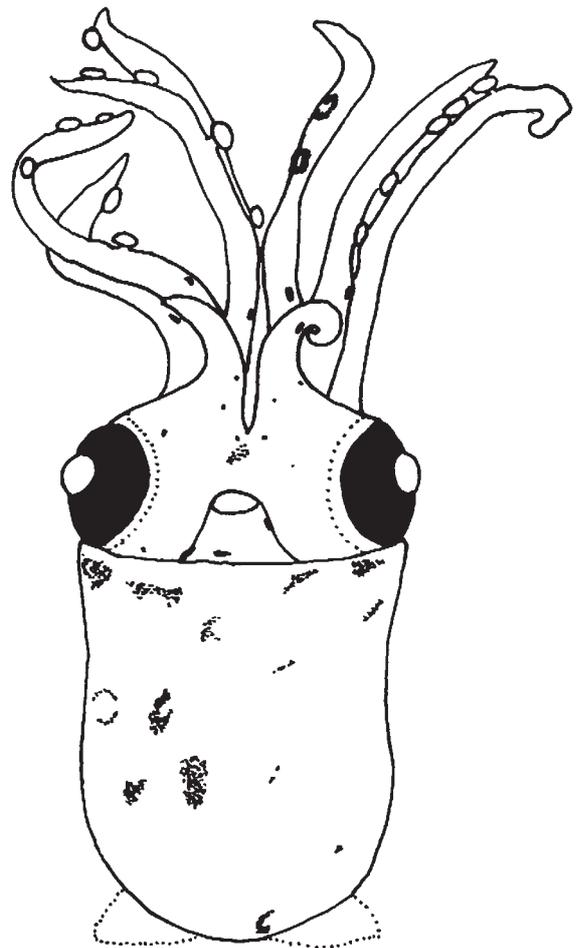


FIG. 8. – *Thysanoteuthis rhombus*, ML= 2.5 mm, ventral view.

Subfamily ELEDONINAE  
*Eledone cirrhosa* (Lamarck, 1798)

One specimen (2.5 mm ML) was found at 650 m in the northern Aegean (Table 1).

Family ARGONAUTIDAE  
*Argonauta argo* Linnaeus, 1758

One specimen (2.5 mm ML) was found at 100 m in the southern Aegean. A juvenile specimen of this species is being reported for the first time from the Aegean Sea.

**The abundance and vertical distribution of species**

When the distribution of juvenile cephalopods in the two different sections of the Aegean Sea is compared, it is observed that the north is richer in diversity, with ten species, than the south is, with 8 species. On the other hand, in the aspect of quantity the southern Aegean is higher in proportion by 72 to 28% (Table 1). Studies on the vertical distribution of sampled specimens showed that 41% of the species were at 350 m, 38% of the species were at 650 m and 21% of the species were at 100 m (Table 1).

When the Aegean is examined separately as north and south, it is seen that an increase in cephalopod abundance occurs at increasing depths in the northern Aegean, whereas in the south it first increases but later decreases at deeper levels (Table 1).

When the abundance of juvenile cephalopods was investigated in different periods of sunlight, over the whole Aegean the least quantity was 15 specimens at sunrise, whereas it was greatest with 36 specimens at midnight. According to vertical investigations for their distributions, the number of specimens at a depth of 100 m increases from sunrise until noon and then decreases from noon to midnight. At 350 m a constant increase was observed from sunrise until midnight. At 650 m, however an increase was observed from sunrise to noon then a decrease in the evening and another increase at midnight (Table 2).

DISCUSSION

The first records of juvenile cephalopods of the Aegean pelagic ecosystem were given by Degner (1925). Degner found juveniles of six cephalopod

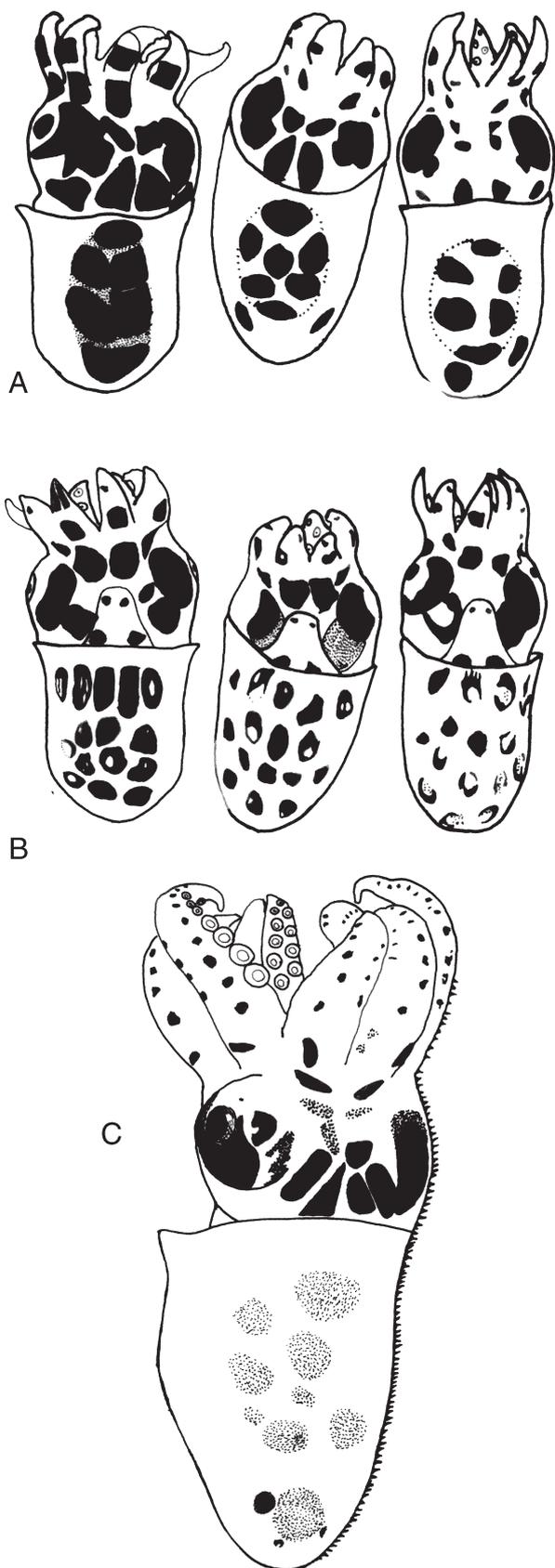


FIG. 9. – Different pigmentation views of *Octopus vulgaris* larvae (A: dorsal view, B: ventral view ML=2.5 mm, C: ML = 5.1 mm).

species (*Heteroteuthis dispar*, *Onychoteuthis banksii*, *Gonatus fabricii*, *Abraliopsis morisi*, *Eledone* sp. *Scaevurgus unicirrhus*). Among these species *G. fabricii* may be wrongly identified because there is no other occasion of an adult *Gonatus* being reported in the courses of all research carried out after Degner (1925) in the Mediterranean. Juveniles reported as *Eledone* spp. are considered to be *E. cirrhosa*. This is because *E. moschata*, which is one of the two *Eledone* species in Mediterranean, is not found in the pelagic zone in any stage of its life including juvenile ages (Sweeney *et al.*, 1992).

A second study in the same area was carried out by Lefkaditou *et al.* (1999) and 9 juvenile cephalopod species were reported from the northern Aegean (*Heteroteuthis dispar*, *Octopus salutii*, *O. vulgaris*, *Histioteuthis reversa*, *H. bonnellii*, *Pyroteuthis margaritifera*, *Ancistrocheirus lesueurii*, *Chiroteuthis veranii*, *Onychoteuthis* sp.)

In this study five of the fourteen species identified were recorded for the first time in the Aegean Sea (*Ctenopteryx sicula*, *Brachioteuthis riisei*, *Illex* cf. *coindetii*, *Thysanoteuthis rhombus*, *Argonauta argo*) as juvenile cephalopods. Sampling which was conducted in four time periods (early morning, noon, late evening and midnight) showed that the caught juvenile and larval cephalopods were more abundant at 350-650 meters. This points to a vertical distribution in larval cephalopods that is dependent on light (Table 2).

When samples were classified in the aspect of abundance it was found that *Heteroteuthis dispar* is dominant in the northern Aegean with 50%, in the southern Aegean with 41.7%, and in the whole Aegean with 44%. *Octopus vulgaris* follows with 22%. The vertical abundance of all species was the greatest at 350-650 m levels.

The only sepiolid species *H. dispar* retrieved in our research was first reported by Degner (1925). Lefkaditou *et al.* (1999) also reported 27 specimens of *H. dispar* with mantle lengths varying between 2.0 and 7.0 mm at 250, 500 and 750 m. Lefkaditou added that this species composed 60% of the whole catch of juvenile cephalopods and was most crowded at 250 m levels with a decreasing in number towards deeper levels.

These results, in conjunction with our results, prove that (Table 1) juvenile populations of *H. dispar* are dense exist just below epipelagic levels. Differences emerge from the different depths of studies. Smaller individuals of this species are found at deeper levels, whereas larger ones are found at lev-

els closer to the surface (Fig. 2). These results are consistent with those of Clarke (1969) who studied in the Canary Islands, and Lefkaditou *et al.* (1999), who studied in the Aegean Sea.

A juvenile of *Ancistrocheirus lesueurii* with 2.5 mm length was obtained at 350 m depth in the southern Aegean. Previously one with a length of 5 mm ML had also been reported by Lefkaditou *et al.* (1999) in the north Aegean at 250 m depth.

*P. margaritifera*, a juvenile of which was reported by Lefkaditou (1999) (20.0 mm ML) at 500 m depth in the northern Aegean, was collected at all depth zones in our study. This result shows similarities with Roper's (1974) results in the Mediterranean. In addition, Vecchione (1987) reports three references for *Pyroteuthis margaritifera* ontogenetic vertical migration, one of which shows a descent pattern (see also Table 1).

Only one specimen of *H. bonnellii* with 10.0 mm ML was sampled at 100 m depth in our study. Lefkaditou *et al.* (1999) sampled a species with 21 mm ML at the 500 m zone. According to Voss *et al.* (1992) *H. bonnellii* specimens with a mantle length of 10-20 mm were found at 100-200 m depths, while juvenile and sub adults with a mantle length exceeding 20 mm were found between 200 and 800 m. Therefore, our findings on the vertical distribution of *H. bonnellii* in the Aegean Sea are in agreement with Voss *et al.* (1992).

Another histioteuthid, *H. reversa* was found in our research in the northern Aegean at 100 m depth. Lefkaditou *et al.* (1999), who worked in the same area, sampled this species at 250, 500, 750 and 1000 m depths. This supports the findings of Voss *et al.* (1992), who report that members of this species may be found in all depth zones from the surface to 1000 m or deeper.

*Ctenopteryx sicula*, which was observed for the first time in the Aegean Sea as a juvenile, was previously reported by Degner (1925) as *Ctenopteryx siculus* in the eastern Mediterranean at 300 m zone. Mangold and Boletzky (1987) stated that the life cycle of this species is completed entirely within the 0-500 m zone.

The juvenile *Brachioteuthis riisei* sampled from the north Aegean at 500 m is a new record from the Aegean. A juvenile with a 25 mm ML was previously reported from the Mediterranean at 300 m depth by Degner (1925). According to Mangold and Boletzky (1987) this species has a distribution from the surface to 500 metres in the whole Mediterranean except the Aegean Sea.

While Vecchione (1987) and Sweeney *et al.* (1992) observed juveniles of this species distributed in surface waters, the present observations are in agreement with those of *Thysanoteuthis rhombus* by Mangold and Boletzky (1987), who reported a broad distribution depth range, the lower limits of which are not known.

*Chiroteuthis veranii* sampled in our research at 650 m depth was previously reported from the Marmara Sea at 1500 m under the name *C. veranyi* by Degner (1925). Four specimens with 16-31 mm ML were reported from the northern Aegean at 250 and 750 m zones by Lefkaditou *et al.* (1999). All findings show that this species occurs in mesopelagic and bathypelagic zones, as reported by Mangold and Boletzky (1987).

*Octopus vulgaris* was reported from the northern Aegean at 750 m by Lefkaditou *et al.* (1999). In our study it was sampled in the same area at 650 m depth. However in the southern Aegean the same species was sampled at 100, 350 and 650 m. It is known that the species, though being mostly related to the continental shelf areas (down to 200 m depth), can also be found on deeper bottoms (Mangold-Wirz, 1963; Sanchez, 1986). Moreover, juveniles being planktonic, the depth range of their distribution is not strictly related to adult habitats. For instance, larvae of planktonic species were found at 1000 m around Sardinia Island and at 400 m in the Marmara Sea by Degner (1925).

A juvenile of *E. cirrhosa* retrieved from the northern Aegean at 650 m is being reported for the first time. Degner (1925) sampled some juveniles of this species in the eastern Mediterranean but he did not distinguish whether they were *E. moschata* or *E. cirrhosa*. In results of studies carried out by Salman *et al.* (2000) on adults, it was observed that *E. cirrhosa* in the northern Aegean was found abundantly down to a depth of 500 m, whereas *E. moschata* distribution was limited to a maximum depth of 200 m zone.

Another first time report for the Aegean Sea is that a juvenile of *Argonauta argo*, an epipelagic species that lives in surface waters, was obtained at 100 m depth. Such a report was previously made by Degner (1925) and Roper (1974) from the Mediterranean.

When vertical distribution of all the 14 species retrieved in this work is analyzed, as Roper (1974) stated *A. argo* juveniles show distributions in the epipelagic zone in the Aegean Sea. When the results of our study and others (Degner, 1925; Roper, 1974;

Sweeney *et al.*, 1992; Lefkaditou *et al.*, 1999) are evaluated together, with the exception of the controversy observed in the distribution of *T. rhombus*, the remaining of eleven species show a broader vertical distribution.

Mangold and Boletzky (1987) reported a total of 40 cephalopod species from the Aegean Sea, which has increased to 50 with later studies (i.e. D'Onghia *et al.*, 1991; Katagan *et al.*, 1992; Vardala-Theodorou *et al.*, 1991; Salman *et al.*, 1999).

Among 14 species retrieved during this study, *O. vulgaris* and *E. cirrhosa* are benthic as adults, *Illex coindetii* is pelagic and semi-demersal, and the remaining eleven are pelagic. When life cycles of recognised species that compose the Aegean cephalopod fauna are examined, it is seen that almost 30 of these species exist in the pelagic ecosystem during their juvenile phase.

As a result, juvenile cephalopods of the Aegean pelagic ecosystem are rich in diversity in the northern Aegean, but rich in quantity in the southern Aegean. Consequently, in order to clarify the definition of juvenile cephalopod species, their abundance, growth and vertical distribution, seasonal samplings in particular should be considered as further studies.

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## REFERENCES

- Amaratunga, T. – 1983. The role of Cephalopods in the marine ecosystem. In: J.F. Caddy (ed.), *Advances in assessment of world Cephalopods resources*. FAO Fish. Tech. Rep. 231: 379-415.
- Bello, G. – 1986. Catalogo dei Molluschi Cephalopodi Viventi nel Mediterraneo. *Boll. Malacologico*, 22(9-12): 197-214.
- Bello, G. – 1990. The Cephalopod fauna of the Adriatic. *Acta Adriat.*, 31(1/2): 275-291.
- Chun, C. – 1910. Die Cephalopoden. 1 Oegopsida. *Wiss. Ergeb. Dtsch. Tiefsee-exped. "VALDIVIA"*, 18: 410 p.
- Clarke, M.R. – 1969. Cephalopoda collected on the Sound cruise. *J. Mar. Biol. Ass. U.K.* 49: 961-976.
- Degner, E. – 1925. Cephalopoda. *Report on the Danish Oceanographic Expeditions 1908-10 to the Mediterranean and adjacent seas*, 9: Vol. II. Biology, C. 1. pp. 1- 94.
- D'Onghia., G., A. Mataresse, A. Tursi and P. Maiorano. – 1996. Cephalopods collected by bottom trawling in the North Aegean Sea (Eastern Mediterranean). *Oebelia* 22: 33-46.
- D'Onghia., G., A. Tursi, C. Papaconstantinou and A. Mataresse. – 1991. Teuthofauna of the North Aegean Sea: Preliminary result on catch, composition and distribution. *FAO Fish. Rep. No. 477*: 69-84.
- Katagan, T. and A. Kocatas. – 1990. Note préliminaire sur les céphalopodes des eaux Turques. *Rapp. Comm.Int. Mer Méditerr.* 32: 242.

- Katagan, T., A. Salman and H.A. Benli. – 1992. Nouvelles observations sur *Ommastrephes bartrami* (Lesueur, 1821) (Cephalopoda, Ommastrephidae) dans le Bassin Méditerranéen Oriental. *Rapp. Comm. Int. MÉR Méditerr.* 33: 298.
- Kocatas, A. and N. Bilecik. – 1992. Aegean Sea and Its Living Resources. *T.C. Tarım ve Köyisleri Bakanlığı. Su Ürünleri Araştırma Enstitüsü Müdürlüğü. Bodrum. Seri A. 7:* 88 pp. (in Turkish)
- Lefkaditou, E., C. Papaconstatinou and K. Anastasopoulou. – 1999. Juvenil cephalopods collected in the midwater macroplankton over a trench in the Aegean Sea (Northeastern Mediterranean). *Isr. J. Zool.* 45: 395-405.
- Mangold, K. and S.V. Boletzky. – 1987. Céphalopodes. In: Fischer, W., M.L. Bauchot, and M. Schneider (eds.), *Fiches d'identification des espèces pour les besoins de la pêche. (Révision 1) Méditerranée et Mer Noire. Vol. I. FAO, Rome*, pp. 633-714.
- Mangold-Wirz, K. – 1963. Biologie des céphalopodes benthiques et nectoniques de la mer Catalane. *Vie Milieu, Suppl.* 13: 1-285.
- Naef, A. – 1923. Die Cephalopoden (Systematik). *Fauna Flora Golf. Neapel*, 35 Monogr. I/1: 1-863. (Translated by A. Mercado, 1972. *Smithsonian Institution*, Washington, 917 p.)
- Orsi-Relini, L., F. Garibaldi, G. Palandri, and C. Cima. – 1994. La comunità mesopelagica e i predatori "di superficie". *Biol. Mar. Méditerr.*, 1: 105-112.
- Roper, C.F.E. – 1974. Vertical and seasonal distribution of pelagic cephalopods in the Mediterranean sea. Preliminary report. *Bull. Am. Malacol. Union.*: 27-30.
- Salman, A., T. Katagan and H.A. Benli. – 1997. Bottom trawl teuthofauna of the Aegean Sea. *Arch. Fish. Mar. Res.*, 45: 183-196.
- Salman, A., T. Katagan and S.V. Boletzky. – 1999. New cephalopod molluscs in the eastern Mediterranean: Previously unnoted species or Lessepsian migrants? *Vie Milieu*, 49(1): 11-17
- Salman, A., T. Katagan and A.C. Gücü. – 2000. The distribution and fishing of two Mediterranean *Eledone* spp. (Octopoda: Cephalopoda) in the Aegean Sea. *Tr. J. Zoolgy.*, 24: 165-171.
- Sanchez, P. – 1986. Distribucion batimétrica y abundancia algunos cefalopodos del mar Catalan. *Inv. Pesq.*, 50(2): 237-345.
- Sanchez, P. and B. Moli. – 1985. An annotated list of Cephalopod larvae collected off the Mediterranean coast of Spain, 1976-1981. *Vie Milieu*, 35: 171-173.
- Stergiou, K.I., E.D. Christou, D. Georgopoulos, A. Zenetos and C. Souvermezoglou. – 1997. The Hellenic Seas: physics, chemistry, biology and fisheries. *Oceanogr. Mar. Biol. Annu. Rev.*, 35: 415-538.
- Sokal, P.R. and Rohlf, F.J. – 1980. *Biometry*. W.H. Freeman and Company, New York. 859 pp.
- Sweeney, M.J. and C.F.E. Roper. – 1998. Classification, type localities and type repositories of recent Cephalopods. In: N.A. Voss et al., (eds.), *Systematics and Biogeography of Cephalopods. Smithsonian. Contrib. Zool.* 586: 561-599.
- Sweeney, M.J., C.F.E. Roper, K.M. Mangold, M.R. Clarke and S.V. Boletzky. – 1992. "Larval" and juvenile Cephalopods: A manual for their identification. *Smithson. Contrib. Zool.* 513: 282 pp.
- Vardala-Theodorou, E., P. Giamas and A. Dimitropoulos. – 1991. A short notice on the occurrence of a pair of *Thysanoteuthis rhombus* Troschel, 1857 in Southern Euboic Gulf. *Boll. Malacol.* 27: 25-34.
- Vecchione, M. – 1987. Juvenile Ecology. In: P.R. Boyle (ed.), *Cephalopoda life cycles*, Vol. II. Academic Press, London. pp. 61-84.
- Voss, N.A., S.J. Stephen and Zh.Dong. – 1992. Histioteuthidae. In: M.J. Sweeney, C.F.E. Roper, K.M. Mangold, M.R. Clarke and S.V. Boletzky (eds.), "Larval" and juvenile Cephalopods: A manual for their identification. *Smithson. Contrib. Zool.* 513: 73-91.

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