

## UNUSUAL MORPHOLOGY OF A SPECIMEN OF *Thysanoessa spinifera* HOLMES, 1900 (CRUSTACEA: EUPHAUSIACEA) AT THE OREGON COAST, USA

**Morfología singular de un espécimen de *Thysanoessa spinifera* Holmes 1900 (CRUSTACEA: EUPHAUSIACEA) en la costa de Oregon, USA**

**RESUMEN.** Se informa de un individuo del eufáusido *Thysanoessa spinifera* Holmes 1900 con morfología singular, recolectado en la costa de Oregon, EUA (Junio 2001). Este es un juvenil con una marcada variación de la morfología descrita originalmente para juveniles y adultos, dada la ausencia de rostro y la presencia de una pequeña quilla dirigida hacia adelante en la parte superior del caparazón. Se define la diferencia entre la variabilidad morfológica intraespecífica a nivel (1) poblacional (ecofenotipo) y (2) variabilidad individual como parte de un gradiente natural de la morfología de los organismos de una misma población. Se considera improbable que este espécimen sea una nueva especie de eufáusido; se propone que se trata de un caso extremo de variabilidad individual de *T. spinifera* o un híbrido de *T. spinifera* y *Euphausia pacifica*

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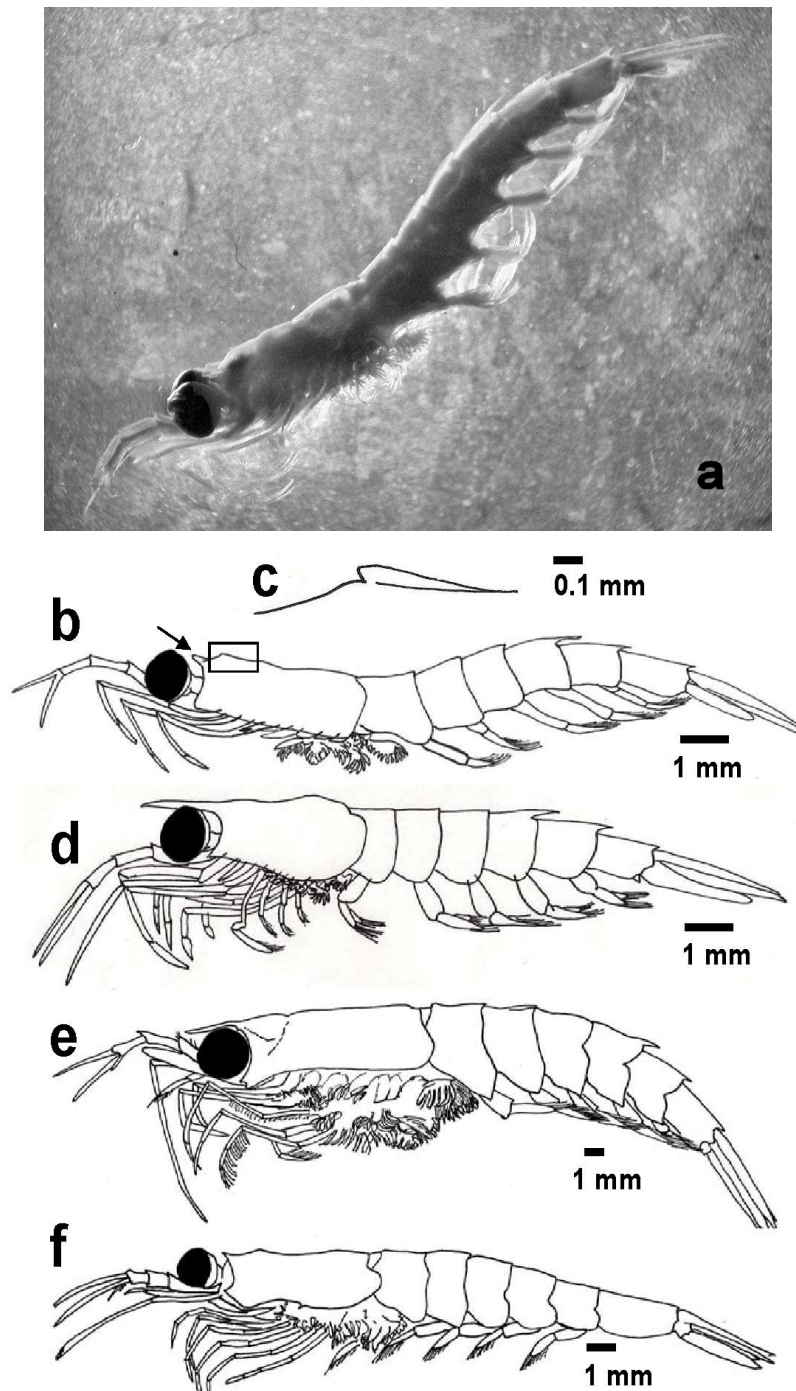
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The euphausiid *Thysanoessa spinifera* Holmes, 1900 is a neritic species (krill) distributed exclusively along the eastern North Pacific from the southeastern Bering Sea to Cali-

fornia. However, during cold years (winter and spring) its distribution can extend as far south as mid-Baja California Peninsula (Brinton, 1962). In this region *T. spinifera* co-dominates in abundance with *Euphausia pacifica* (Gómez-Gutiérrez *et al.*, 2005).

A male specimen of an euphausiid (15.7 mm total length) with unusual morphology was collected during June 2001 with a MOCNESS net during a Northeast Pacific Long Term Observation Program (LTOP) cruise (Fig. 1a). This specimen did not have a prominent petasma or reproductive characteristics. Therefore, we conclude it was in a juvenile stage. It had the unique morphological feature of a small keel on the dorsal part of the carapace directed forward, a trait not registered in any described euphausiid species (Fig. 1b,c). Additionally, the specimen features three heavy dorsal backward-directed spines in the fourth, fifth, and sixth segments, no lateral carapace spine, and an oval eye shape. These correspond with the original description of juvenile *T. spinifera* (10.5 mm - 19.8 mm total length) (Summers, 1993) and is similar to adults (20 mm to 38 mm total length), except that in adults the eyes are almost spherical (Holmes, 1900) (Fig. 1b,d). However this specimen lacks the typical narrow triangular, long, and very acute rostrum characteristic of *T. spinifera*. Because the body shape is more slender than in a typical *T. spinifera* juvenile and lacks a rostrum, resembling a juvenile *E. pacifica* (Fig. 1f), originally we thought it was a hybrid of *T. spinifera* and *E. pacifica* (Fig. 1a-f). The eye is oval, resembling the eye of a *T. spinifera* juvenile stage (Fig. 2a, b), and is distinct from the usual spherical eye of adults of *T. spinifera* and juveniles and adults of *E. pacifica* (Fig. 2c, d).

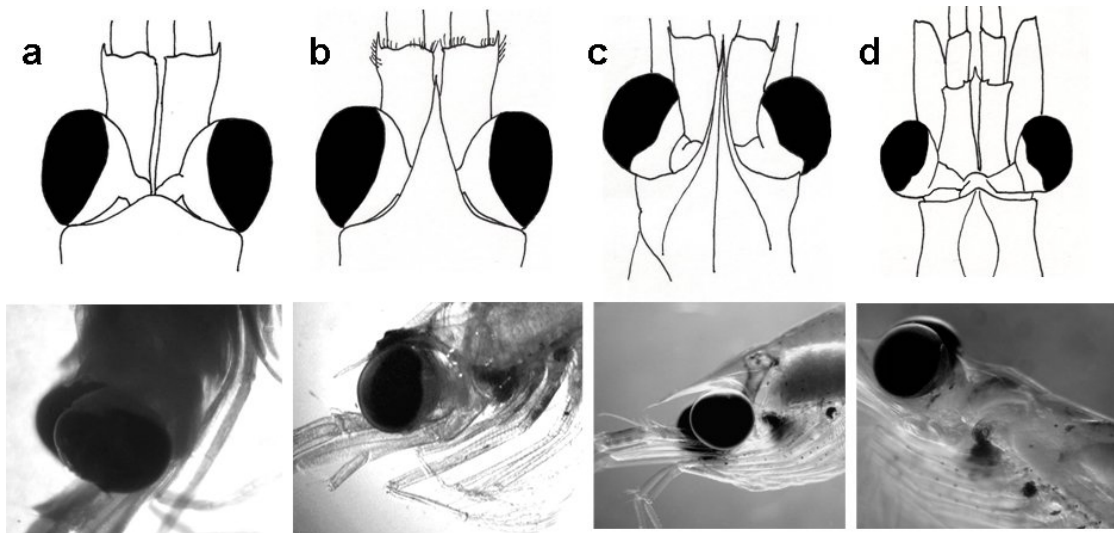
Digital pictures of the specimen were sent to Edward Brinton and Annie Townsend (Scripps Institution Oceanography, USA) and they both agree on it as an unusual juvenile of *T. spinifera*. Although the specimen has completely different morphological characteristics from *T. spinifera* or any other *Thysanoessa*



**Figure 1.** *Thysanoessa spinifera* (Holmes, 1900) a,b) juvenile with unusual morphology; c) detail of the small forward directed dorsal keel on the carapace; d) typical juvenile morphology, modified from Summers (1993); e) typical adult morphology, and f) typical morphology of *Euphausia pacifica* juvenile modified from Brinton *et al.* (1999).

known species (Nemoto, 1966; Baker *et al.*, 1990) and has a few characteristics similar to *E. pacifica*, it is unlikely that it is a new species since the large (bi-weekly) sampling efforts in

the region following the Newport Hydrographic line from 1970-1972 (Gómez-Gutiérrez *et al.*, 2005) and 1996-2002 (Feinberg & Peterson, 2003), and the California Cooperative Fishe-



**Figure 2.** *Thysanoessa spinifera* rostrum (upper and lateral view) and eye morphology. a) juvenile with unusual morphology; b) typical juvenile, modified from Summers (1993); c) typical adult morphology. d) *Euphausia pacifica* juvenile rostrum. All photographs are from specimens collected at Oregon.

ries Investigation (CalCOFI) program (1959-2003) (Brinton & Townsend, 2003) have not reported any other similar specimen.

Dissection of the specimen revealed no parasites and its appearance is that of a healthy animal even with its unusual small keel on the carapace.

A species may have a range of ecophenotype variability, perhaps reflecting the genotype diversity. Here, we describe morphological variability between (1) populations of the same species, better known as ecophenotypes (Brinton, 1962), and (2) among individuals of the same population as a natural gradient of morphological characteristic of valuable or non-valuable taxonomic purpose.

Brinton (1962, 1975) established the concept of ecophenotypes (or races) in euphausiids, in which a species possess a wide-range of morphological variability recognized in several populations associated with environmental gradients among distinct water masses. Thus, there is a concurrence of morphologically intermediate specimens with geographically intermediate habitats. The best example is *Stylocheiron affine* Hansen 1910 with five eco-phenotypes in the Pacific Ocean associated to different water masses (Brinton, 1962). Another example is *Stylocheiron longicorne*

G.O. Sars 1883 with three ecophenotypes (short, long, and the Indian Ocean forms), but in this case distribution ranges strongly overlap between the short and long forms, therefore with less obvious association to water masses (Brinton, 1962, 1975). *T. spinifera* has a relatively restricted distribution range in the neritic region of the Eastern North Pacific (Brinton, 1962), thus it is unlikely that this species distributes in distinct water masses that has led to evolution of distinct ecophenotypes, as observed in species with large distribution ranges (cosmopolitan or circumtropical).

Other species of Euphausiacea seem to have high morphological variability when local populations are examined or even when specimens collected in the same sample are examined (*i.e.*, intrapopulation individual variability). Hansen (1911) reported "remarkable variation" in *Euphausia diomedea* Ortmann, 1894, indicating that sometimes unusual forms of the typical morphology occur. Several species have considerable variability in characters considered of taxonomic utility in other species, such as the length and shape of the rostrum (Baker *et al.*, 1990). Populations have morphological gradients as part of the complex process of speciation. We cannot specifically explain the aberrant characters seen here, but the lack of the rostrum may be the extreme in



the natural gradient of length of rostrum of the specimens in the population. An argument against this hypothesis is that *T. spinifera* has not shown a continuum gradient of rostrum length, partially supporting the *T. spinifera* - *E. pacifica* hybrid hypothesis. Williamson & Rice (1996) and Williamson (2006) proposed that hybridization may occur in zooplanktonic crustaceans to explain the larval transfer and abrupt larval metamorphoses. From a practical point of view, we propose that individuals of *T. spinifera* could also lack the typical prominent rostrum and/or possess a small keel above the cephalothorax.

Considering that the Order Euphausiacea includes only 86 taxonomic valid species (Baker *et al.*, 1990; Brinton *et al.*, 1999), the description of a new species should represent a notable discovery in the knowledge of these holoplanktonic marine crustaceans. However, morphology variability of any species within its population is a rule rather than an exception as a natural gradient of phenotypic expression of the species or potential hybridization of distinct species. Hybrids should be extremely rare due to pre-cygotic (petasm specific form) and post-cygotic mechanisms to prevent such events. Thus, in regular studies of euphausiid distribution and abundance commonly many specimens cannot be easily assigned to a species level because they possess morphological differences compared to the original descriptions. It is relevant to publish such morphological anomalies because they are frequently obviated, unpublished, and/or simply considered as non-identified specimens in published articles providing little progress in the knowledge of natural phenotypic variability of the euphausiids. We are aware that the proportion of "non identified specimens" has a high correlation with taxonomic experience of the researchers in charge of the identification of euphausiid species. However, if researchers take into account the natural morphological variability of any euphausiid species, it will allow precise identification of their distribution range with zoogeographic, ecological, and/or evolutionary significance. Future studies should compare the DNA sequences of specimens with typical and unusual morphologies to test whether they are individuals of the same species or

hybrids of species with overlapping distribution range. Our specimen was preserved in formaline preventing us from performing a DNA analysis. Currently this is feasible since several research groups have developed DNA code bars for different euphausiid species world-wide (Bucklin *et al.*, 2007).

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#### REFERENCES

- Baker, A. de C., B.P. Boden & E. Brinton. 1990. A practical guide to the euphausiids of the world. *British Museum (Natural History)*, London, 96 p.
- Brinton, E. 1962. The distribution of Pacific euphausiids. *Bulletin of the Scripps Institution of Oceanography, University of California*, 8:51-270.
- Brinton, E. 1975. Euphausiids of Southeast Asian waters. *Naga Report*, 4:1-287.
- Brinton, E., M.D. Ohman, A.W. Townsend, M.D. Knight & A.L. Bridgeman. 1999. Euphausiids of the world ocean, Series: *World Biodiversity Database CD-ROM Series Window version 1.0. Expert Center for Taxonomic Identification, Amsterdam, Netherlands*.
- Brinton, E. & A.W. Townsend. 2003. Decadal variability in abundances of the dominant euphausiid species in Southern Sectors of the California Current. *Deep-Sea Res. II*, 50(14-16):2449-2472.

- Bucklin, A., P.H. Wiebe, S.B. Smolenack, N.J. Copley, J.G. Beaudet, K.G. Bonner, J. Färber-Lorda & J.J. Pierson. 2007. DNA barcodes for species identification of euphausiids (Euphausiacea, Crustacea). *J. Plankton Res.* 29(6):483-493.
- Feinberg, L.R. & W.T. Peterson. 2003. Variability in duration and intensity of euphausiid spawning off central Oregon, 1996-2001. *Progr. Oceanogr.*, 57(3-4): 363-379.
- Gómez-Gutiérrez, J., W.T. Peterson & C.B. Miller. 2005. Cross-shelf life-stage segregation and community structure of the euphausiids off central Oregon (1970-1972). *Deep-Sea Res II*, 52/1-2: 289-315. .
- Hansen, H.J. 1910. The Schizopoda of the Siboga Expedition. *Siboga Expedition*, 37:1-123.
- Hansen, H.J. 1911. The genera and species of the order Euphausiacea, which account of remarkable variation. *Bulletin de l'Institut Océanographique de Monaco*, 210: 1-54.
- Holmes, S.J. 1900. California stalk-eyed Crustacea. *Occasional papers of the California Academy of Sciences*, 7:1-262.
- Nemoto, T. 1966. *Thysanoessa* euphausiids, comparative morphology, allomorphy and ecology. *Scientific Reports of the whales Research Institute of Tokio*. 20:109-155.
- Summers, P.L. 1993. *Life history, growth and aging in Thysanoessa spinifera*. MSc thesis, University of Victoria, Canada.
- Williamson, D. I. & Rice, A. L. 1996. Larval evolution in the Crustacea. *Crustaceana* 69:267-287.
- Williamson, D.I. 2006. Hybridization in the evolution of animal form and life-cycle. *Zool. J. Linnean Soc.* 148:585-602.