# Records of Oncaeidae (Copepoda) from the Gulf of Naples, with new records of three species of Triconia

**Article** *in* Journal of the Marine Biological Association of the UK · November 2008

DOI: 10.1017/S002531540800194X



Iole Di Capua
Stazione Zoologica Anton Dohrn

*Journal of the Marine Biological Association of the United Kingdom*, page 1 of 9. 
doi:10.1017/S002531540800194X Printed in the United Kingdom

# Records of Oncaeidae (Copepoda) from the Gulf of Naples, with new records of three species of *Triconia*

IOLE DI CAPUA[1] AND GEOFF A. BOXSHALL[2]

[1]Stazione Zoologica A. Dohrn, Napoli, Italy, [2]Department of Zoology, The Natural History Museum, Cromwell Road, London SW7 5BD, UK

*Three species of Oncaeidae,* Triconia umerus, T. hawii *and* T. rufa *are reported for the first time in the coastal waters of the Gulf of Naples, Tyrrhenian Sea, western Mediterranean Sea. They were found in meso-zooplankton samples collected in 2004 and were absent from samples collected prior to 2004. Specimens of* Triconia umerus *and* T. hawii *were compared with material collected from the type locality (the Red Sea). In order to facilitate identification, brief differential diagnoses, supported by scanning electron micrographs, are presented for the five species of* Triconia *that have small body size (450 to 600 μm) and co-occur in the upper 50 m of the water column of the Gulf of Naples. Surface ornamentation on the genital double-somite of the female is reported in* T. minuta *and* T. hawii *for the first time, but it is difficult to observe using light microscopy and we infer that it has probably been overlooked in these species hitherto. Possible explanations for the new discovery of these species in such a well-studied area are discussed and it is suggested that they represent relatively recent additions to the fauna. A key to the eleven species of Oncaeidae found in the Gulf of Naples is presented.*

**Keywords:** Oncaeidae, Gulf of Naples, new records, *Triconia* spp.

Submitted 9 March 2007; accepted 5 March 2008

## INTRODUCTION

The Oncaeidae is a speciose family of copepods, that contributes to zooplankton communities in a wide range of marine environments, from low to high latitudes (Star & Mullin, 1981; Cowles *et al*., 1987; Paffenhöffer, 1993; Richter, 1994; Metz, 1995) and from near surface waters to the deep sea (Boxshall, 1977a; Wishner, 1979; Roman *et al*., 1985; Yamaguchi *et al*., 2002). The taxonomic diversity of the Oncaeidae, as re-defined by Huys & Böttger-Schnack (1997), has been increasingly recognized during recent years (Shmeleva, 1969; Boxshall, 1977b; Heron, 1977; Heron *et al*., 1984; Heron & Bradford-Grieve, 1995; Böttger-Schnack, 1999, 2001; Heron & Frost, 2000). The generic level classification of this family is under review (Böttger-Schnack & Huys, 1998), but Boxshall & Halsey (2004) listed seven valid genera, *Archioncaea* Böttger-Schnack & Huys, *Monothula* Böttger-Schnack & Huys, *Spinoncaea* Böttger-Schnack, *Oncaea* Philippi, *Triconia* Böttger-Schnack, *Epicalymma* Heron and *Conaea* Giesbrecht. These genera have been recorded from distant localities in the world ocean, including the Mediterranean (Shmeleva, 1966, 1968, 1969; Malt *et al*., 1989; Böttger-Schnack, 1997; Kršinic, 1998), the Red Sea and Arabian Sea (Böttger-Schnack, 1990a, b, 1995, 1996), the north-west and north-east Pacific (Heron & Frost, 2000; Nishibe & Ikeda, 2004) and the Antarctic (Metz, 1995).

**Corresponding author:**
I.D. Capua
Email: dicapua@szn.it

The genus *Triconia* was established by Böttger-Schnack (1999) to accommodate eleven species of Oncaeidae characterized by the presence of a conical process on the distal margin of the endopod of swimming leg 4. It corresponds to the *Oncaea conifera* Giesbrecht and *Oncaea similis* Sars groups recognized in the phylogenetic analysis of Böttger-Schnack & Huys (1998). *Triconia umerus* (Böttger-Schnack & Boxshall) and *T. hawii* (Böttger-Schnack & Boxshall), originally placed in the genus *Oncaea*, were based on females collected in the Red Sea (Böttger-Schnack & Boxshall, 1990). Böttger-Schnack (1999) subsequently redescribed both species, transferred them to *Triconia*, and described the males for the first time.

The oncaeids of the Mediterranean Sea are relatively well known: forty-seven species have been reported and many small-size *Oncaea* species (less than 0.6 mm) were first described from the Adriatic (Shmeleva, 1966, 1968, 1969, 1979). *Triconia* is represented by only eight species in the Mediterranean whereas 12 species have been reported from the Red Sea. Identification of oncaeid species requires detailed investigation of numerous characters, including mouthparts and surface ornamentation, which are difficult to examine in these small copepods. Recent detailed taxonomic studies (Heron & Bradford-Grieve, 1995; Heron & Frost, 2000, Böttger-Schnack, 2001) have demonstrated that many apparently well known species, such as *Triconia conifera* (Giesbrecht) and *Oncaea media* Giesbrecht, represent complexes of closely related yet distinct species. A recent phylogeographical study of *Oncaea venusta* Philippi revealed genetically distinct clades at five different locations in the Indo-West Pacific (Elvers *et al*., 2006).

Temporal changes in the community of oncaeid copepods at a fixed coastal station in the Gulf of Naples (Tyrrhenian Sea) have been investigated over seasonal and inter-annual scales (Mazzocchi & Aguzzi, 1998). This study has shown for the first time the presence of *Triconia umerus*, *T. hawii* and *T. rufa* (Boxshall & Böttger-Schnack) in the western Mediterranean. The record of *T. hawii* is the first for the Mediterranean Sea. These new records highlight the importance of improved taxonomic resolution of oncaeids in time-series studies in providing further evidence of faunistic change.

## MATERIALS AND METHODS

Mesozooplankton samples were collected between 08:00 h and 12:00 h to minimize the variability due to vertical migration. Vertical hauls were taken from 50 m depth to the surface using a Nansen net (113 cm mouth diameter, 200 μm mesh aperture). The samples were fixed immediately after collection and preserved in a 4% buffered formaldehyde–seawater solution. The samples examined were part of an on-going time-series study of the pelagic system at a fixed station Marechiara (Station MC) in the Gulf of Naples which commenced in January 1984 (Ribera d'Alcalà *et al.*, 2004).

The sampling site (40°48.5′N 14°15′E) is located two nautical miles from the coast, close to the 80 m isobath (Figure 1). The Gulf of Naples is a wide embayment (870 km$^2$) in the Tyrrhenian Sea (western Mediterranean). The littoral area is influenced by land runoff from a densely populated region. However, due to the general physiography and bottom topography, the inner shelf area is strongly coupled with offshore Tyrrhenian waters. These features result in the coexistence of two subsystems within the Gulf: a wide oligotrophic area with Tyrrhenian characteristics and a narrower eutrophic coastal zone. The Marechiara station is located at the boundary between the two subsystems (Ribera d'Alcalà *et al.*, 2004).

Oncaeids from samples taken at the Marechiara station on 31 January and 8 February 2005 were sorted and examined. About 20 females of each species were identified under a Wild M3C stereomicroscope. Specimens were dissected in lactic acid and examined as temporary mounts in lactophenol. Measurements were taken under the microscope using an ocular micrometer. Total body length was measured dorsally from the tip of prosome to the distal end of the caudal ramus.

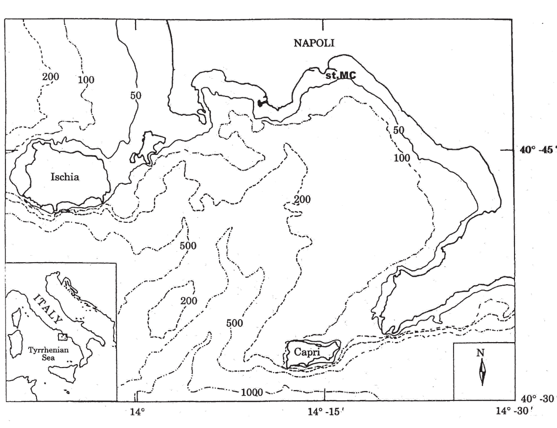


**Fig. 1.** Location of the sampling site (Station MC) of the long-term study conducted in the Gulf of Naples (Tyrrhenian Sea, western Mediterranean).

Diagnostic morphological details were verified using scanning electron microscopy (SEM). Specimens, pre-fixed in formaldehyde, were rinsed with distilled water and left overnight to enhance body turgidity. They were post-fixed for 5 h in 2.5% gluteraldehyde at room temperature before dehydration through graded methanol series. Specimens were critical-point dried and coated with gold-palladium before being mounted on stubs. We compared the general body shape of *Triconia umerus* and *T. hawii* from the Gulf of Naples with the same species from the Red Sea (type material from collections of the Natural History Museum, London).

## RESULTS

In addition to nine common species of Oncaeidae (*Oncaea curta* Sars, *O. scottodicarloi* Heron & Bradford-Grieve, *O. media*, *O. mediterranea* (Claus), *O. venusta*, *Monothula subtilis* (Giesbrecht), *Triconia conifera*, *T. dentipes* (Giesbrecht) and *T. minuta* (Giesbrecht)), three other *Triconia* species were present. Two of these, *Triconia umerus* and *T. rufa*, have already been reported from the eastern Mediterranean (Böttger-Schnack, 1997) but the third species, *Triconia hawii*, has not been reported before from the Mediterranean Sea. These species were first discovered in the Gulf of Naples in April 2004. Their abundances were lower than those of other oncaeid species at the same station. Abundance ranged from 0.2 to 3.2 ind m$^{-3}$ for all three species, but the mesh size (200 μm) of the net used to collect the meso-zooplankton was too large to efficiently collect these microcopepods. They can be reliably collected using 55 μm mesh nets (Böttger-Schnack, 1997, 1999).

*Triconia conifera* is a large and distinctive species, but the other five species of *Triconia* present in the Gulf of Naples are all of similar size, with adult female body length between about 450 and 600 μm. The females of these species can most readily be distinguished by combinations of fine-scale characters, including body length, shape of urosome, relative lengths of setal elements on leg 5, and the positions of the gonopores and integumental pores on the dorsal surface of the genital double-somite. These characters are summarized for the three most similar species in Table 1 and are briefly outlined in a series of differential diagnoses based specifically on Gulf of Naples material taken in the 0–50 m depth horizon.

**Table 1.** Morphological characters separating females of *Triconia minuta*, *T. umerus* and *T. hawii* in the Gulf of Naples.

| Character | *T. minuta* | *T. umerus* | *T. hawii* |
|---|---|---|---|
| Urosome form | Elongate | Oval | Flask-like |
| P5 setae | Medium length | Short and stout | Elongate |
| P4 enp-3:length ratio of OSDS:ODS | Equal | Shorter | Equal |
| Position of dorsal integumental pores (% distance along double-somite) | 73% | 72% | 56% |

OSDS, outer subdistal spine; ODS, outer distal spine.

*Triconia dentipes* (Giesbrecht, 1891)
(Figure 2A–D)

Body length 478 μm. Prosome slender; second pedigerous somite lacking any dorsal process. Genital double-somite (in dorsal view) about 1.5 times longer than wide, with evenly convex lateral margins; gonopores located at about 47% of distance along double-somite from anterior margin. Pair of integumental pores located at about 78% of distance along double-somite from anterior margin. Surface of double-somite lacking ornamentation of spinules. Leg 5 with surface seta (derived from incorporated basis) just extending to level of gonopores; exopodal setal elements of similar length, short, not reaching gonopores. Live specimens with distinctive coloration, with orange pigment located anteriorly in narrow band across cephalosome.

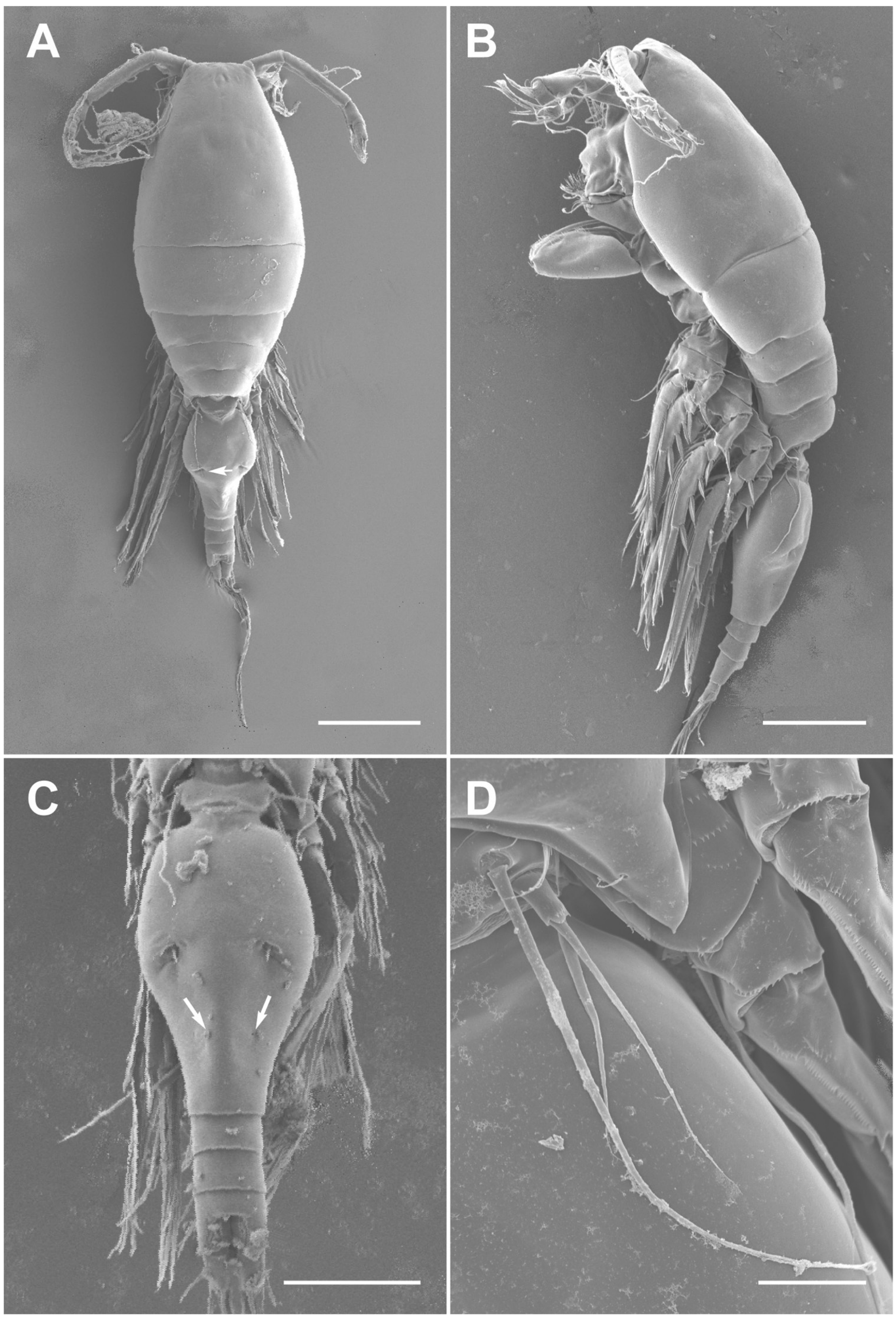


**Fig. 2.** *Triconia dentipes* (Giesbrecht, 1891). (A) Entire, dorsal view showing position of gonopores (arrowed); (B) entire, lateral view showing long surface seta of leg 4 reaching to level of gonopore (arrowed); (C) urosome, dorsal view showing dorsal integumental pores (arrowed); (D) leg 5. Scale bars: A, B, D, 100 μm; C, 50 μm.

## REMARKS

*Triconia dentipes* was originally described from Gulf of Naples material (Giesbrecht, 1891). Giesbrecht's figures showed the same distinctive morphological characters, especially the flask-like form of the genital double-somite (cf. plate 47, figure 7; our Figure 2C). This species was reported from other Mediterranean areas and the Red Sea by Böttger-Schnack (1999) who discussed the differences between Giesbrecht's drawing (1892, plate 47, figure 7) and her redescription (1999, figure 13C) with reference to the length of the terminal accessory seta on the caudal ramus. In accord with Böttger-Schnack (1999), our specimens of *T. dentipes* from the Gulf of Naples have a long terminal accessory seta on the caudal ramus (Figure 2D).

*Triconia minuta* (Giesbrecht, 1892)
(Figure 3A, B)

Body length 474 µm. Prosome slender; second pedigerous somite lacking any dorsal process. Genital double-somite (in dorsal view) about 1.6 times longer than wide, with evenly convex lateral margins; gonopores located at about 33% of distance along double-somite from anterior margin. Pair of integumental pores located at about 73% of distance along double-somite from anterior margin. Surface of double-somite ornamented with lateral patches of spinules extending posteriorly from level of gonopores. Leg 5 with surface seta (derived from incorporated basis) short, not reaching level of gonopores; exopodal setal elements of similar length, short, not reaching gonopores.

*Triconia umerus* (Böttger-Schnack & Boxshall, 1990)
(Figures 3C–D & 4A)

Body length 580 µm. Prosome slender; second pedigerous somite lacking any dorsal process. Genital double-somite (in dorsal view) about 1.5 times longer than wide, bottle-shaped with distinct 'bottleneck' narrowing posteriorly; gonopores located at about 35% of distance along double-somite from anterior margin. Pair of integumental pores located at about 72% of distance along double-somite from anterior margin. Lateral surface of double-somite ornamented with patches of surface spinules just posterior to gonopores, including defined row of spinules at 'shoulders' of bottleneck. Leg 5 with plumose surface seta (derived from incorporated basis) strong and short, not reaching level of gonopores; exopodal setal elements of similar length, short, not reaching level of gonopores.

## REMARKS

*Triconia umerus* is very similar to *T. minuta* but is larger and can be distinguished easily by the orange coloration on the urosome and anterior part of the prosome. In *T. umerus* the row of small denticles on the margin of genital double-somite is visible under the stereomicroscope.

*Triconia rufa* (Boxshall & Böttger, 1987)
(Figure 4B)

Body length 497 µm. Prosome very slender; second pedigerous somite with rounded dorsal process visible in lateral view. Genital double-somite (in dorsal view) about 1.6 times longer than wide, bottle-shaped with distinct 'bottleneck' narrowing posteriorly; gonopores located at about 30% of distance along double-somite from anterior margin. Pair of integumental pores located at about 60% of distance along double-somite from anterior margin. Surface of double-somite ornamented with lateral patches of spinules extending from level of gonopores to 'shoulders' of bottleneck. Leg 5 with very long, curved surface seta (derived from incorporated basis) reaching beyond gonopores as far as 'shoulders' of bottleneck; exopodal setal elements distinctly different in length, one elongate and one short, not reaching gonopores: exopodal segment with small spinule.

## REMARKS

In this species the ornamentation of surface spinules on the genital double-somite is not visible under the stereomicroscope. The extreme length of the surface seta derived from the incorporated basis of the fifth leg is characteristic for *T. rufa*.

*Triconia hawii* (Böttger-Schnack & Boxshall, 1990)
(Figure 4C, D)

Body length 497 µm. Prosome slender; second pedigerous somite lacking any dorsal process. Genital double-somite (in dorsal view) about 1.4 times longer than wide, bottle-shaped with distinct 'bottleneck' narrowing posteriorly; gonopores located at about 30% of distance along double-somite from anterior margin. Pair of integumental pores located at about 56% of distance along double-somite from anterior margin. Surface of double-somite ornamented with extensive lateral patches of spinules. Leg 5 with surface seta (derived from incorporated basis) short, not reaching level of gonopores; exopodal setal elements of similar length, short, not reaching gonopores.

## COMPARISONS

Some new morphological details are revealed here. Most notably the presence of an ornamentation of surface spinules on the lateral margins of the genital double-somite in *T. minuta* and *T. hawii*, that has not previously been reported. Similar ornamentation has been reported for both *T. umerus* and *T. rufa* (Böttger-Schnack, 1999) but it is difficult to observe by light microscopy and we infer that it has previously been overlooked in *T. minuta* and *T. hawii.*

The specimens collected in the Gulf of Naples were compared with data on populations from the Red Sea. Small differences were observed between females from the two localities in size and in body proportions (cf. Table 2). However, size differences are unreliable because of differences in mesh sizes used between the Red Sea survey and the Gulf of Naples study. The differences in body proportions are not regarded here as significant and, indeed, Böttger-Schnack (1999) has already noted slight differences in urosome shape between material of *T. dentipes* from the Red Sea and the Adriatic. We also note slight differences in the positions of the gonopores and the dorsal integumental pores along the genital double-somite. We infer that these differences

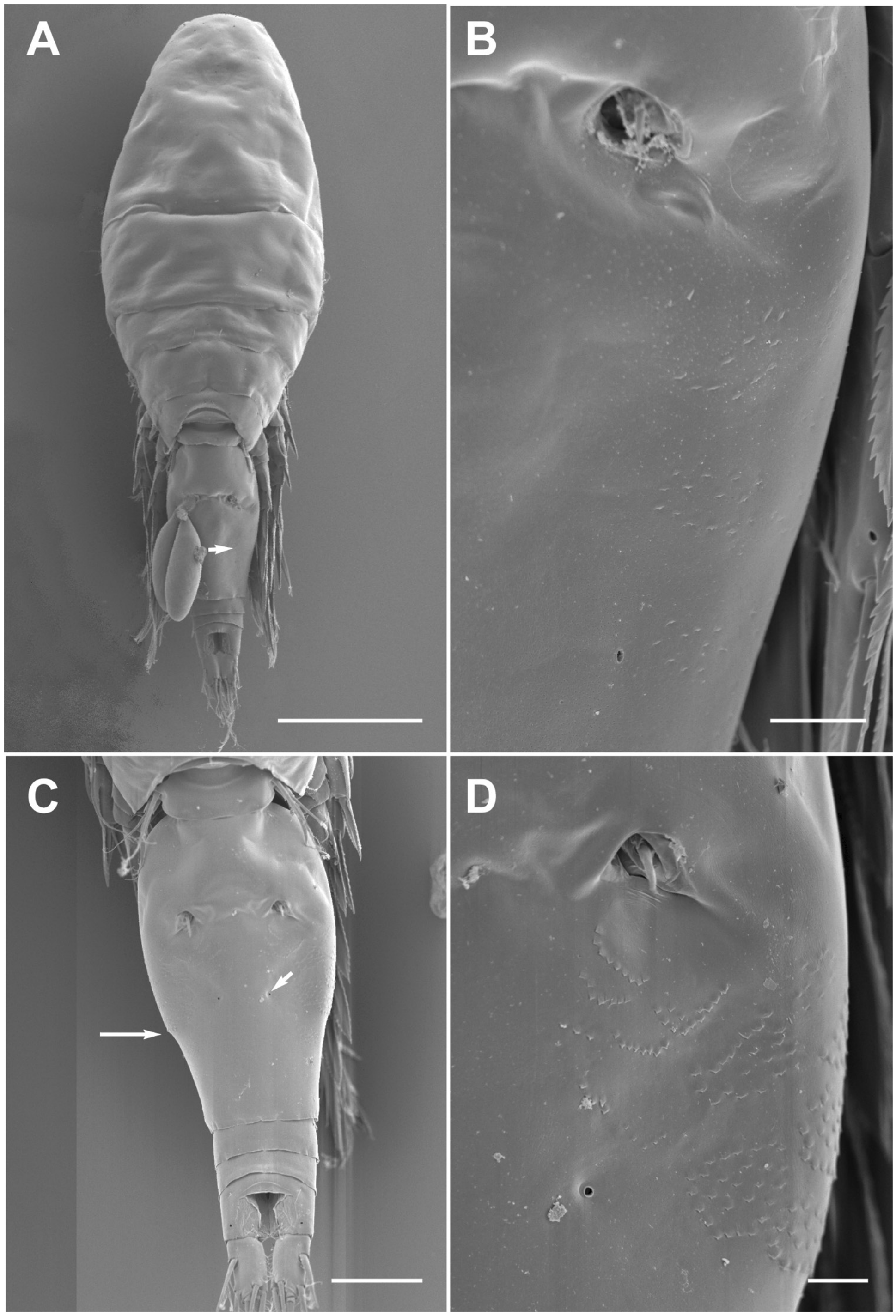


**Fig. 3.** *Triconia minuta* (Giesbrecht, 1892). (A) Entire, dorsal view showing position of dorsal integumental pore (arrowed); (B) genital double-somite spinular ornamentation. *Triconia umerus* (Böttger-Schnack & Boxshall, 1990); (C) genital double-somite, dorsal view showing position of integumental pore (small arrow) and marginal spinule row at angle of shoulder of double-somite (large arrow); (D) same, showing spinular ornamentation and location of integumental pore. Scale bars: A, 100 μm; B, C, D, 20 μm.

represent geographical variation in all species with the possible exception of *T. hawii. Triconia hawii* is unusual in exhibiting variation in the position of the gonopores on the genital double-somite: with Böttger-Schnack (1999) showing gonopores located between 33% and 50% of the distance along the double-somite. In other species this character is relatively stable. We consider this degree of variability to indicate a possible taxonomic problem. Also in *T. hawii*, the dorsal integumental pore is located at about 71% of distance along double-somite from anterior margin in Red Sea material (Böttger-Schnack, 1999) compared with only 56% in Gulf of Naples material. In addition, our Gulf of Naples material has spinular ornamentation, not reported by Böttger-Schnack (1999). These results cause some uncertainty over the identity

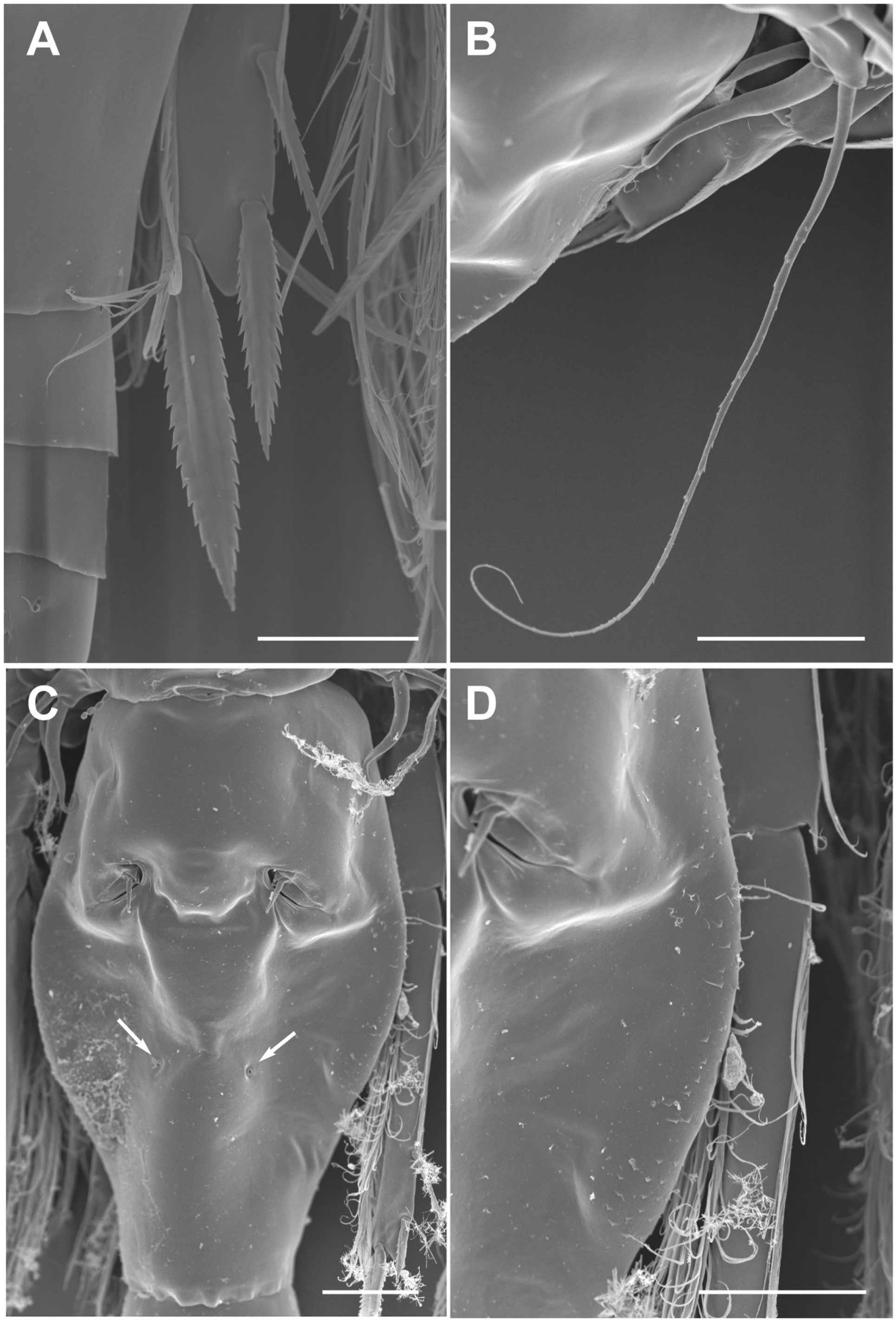


**Fig. 4.** *Triconia umerus* (Böttger-Schnack & Boxshall, 1990). (A) Leg 4, tip endopod showing relative lengths of distal spines *Triconia rufa* (Boxshall & Böttger, 1987); (B) leg 5, showing extreme length of outer exopodal seta *Triconia hawii* (Böttger-Schnack & Boxshall, 1990); (C) genital double-somite, dorsal view showing position of integumental pores (arrowed) (the highlighted transverse ridges adjacent to the gonopores are artefacts of the drying process); (D) genital double-somite, dorsal view of right side showing spinular ornamentation. Scale bars: A, B, C, D, 20 μm.

of the *T. hawii* from the Gulf of Naples. Further taxonomic research is needed to investigate the significance of this level of variability between populations of this species, although the current diagnosis of the species accommodates much of this variability.

There are also marked differences in the depth distributions of the species between the Red Sea and the Gulf of Naples. In the Gulf, all five species co-occur in the top 50 m of the water column whereas in the central Red Sea *T. minuta* and *T. umerus* both are found primarily in the 50 to 100 m depth horizon, *T. dentipes* at depths of 150 to 200 m, and both *T. hawii* and *T. rufa* much deeper, at 650 to 700 m (Böttger-Schnack, 1990a, b, 1992).

**Table 2.** A comparison of prosome lengths and body proportions of *Triconia umerus* and *T. hawii* from the Gulf of Naples and the type locality (Red Sea).

| | *T. umerus* | | *T. hawii* | |
|---|---|---|---|---|
| | **Mediterranean** | **Red Sea** | **Mediterranean** | **Red Sea** |
| Total length (mm) | 0.58 ± 1 | 0.57 ± 0.5 | 0.51 ± 1 | 0.49 ± 0.7 |
| Prosome/urosome length | 2.6 | 2.3 | 2.2 | 2.7 |
| Genital double-somite L:W | 1.6 | 1.3 | 1.6 | 1.5 |
| Anal somite: L:W | 1.29 | 1.3 | 1.5 | 1.6 |
| Caudal ramus: L:W | 1.3 | 1.5 | 1.7 | 1.6 |

L:W, length to width ratio.

## KEY TO SPECIES OF ONCAEIDAE IN GULF OF NAPLES (ADULT FEMALES ONLY)

1. Large, heavily-chitinized forms with body length in excess of 1.0 mm. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 2
   Small forms with body length less than 1.0 mm. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 3
2. Caudal rami about 3.5 times longer than wide; anal somite about 0.63 times long as wide. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *Oncaea venusta*
   Caudal rami about 3.0 times longer than wide; anal somite about 0.77 times long as wide. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .*Oncaea mediterranea*
3. Endopod of leg 4 with distal conical process between apical and outer distal margin spines (Figure 4A) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 4
   Endopod of leg 4 without distal conical process between apical and outer distal margin spines. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 8
4. In lateral view, prosome with conspicuous dorso-posterior projection on second pedigerous somite. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .*Triconia conifera*
   In lateral view, prosome without conspicuous dorso-posterior projection (bearing small rounded dorsal process in *T. rufa* only) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 5
5. Prosome 1.9 times as long as urosome (excluding caudal setae); anal somite about as wide as long; body length 0.47 mm ± 0.05 mm. . . . . . . . . . . . . . . . .*Triconia dentipes*
   Prosome at least 2.3 times as long as urosome (excluding caudal setae); anal somite at least 1.2 times wider than long; body length 0.49 to 0.60 mm. . . . . . . . . . . . . . . . . . . .6
6. Prosome about 2.7 times as long as urosome (excluding caudal setae); anal somite at least 1.6 times wider than long; body length 0.49 ± 0.07 mm. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *Triconia hawii*
   Prosome about 2.3 to 2.4 times as long as urosome (excluding caudal setae); anal somite 1.2 to 1.3 times wider than long; body length 0.50–0.57 mm. . . . . . . . . . . . . . . . . . . . . 7
7. Genital double-somite about 1.6 times longer than wide and with evenly convex lateral margins; body length 0.50 mm ± 0.06 mm. . . . . . . . . . . . . . . . . *Triconia minuta*
   Genital double-somite about 1.5 times longer than wide, bottle-shaped, with distinct bottleneck narrowing posteriorly; body length 0.58 mm ± 0.05 mm. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *Triconia umerus*
8. Prosome about 2.0 times as long as urosome (excluding caudal setae); body length 0.44 mm ± 0.08 mm. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *Monothula subtilis*
   Prosome about 2.5 to 2.8 times as long as urosome (excluding caudal setae); body length in the range 0.62 to 0.82 mm. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 9
9. Prosome 2.8 times as long as urosome (excluding caudal setae); genital double-somite 1.5 times as long; body length 0.69 ± 0.01 mm. . . . . . . . . . . *Oncaea scottodicarloi*
   Prosome 2.6 times as long as urosome (excluding caudal setae); genital double-somite 1.9 times as long; body length 0.82 ± 0.02 mm. . . . . . . . . . . . . . . . .*Oncaea media*
   Prosome 2.5 times as long as urosome (excluding caudal setae); genital double-somite 1.6 times as long; body length 0.62 ± 0.08 mm. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *Oncaea curta*

## DISCUSSION

We report three species belonging to the genus *Triconia* (Oncaeidae) from the western Mediterranean for the first time, all of which were originally described from the Red Sea. There are three possible explanations of this discovery: firstly, they may represent recent lessepsian migrants through the Suez Canal from the Red Sea, secondly, they may represent invasive species transported into the Naples region anthropogenically, possibly in ballast water, and thirdly, they may have been present but overlooked in previous studies. Using morphology, we have no way of distinguishing between the first two possibilities, which constitute the recent arrival hypothesis. The copepod fauna of the Gulf of Naples has been extensively studied by one of the most accurate and reliable taxonomists in the history of copepodology, Wilhelm Giesbrecht. He described *T. minuta* from the Gulf of Naples in 1892 and also recorded *T. dentipes* from the Gulf (Giesbrecht, 1892). These species are similar in size, or smaller than *T. hawii*, *T. umerus* and *T. rufa*, and all co-occur today in the top 50 m of the water column in the Gulf. We regard it as highly unlikely that Giesbrecht would have failed to notice these distinctive species in his comprehensive studies. In addition, these species were missing from time-series samples taken at the same station prior to April 2004 (M.G. Mazzocchi, personal communication). We therefore regard the most likely explanation of these new records from the Mediterranean as due to the recent arrival of these species. The breakdown of the depth segregation that is apparent in the distributions of these species in the central Red Sea may be interpreted as additional evidence of recent arrival.

In total, the number of oncaeid species currently known from the Gulf of Naples is low compared to the 47 species reported for the Mediterranean Sea and the 34 for the Red Sea, but the presence of six *Triconia* species in the Gulf, including the three new records, is comparable with the eight reported for the whole Mediterranean Sea. The revised genus *Triconia* (Böttger-Schnack, 1999) includes twelve species worldwide, all of which occur in the Red Sea, double the number from the Gulf of Naples.

## ACKNOWLEDGEMENTS

The project is a contribution to the work of the MarBEF Network of Excellence 'Marine Biodiversity and Ecosystem Functioning' which is funded by the European Union's Sixth Framework Programme (contract No. GOCE-CT-2003-505446). The study was supported by a grant from the MarBEF Taxonomy Clearing System. This publication is contribution No. MPS-07001 of MarBEF. The first author would like to thank Franco and Gennaro Iamunno for technical assistance at the scanning electron microscope, Dr M.G. Mazzocchi Dr V. Saggiomo and the staff of the Area of Environmental Management and Ecology of Temperate and Polar Coastal Areas (MECA), Stazione Zoologica A. Dohrn for their support.

## REFERENCES

**Böttger-Schnack R.** (1990a) Community structure and vertical distribution of cyclopoid copepods in the Red Sea. I. Central Red Sea, autumn 1980. *Marine Biology* 106, 473–485.

**Böttger-Schnack R.** (1990b) Community structure and vertical distribution of cyclopoid copepods in the Red Sea. II. Aspect of seasonal and regional differences. *Marine Biology* 106, 487–501.

**Böttger-Schnack R.** (1992) Community structure and vertical distribution of cyclopoid and poecilostomatoid copepods in the Red Sea. III. Re-evaluation for separating a new species of *Oncaea*. *Marine Ecology Progress Series* 80, 301–304.

**Böttger-Schnack R.** (1995) Summer distribution of micro- and small mesozooplankton in the Red Sea and Gulf of Aden, with special reference to non-calanoid copepods. *Marine Ecology Progress Series* 118, 81–102.

**Böttger-Schnack R.** (1996) Vertical structure of small metazoan plankton, especially non-calanoid copepods. I. Deep Arabian Sea. *Journal of Plankton Research* 18, 1073–1101.

**Böttger-Schnack R.** (1997) Vertical structure of small metazoan plankton, especially non-calanoid copepods. II. Deep Eastern Mediterranean (Levantine Sea). *Oceanologica Acta* 20, 399–419.

**Böttger-Schnack R.** (1999) Taxonomy of Oncaeidae (Copepoda, Poecilostomatoida) from the Red Sea. I. 11 species of *Triconia* gen. nov. and a redescription of *T. similis* (Sars) from Norwegian waters. *Mitteilungen aus dem Hamburgischen Zoologischen Museum und Institut, Hamburg* 96, 37–128.

**Böttger-Schnack R.** (2001) Taxonomy of Oncaeidae (Copepoda, Poecilostomatoida) from the Red Sea. II. Seven species of *Oncaea* s.str. *Bulletin of the British Museum* 67, 25–84.

**Böttger-Schnack R. and Boxshall G.A.** (1990) Two new *Oncaea* species (Copepoda: Poecilostomatoida) from the Red Sea. *Journal of Plankton Research* 12, 861–871.

**Böttger-Schnack R. and Huys R.** (1998) Species groups within the genus *Oncaea* Philippi, 1843 (Copepoda, Poecilostomaoida). *Journal of Marine Systems* 15, 369–371.

**Boxshall G.A.** (1977a) The planktonic copepods of the northeastern Atlantic Ocean: some taxonomic observations on the Oncaeidae (Cyclopoida). *Bulletin of the British Museum (Natural History) Zoology* 31, 103–123.

**Boxshall G.A.** (1977b) The depth distribution and community organization of the planktonic cyclopoids (Crustacea: Copepoda) of the Cape Verde Islands region. *Journal of the Marine Biological Association of the United Kingdom* 57, 543–568.

**Boxshall G.A. and Böttger R.** (1987) Two new species of *Oncaea* (Copepoda: Poecilostomatoida) from the Red Sea and a redescription of *O. atlantica* Shmeleva. *Journal of Plankton Research* 9, 553–564.

**Boxshall G.A. and Halsey S.H.** (2004) *An introduction to copepod diversity*. London: The Ray Society, 966 pp.

**Cowles T.S., Roman M.R., Gauzens A.L. and Copley N.J.** (1987) Short-term changes in the biology of a warm-core ring: zooplankton biomass and grazing. *Limnology and Oceanography* 32, 653–664.

**Elvers D., Böttger-Schnack R., Blohm D. and Hagen W.** (2006) Sympatric size variants of the microcopepod *Oncaea venusta* exhibit distinct lineages in DNA sequences. *Marine Biology* 149, 503–513.

**Giesbrecht W.** (1891) Elenco dei Copepodi pelagici raccolti dal tenente di vascello Gaetano Chierchia durante il viaggio della R. Corvetta 'Vettor Pisani' negli anni 1882–1885, e dal tenente di vascello Francesco Orsini nel Mar Rosso, nel 1884. *Atti della Academia Nazionale dei Lincei. Rendiconti* 4, 474–481.

**Giesbrecht W.** (1892) Systematik und Faunistik der pelagischen Copepoden des Golfes von Neapel und der angrenzenden Meeres-Abschnitte. *Fauna und Flora des Golfes von Neapel und der Angrenzenden Meeres-Abschnitte, Herausgegeben von der Zoologishen Sration zu Neapel* 19, 1–831, pls. 1–54.

**Heron G.A.** (1977) Twenty-six species of Oncaeidae (Copepoda: Cyclopoida) from the Southwest Pacific–Antarctic Area. In *Biology of the Antarctic seas VI. Antarctic Research Series, Washington* 26, 37–96.

**Heron G.A. and Bradford-Grieve J.M.** (1995) The marine fauna of New Zealand: pelagic Copepoda: Poecilostomatoida: Oncaeidae. *New Zealand Oceanographic Institute Memoir* 104, 1–57.

**Heron G.A. and Frost B.W.** (2000) Copepods of the family Oncaeidae (Crustacea: Poecilostomatoida) in the northeast Pacific Ocean and inland coastal waters of Washington State. *Proceedings of the Biological Society of Washington* 113, 1015–1063.

**Heron G.A., English T.S. and Damkaer D.M.** (1984) Arctic Ocean Copepoda of the genera *Lubbockia, Oncaea*, and *Epicalymma* (Poecilostomatoida: Oncaeidae), with remarks on distributions. *Journal of Crustacean Biology* 4, 448–490.

**Huys R. and Böttger-Schnack R.** (1997) On the diphyletic origin of the Oncaeidae Giesbrecht, 1982 (Copepoda: Poecilostomatoida) with a phylogenetic analysis of the Lubbockiidae fam. nov. *Zoologischer Anzeiger* 235, 243–261.

**Kršinic F.** (1998) Vertical distribution of protozoan and micro-copepod communities in the South Adriatic Pit. *Journal of Plankton Research* 20, 1033–1060.

**Malt S.J., Lakkis S. and Ziedanz R.** (1989) The copepod genus *Oncaea* (Poecilostomatoidea) from the Lebanon: taxonomic and ecological observations. *Journal of Plankton Research* 11, 949–969.

**Mazzocchi M.G. and Aguzzi L.** (1998) Il genere *Oncaea* (Copepoda: Poecilostomatoida) nella serie temporale 'Marechiara' nel Golfo di Napoli (1984–1990). *Biologia Marina Mediterranea* 5, 246–252.

**Metz C.** (1995) Seasonal variation in the distribution and abundance of *Oithona* and *Oncaea* species (Copepoda, Crustacea) in the southeastern Weddel Sea, Antarctica. *Polar Biology* 15, 187–194.

**Nishibe Y. and Ikeda T.** (2004) Vertical distribution, abundance and community structure of oncaeid copepods in the Oyashio region, western subarctic Pacific. *Marine Biology* 145, 931–941.

**Paffenhöfer G.-A.** (1993) On the ecology of marine cyclopoid copepods (Crustacea, Copepoda, Cyclopoida). *Journal of Plankton Research* 15, 37–55.

**Ribera d'Alcalà M., Conversano F., Corato F., Licandro P., Mangoni O., Marino O., Mazzocchi M.G., Modigh M., Montressor M., Nardella M., Saggiomo V., Sarno D. and Zingone A.** (2004) Seasonal patterns in plankton communities in a pluriannual time series at a coastal Mediterranean site (Gulf of Naples): an attempt to discern recurrences and trends. *Scientia Marina* 68, 65–83.

**Richter C.** (1994) Regional and seasonal variability in the vertical distribution of mesozooplankton in the Greenland Sea. *Berichter zur Polarforschung* 154, 1–79.

**Roman M.R., Gauzens A.L. and Cowles T.S.** (1985) Temporal and spatial change in the epipelagic microzooplankton and mesozooplankton biomass in warm-core Gulf Stream ring 82-B. *Deep-Sea Research* 32, 1007–1022.

**Shmeleva A.A.** (1966) New species of the genus *Oncaea* (Copepoda, Cyclopoida) from the Adriatic Sea. *Zoologicheskii Zhurnal* 45, 932–936.

**Shmeleva A.A.** (1968) Novy vidy planktonnykh Copepoda, Cyclopoida iz Adriaticheskogo morya. New species of planktonic Copepoda, Cyclopoida from the Adriatic Sea. *Zoologicheskii Zhurnal* 47, 1784–1793.

**Shmeleva A.A.** (1969) Espéce nouvelles du genre *Oncaea* (Copepoda, Cyclopoida) de la mer Adriatique. *Bulletin de l' Institut Océanographique, Monaco* 68, 1–28.

**Shmeleva A.A.** (1979) New species and some previously unknown males of the genus *Oncaea* from the Mediterranean. *Zoologicheskii Zhurnal* 58, 491–498.

**Star J.L. and Mullin M.M.** (1981) Zooplankton assemblages in three areas of the North Pacific as revealed by continuous horizontal transects. *Deep-Sea Research* 28, 1303–1322.

**Wishner K.F.** (1979) *The biomass and ecology of the deep-sea benthopelagic (near-bottom) plankton*. PhD thesis, University of California, San Diego.

and

**Yamaguchi A., Watonabe Y., Ishida H., Harimoto T., Furusawa K., Suzuki S., Ishizaka J., Ikeda T. and Takahashi M.** (2002) Community and trophic structures of pelagic copepods down to greater depths in the western subarctic Pacific (WEST-COSMIC). *Deep-Sea Research (Part I, Oceanographic Research Papers)* 49, 1007–1025.

**Correspondence should be addressed to:**
Iole Di Capua
Stazione Zoologica A. Dohrn
Napoli, Italy
email: dicapua@szn.it