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On the phylogeny of Euryteinae (Crustacea, Copepoda, Cyclopoida), with description of one new species from Korea

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ABSTRACT

Euryte koreana sp. nov. is described from the shallow littoral on the East Coast of South Korea, and represents the first record of the subfamily Euryteinae Monchenko, 1974 in the Pacific Ocean north of the tropics. It belongs to a group of species that have the caudal rami length/width ratio of around four, but differs from all congeners by a number of morphological features. Detailed drawings and extensive scanning electron micrographs of many characters of ornamentation provided for this species should serve as a benchmark for distinguishing closely related species in this subfamily with conservative macro-morphology. A morphologically distinct population from anchialine caves in Mallorca, identified previously as *Euryte longicauda* Philippi, 1843, is described as another new species: *Euryte jaumei* sp. nov. To test the phylogenetic relationships of its members and previous hypotheses about generic placement of two species associated with scleractinian corals, several cladistic analyses are performed on all 16 currently recognized species of Euryteinae and two outgroups, *Neocyclops australiensis* Karanovic, 2008 and *Troglocyclops janstocki* Rocha and Iliffe, 1994, using 25 morphological characters. All resulting trees suggest a close relationship between the two commensal species and them as a sister clade to all other Euryteinae. They are transferred into a newly erected genus *Coraleuryte* gen. nov., as *C. bellatula* (Humes, 1991) comb. nov. and *C. verecunda* (Humes, 1992) comb. nov., and a revised diagnoses is provided for the genus *Euryte* Philippi, 1843. Obtained cladograms also show that *Ancheuryte* Herbst, 1989 is nested deeply within the *Euryte* clade, so the genus is synonymized and its only species is transferred, as *E. notabilis* (Herbst, 1989) comb. nov. A key to species of Euryteinae is also provided.

1. Introduction

Cyclopoid copepods have been studied quite intensively in continental waters in South Korea, with more than 50 species recorded so far (Chang, 2009), although the survey of their diversity is far from finished, especially in subterranean habitats (Karanovic et al., 2012, 2013). Marine habitats, on the other hand, are completely unsurveyed for cyclopoids here, in a clear contrast to other groups of copepods, such as harpacticoids (Lee et al., 2012). This is obviously a sampling/expert bias, and it is one of the priority gaps to be filled by the ongoing project "Survey of the Korean Indigenous Fauna", administered through a series of grants from the National Institute of Biological Resources (NIBR) and funded by the Ministry of Environment of the Republic of Korea. In this paper a member of the cyclopoid subfamily Euryteinae Monchenko, 1974 is reported from shallow littoral on the East Coast of Korea, which represents the first record of this subfamily in the Pacific Ocean north of the tropics.

With 14 valid species in two genera, Euryteinae is the least diverse of the four subfamilies of the family Cyclopidae Rafinesque, 1815, the other three being Halicyclopinae Kiefer, 1927 (85 species in six genera), Eucyclopinae Kiefer, 1927 (about 160 species in 11 genera), and the nominotypical Cyclopinae Rafinesque, 1815 (over 500 species in 59 genera) (see Boxshall and Halsey, 2004; Walter and Boxshall, 2013). Even though this small subfamily is distributed worldwide, with the possible exception of the Pacific coast of South America (Jaume and Boxshall, 1996), it is not well studied. Its almost complete taxonomy can be surveyed today by reading no more than 15 papers, spanning more than 150 years of research. They are typically shallow water hyperbenthic elements, although some species were found in deeper waters (to about 400 m), and two are described as associates of scleractinian corals (Humes, 1991, 1992).

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It is probably the lack of surveys in shallow littoral (typically inaccessible by boats for standard littoral dredging surveys), and the lack of copepod experts interested in these animals, that give a false impression of their rarity. They are certainly not missed because of their size, because at 0.53–1.42 mm in length for females and 0.46–1.1 mm for males (excluding appendages and caudal setae) they are considered quite large for benthic copepods.

Philippi (1843) established the genus *Eurtye* Philippi, 1843 for a new species of cyclopoids, *Euryte longicauda* Philippi, 1843, from the Gulf of Napels, Italy. Because his description was lacking in detail and the type material was lost, many inadvertent and intentional subjective synonyms were introduced for specimens of similar appearance from other parts of the Mediterranean, as well as from the Northeast Atlantic. Giesbrecht (1900) redescribed this species from its type locality, and synonymized all junior subjective synonyms, and it is his redescription that all subsequent identifications of this species refer to. This work also cemented a notion of a very wide distribution of this taxon, spanning several climatic zones around the European continent and even including (although with some reservation) records from the South Pacific. Many of these records, however, were accompanied by inadequate descriptions, and the identity of some disjunct populations still remains unresolved. Giesbrecht (1900), being an excellent "regional taxonomist", was able to distinguish another species of *Euryte, E. robusta* Giesbrecht, 1900, that lives sympatrically with *E. longicauda* in the Gulf of Naples, and differs from it mostly in the proportions of the caudal rami and the third endopodal segment of the fourth leg. Several years later, T. Scott (1905) described a variety of *E. longicauda* from Scotland, which was elevated to full specific status by Sars (1913), as *E. minor* T. Scott, 1905, although its validity was doubted by Jaume and Boxshall (1996). Sars was the epitome of a "regional taxonomist", who was able to recognize four different species of *Euryte* along the Norwegian coast. He found that *E. minor* was also separated ecologically from other congeners, being only found in deeper water. It would be difficult to dismiss his conclusions, especially as he admitted (Sars, 1913, p. 107) to arriving at them through a long and gradual process. Brady (1910) described *E. propinqua* Brady, 1910 from 385 m in the Southern Ocean, and T. Scott (1912) described *E. similis* T. Scott, 1912 from the South Orkney Islands also in the Southern Ocean. Sars (1913) provided redescriptions of Norwegian populations of *E. minor, E. longicauda*, and *E. robusta*, and described one new species: *E. curticornis* Sars, 1913. It was his skillful drawings that many generations of European taxonomists relied upon for the identification of *Euryte* species, and those same drawings are used to score morphometric characters for these four species in the phylogenetic analysis below. Grandori (1925) described *E. longiseta* Grandori, 1925 from the Venice Lagoon, Italy. Sewell (1949) redescribed *E. robusta* from the Maldives, Indian Ocean, although mentioning several differences from the Mediterranean and Atlantic populations, and thus intentionally significantly widening the diagnosis of this taxon. He did not even entertain the hypothesis that he may have been dealing with a closely related but distinct new species (which is a definite possibility), but argued in favor of a very wide distribution of *E. robusta*, and classically overcompensated by trying to synonymize with it many other species and variable populations of other species. He did, however, describe one new species from the Maldives, *E. brevicauda* Sewell, 1949, illustrated another "aberrant" specimen identified only as *Euryte sp.*, expressed some doubt about the identification of the disjunct New Zealand population of *E. longicauda* reported by Thomson (1882), and pointed out errors in the swimming legs identification of *E. similis* made by T. Scott (1912). Vervoort (1964) described Sewell's aberrant specimen from the Maldives as a distinct new species, *E. sewelli* Vervoort, 1964, established another new species for his own specimens from Ifaluk in Micronesia, *E. pseudorobusta* Vervoort, 1964, and provided a key to seven species of the genus recognized by him as valid. Monchenko (1974) established a new subfamily for the genus *Euryte* and redescribed a population of *E. longicauda* from the Black Sea. Herbst (1989) added another new species to this genus from Puerto Rico, *E. grata* Herbst, 1989, and erected a new genus *Ancheuryte* Herbst, 1989 for a different new species from the same place, *A. notabilis* Herbst, 1989. He also provided the most recent key to species of *Euryte*, including nine species and subspecies. Humes (1991, 1992) described two quite similar new species associated with scleractinian corals, which differ from all congeners by a number of morphological features: *Euryte bellatula* Humes, 1991 was described from several localities in the Southeast Pacific, and *E. verecunda* Humes, 1992 was reported from the Pacific coast of Panama. Huys and Boxshall (1991) provided several detailed drawings of what they identified as *E. robusta* from Norway, but unfortunately not of the diagnostically important caudal rami or the fourth swimming leg, so these have to be taken with caution. Finally, Jaume and Boxshall (1996) provided a detailed redescription of the population from anchialine caves in Mallorca, Spain, which they identified as *E. longicauda*, although noting several differences from previous redescriptions and many similarities with *E. robusta.* In this way they almost completely blurred the diagnostic boundaries between these two species. They also suggested that the two species associated with corals (*E. bellatula* and *E. verecunda*) may belong to the genus *Ancheuryte*, because of their two-segmented fifth leg. This hypothesis is tested below using a cladistic analysis of morphological characters, performed on all 14 currently known members of the subfamily and two new species described below.

2. Material and methods

All specimens of the new Korean species were collected by plankton hand-nets (mesh size 100 μm) in shallow littoral (between 0.5 and 1.2 m) at low tide, but their precise habitat is unknown. Samples combined sweeps through algal meadows, over sandy and gravelly bottom, as well as over rocks covered by various sessile marine fauna (sponges, cnidarians, mussels, ascidians etc.). Animals were fixed in 99% ethanol. Locality data and number of specimens are given in the type material section of the new species below, and all types are deposited at the National Institute of Biological Resources, Incheon, South Korea.

All specimens were initially examined in propylene-glycol on cavity microscope slides. Specimens for light microscopy were dissected and mounted on microscope slides in Fauré's medium, which was prepared following the procedure discussed by Stock and von Vaupel Klein (1996), and dissected appendages were then covered by a coverslip. For the urosome or the entire animal, two human hairs or other suitably thick objects were mounted between the slide and coverslip, so the parts would not be compressed. By manipulating the coverslip carefully by hand, the whole animal or a particular appendage could be positioned in different aspects, making possible the observation of morphological details. During the examination, water slowly evaporates and appendages eventually remain in a completely dry Fauré's medium, ready for long term storage. All line drawings were prepared using a drawing tube attached to a Leica MB2500 phase-interference compound microscope, with N-PLAN (5×, 10×, 20×, 40× and 63× dry) or PL FLUOTAR (100× oil) objectives. Specimens for scanning electron micrography (SEM) were dehydrated in progressive ethanol concentrations, transferred into pure isoamyl-acetate, critical-point dried, mounted on stubs, coated in gold, and observed under a Hitachi S-4700 microscope on the in-lens detector, with an accelerating voltage of 10 kV and working distances between 12.9 and 13.2 mm; micrographs were taken with a digital camera. Digital