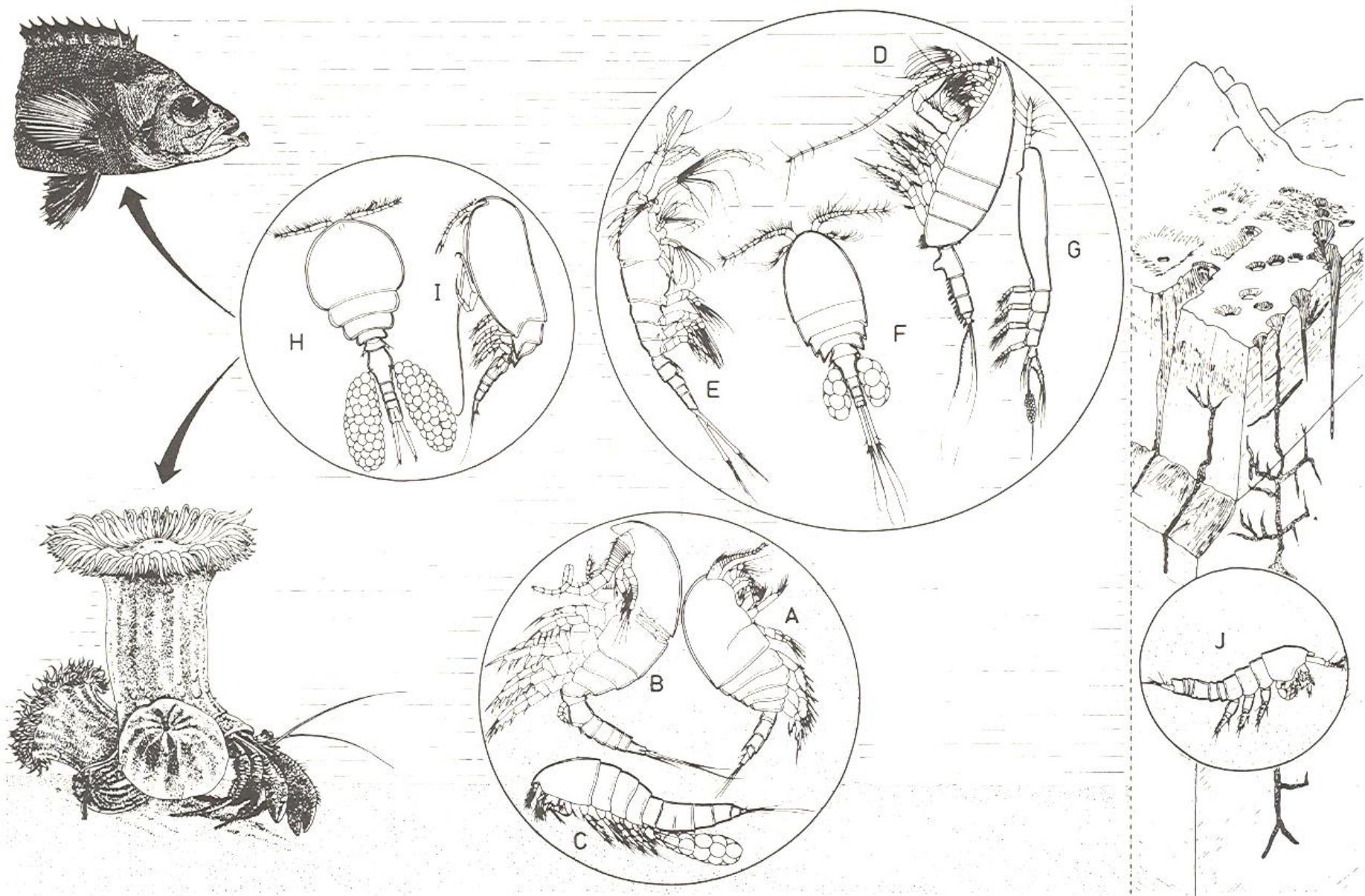


# Diversity of Copepoda

Wonchoel Lee

Department of Life Science,  
Hanyang University

Seoul, Korea



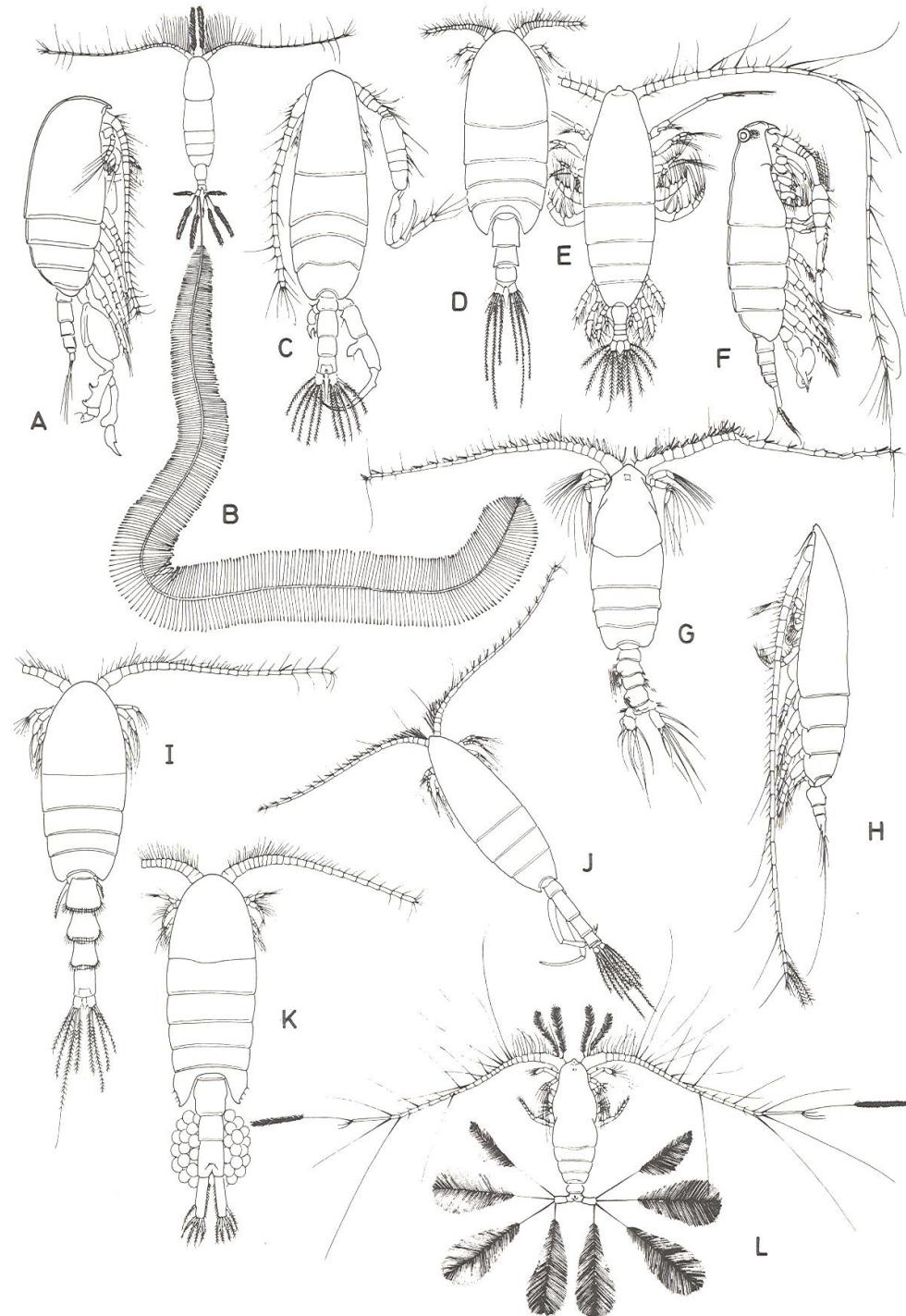
**Figure 1.1.** Copepod habitats: a schematic representation of the primary habitat of each of the ten copepod orders. **A.** Platycopioida. **B.** Misophrioida. **C.** Harpacticoida. **D.** Calanoida. **E.** Mormonilloida. **F.** Cyclopoida. **G.** Monstrilloida. **H.** Poecilostomatoida. **I.** Siphonostomatoida. **J.** Gelyelloida. [A-C, benthic; D-G, planktonic; H and I, associated; J, groundwater.]

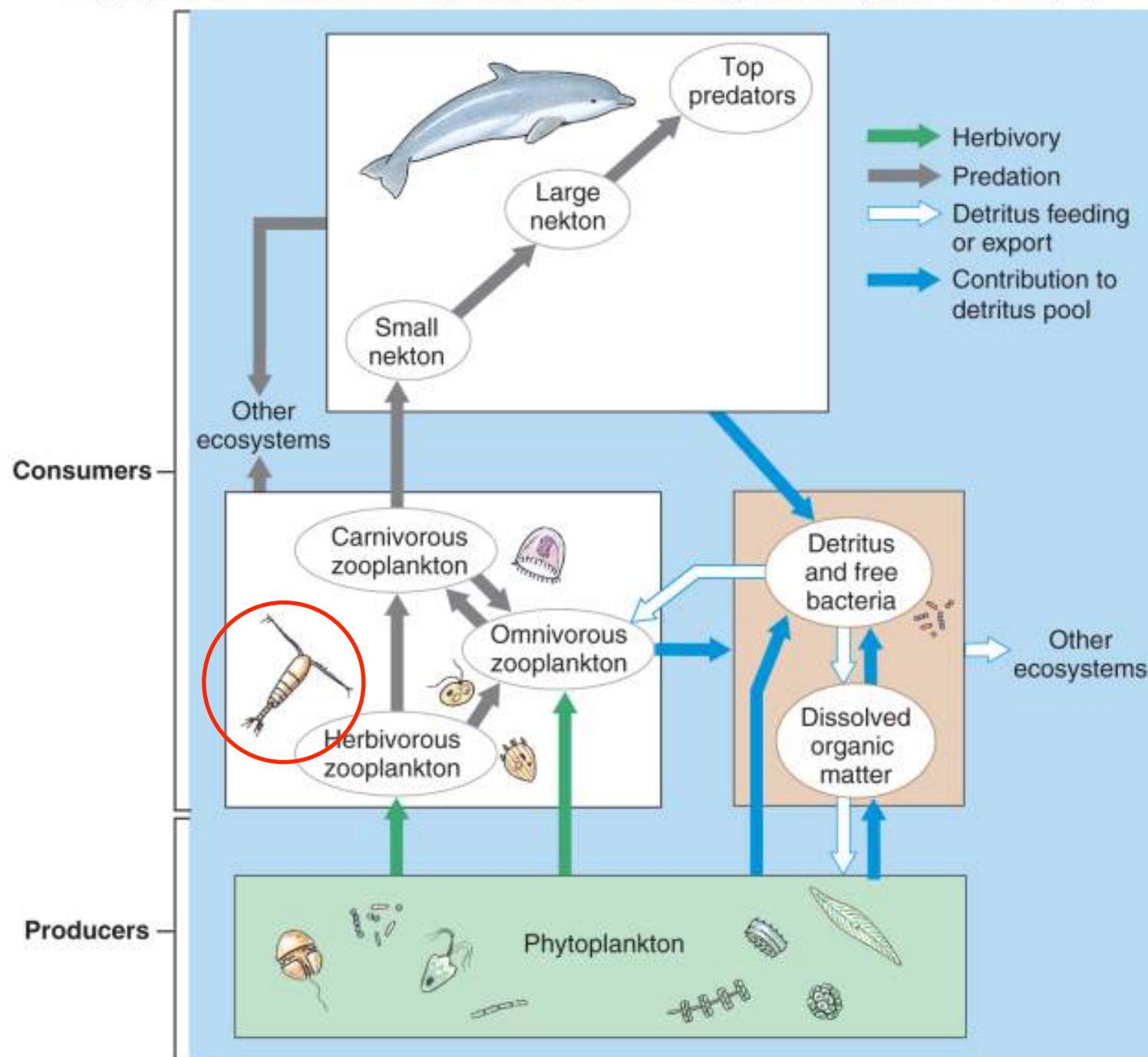
# Subclass Copepoda

- About 12,000 species in ten Orders
- Diverse life forms: Plankton, Benthos, Parasite
- The most numerous animal except for single celled protozoan.
- Size small : <10mm

# Plankton

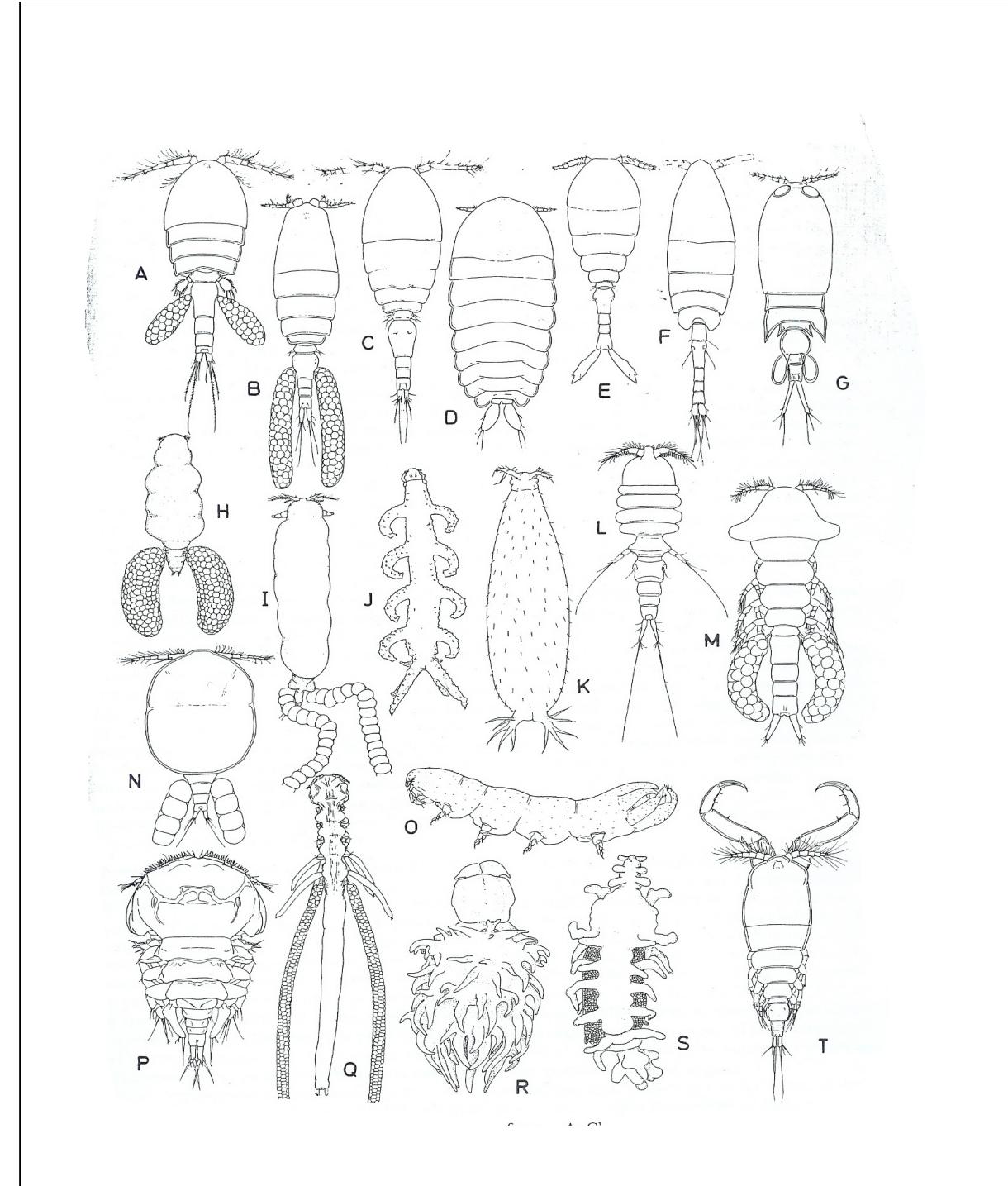
- Calanoida
- Mormonilloida
- Cyclopoida
- Important food items for many marine animals.
- Active vertical migrator

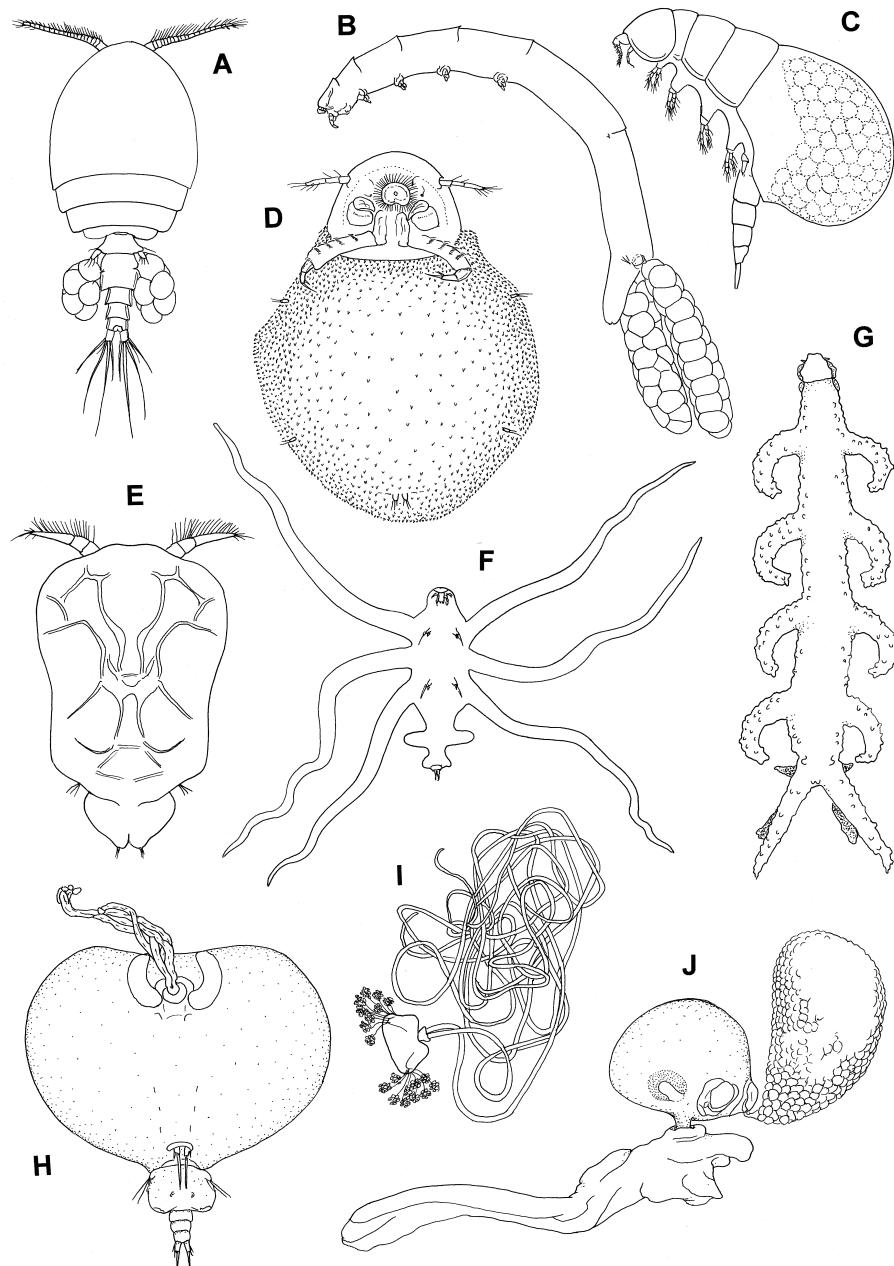




# Parasites

- Cyclopoida♪
- Siphonostomatoida♪
- Monstrilloida♪
- Freshwater♪
- marine ♪
- parasites♪





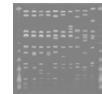
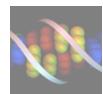
**Extreme variation in  
body form in parasites  
of invertebrate hosts**

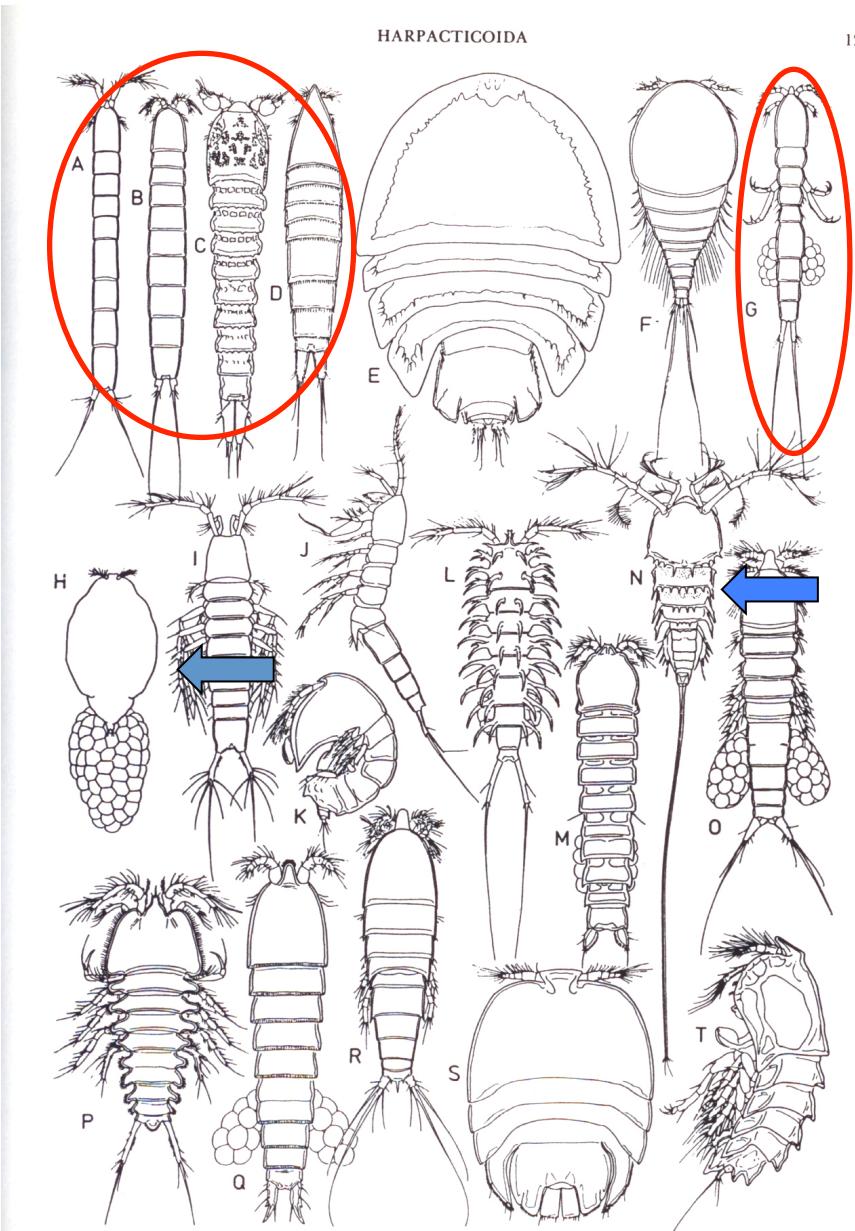
# Benthos

- Platycopioida - near bottom
- Misophrioida - near bottom
- Gelyelloida - groundwater
- Harpacticoida - meiofauna
  - Marine more than 3,000 species, Freshwater about 950 species in the world
  - dominant among Meiofauna
  - Possible environmental indicator

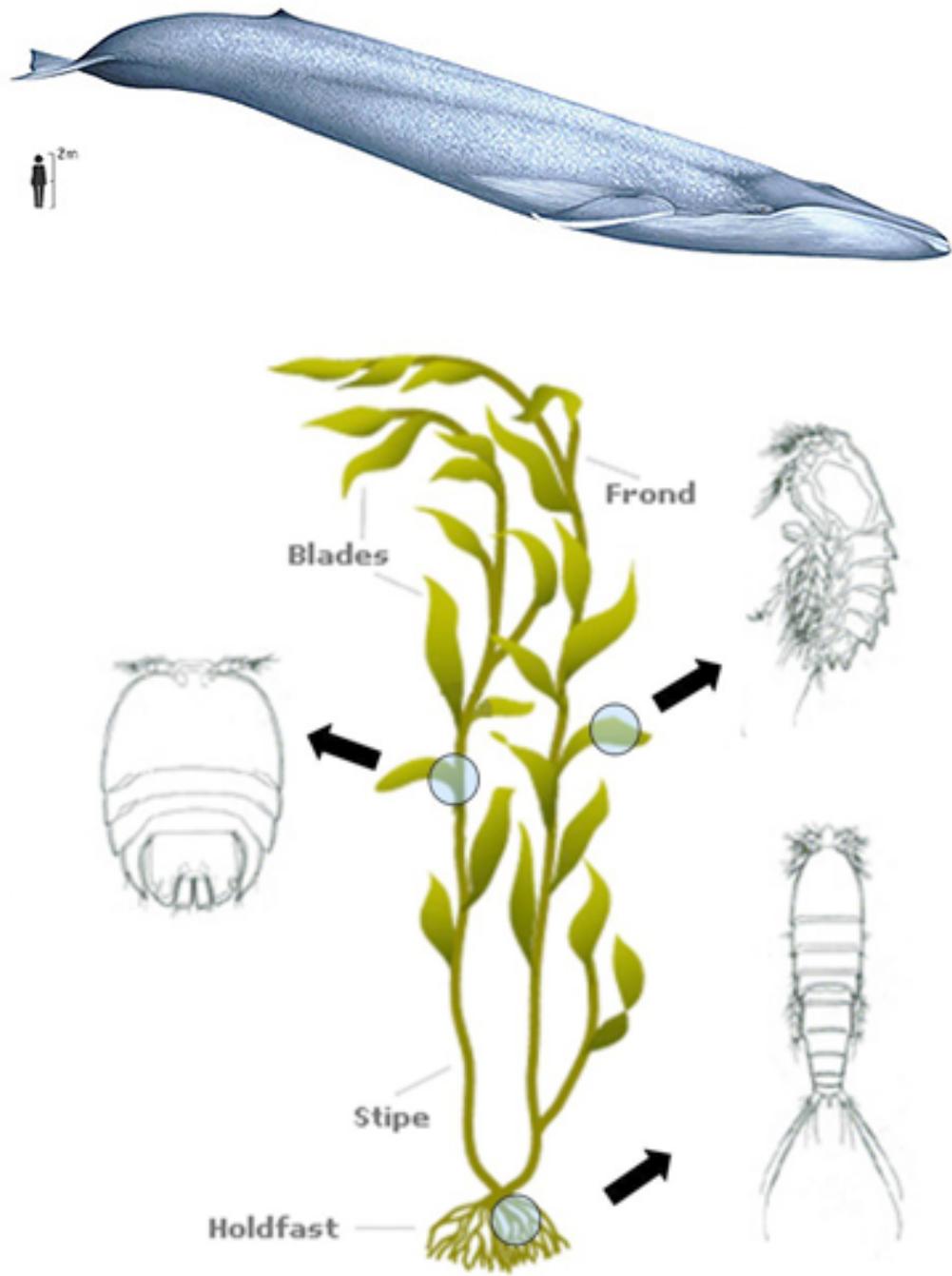
# Meiofauna

- Benthic Organisms passing through the sieve of  $500\mu\text{m}$ , and retaining on  $42\mu\text{m}$
- High density up to more than 100,000 individuals /  $1\text{m}^2$
- Good prey items to macrofauna and fishes and affected to their community structure
- Short life cycles, and response quickly to environmental variations



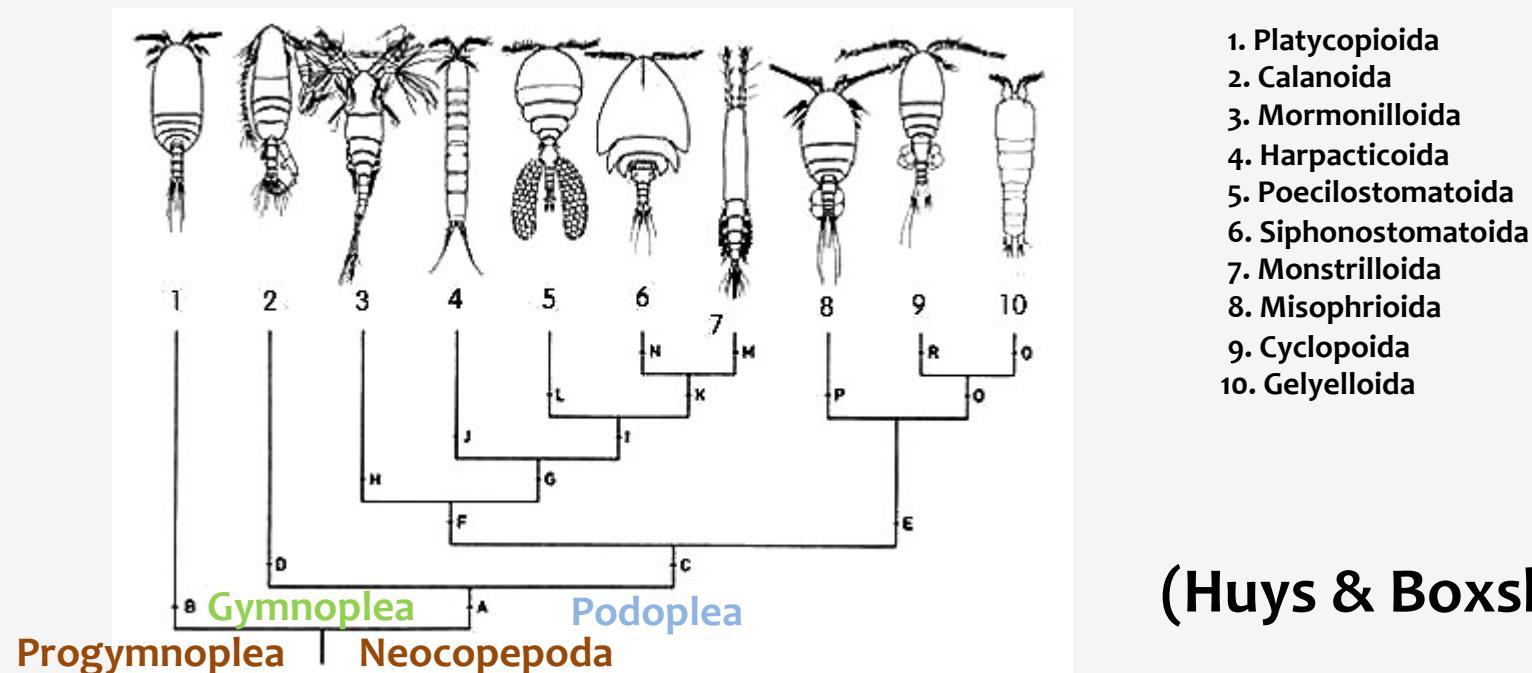


**Figure 2.4.1.** The diversity of harpacticoid body form. A. Cylindropsyllidae, Cylindropsyllinae. B. Darcy-thompsoniidae. C. Laophontopsidae. D. Ectinosomatidae. E. Hamondiidae. F. Metidae. G. Balaenophilidae. H. Tibidae, Cholidynae. I. Ameiridae, Stenocopiinae. J. Cylindropsyllidae, Leptastacinae. K. Tegastidae. L. Ancorabolidae. M. Cletodidae. N. Cerviniidae. O. Canuellidae. P. Ancorabolidae, Laophontodinae. Q. Huntemannidae. R. Longipediidae. S. Porcellidiidae. T. Peltidiidae.



# Copepod Orders

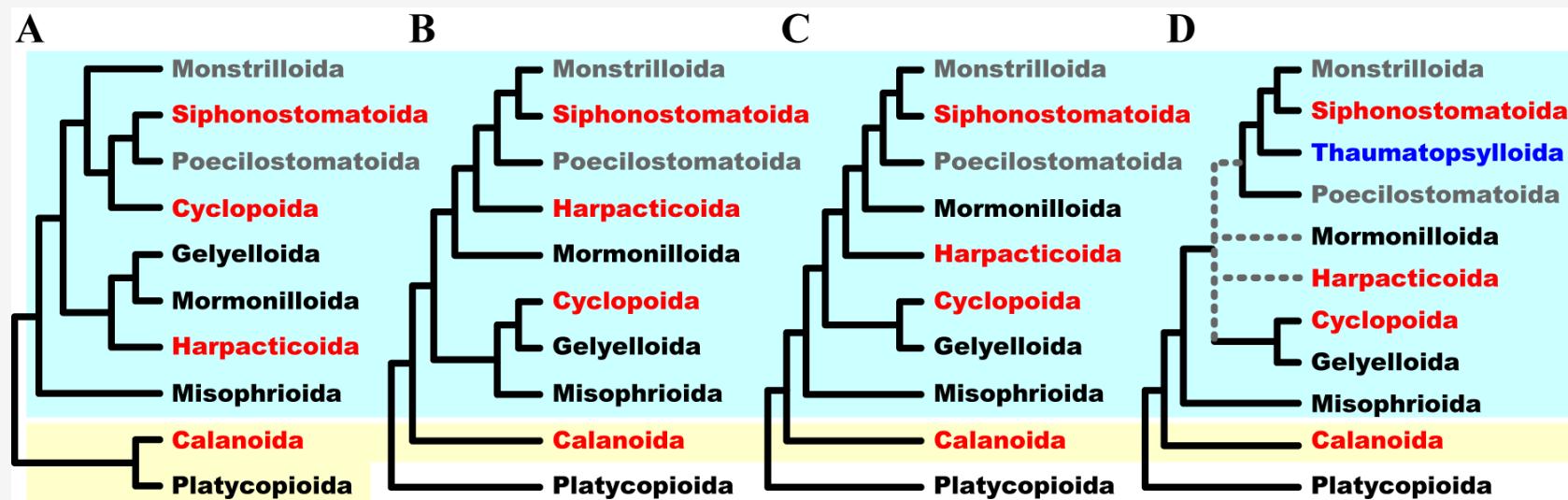
- ❖ Morphological and molecular evidence supports the monophyly of copepods
- ❖ Interordinal relationships continue to be debated



(Huys & Boxshall, 1991)

# Morphological Phylogeny

- ❖ The phylogenetic position of the order Harpacticoida is still ambiguous and inconsistent among studies



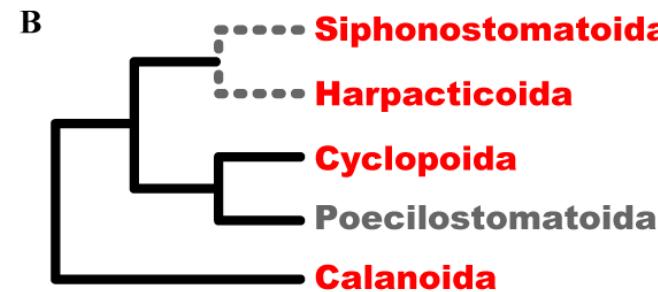
A) Ho (1990)

B) Huys and Boxshall (1991)

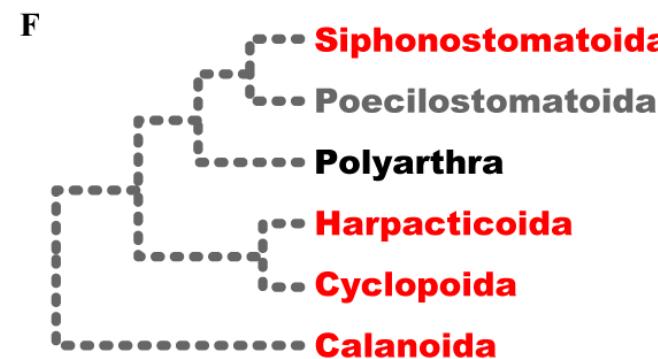
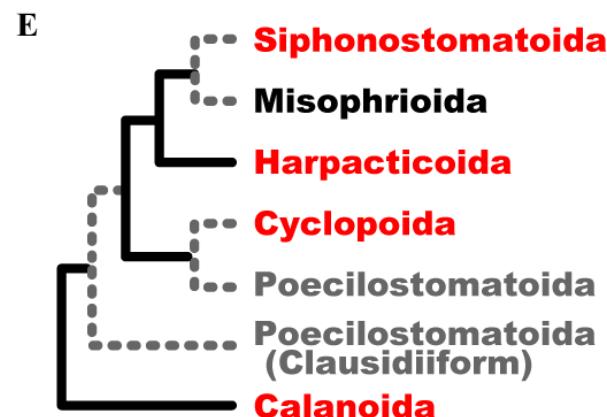
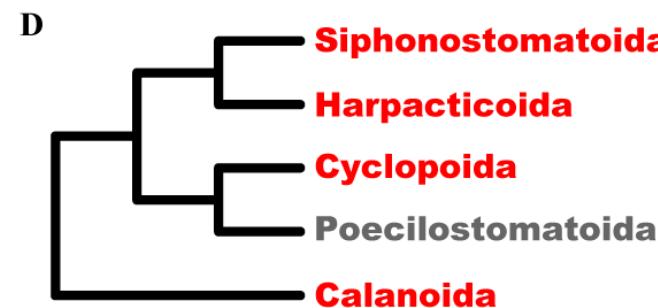
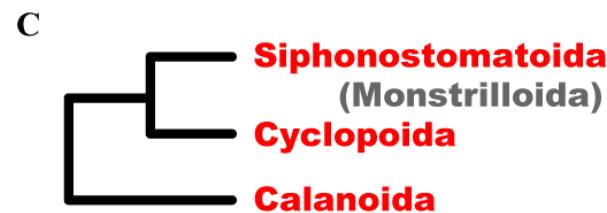
C) Ho (1994)

D) Ho et al. (2003)

# Molecular Phylogeny



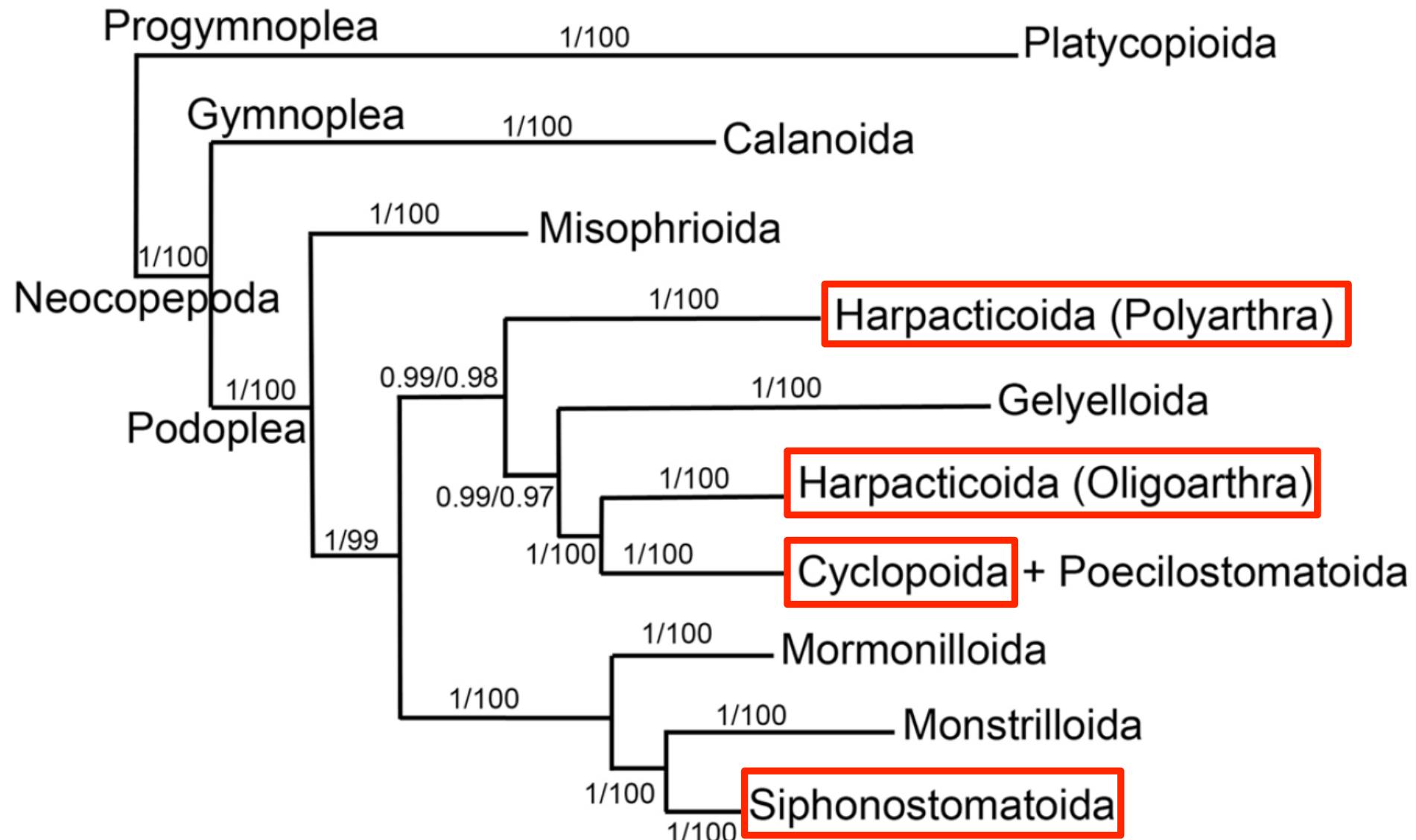
Harpacticoida is more closely related to Siphonostomatoida



Polyarthra taxa are more closely related to other copepods than to Oligoarthra (*Tigriopus*) (28S 505bp)

A) Braga et al (1999), B) Huys et al (2006), C) Huys et al (2007), D) Minxiao et al (2011), E) Tung et al (2014), and F) Schizas et al (2015)

# 18S and 28S rRNA, mtCOI, and H3



(Khodami et al., 2017)

# World Copepoda Database (WoRMS 2018)

**Subclass Copepoda has Ten orders**

**Harpacticoida → Cauelloida + Harpacticoida**

**Poecilostomatoida → Cyclopoida**

**Order Canuelloida (Polyarthra)**

**Family Canuellidae**

**Family Longipedidae**

**Order Harpacticoida (Oligoarthra): all others**

# Morphology of Harpacticoida

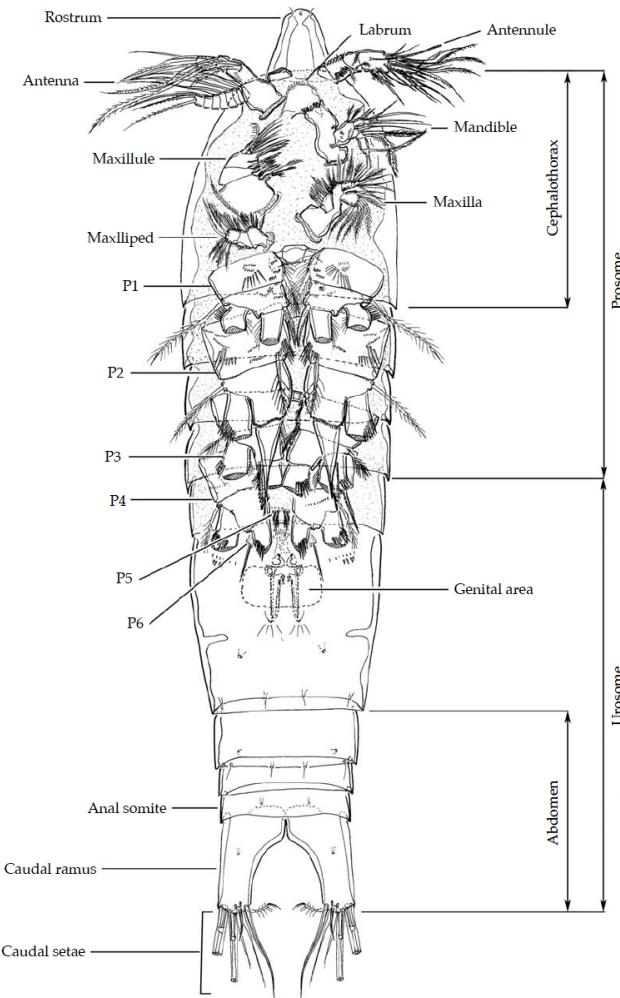
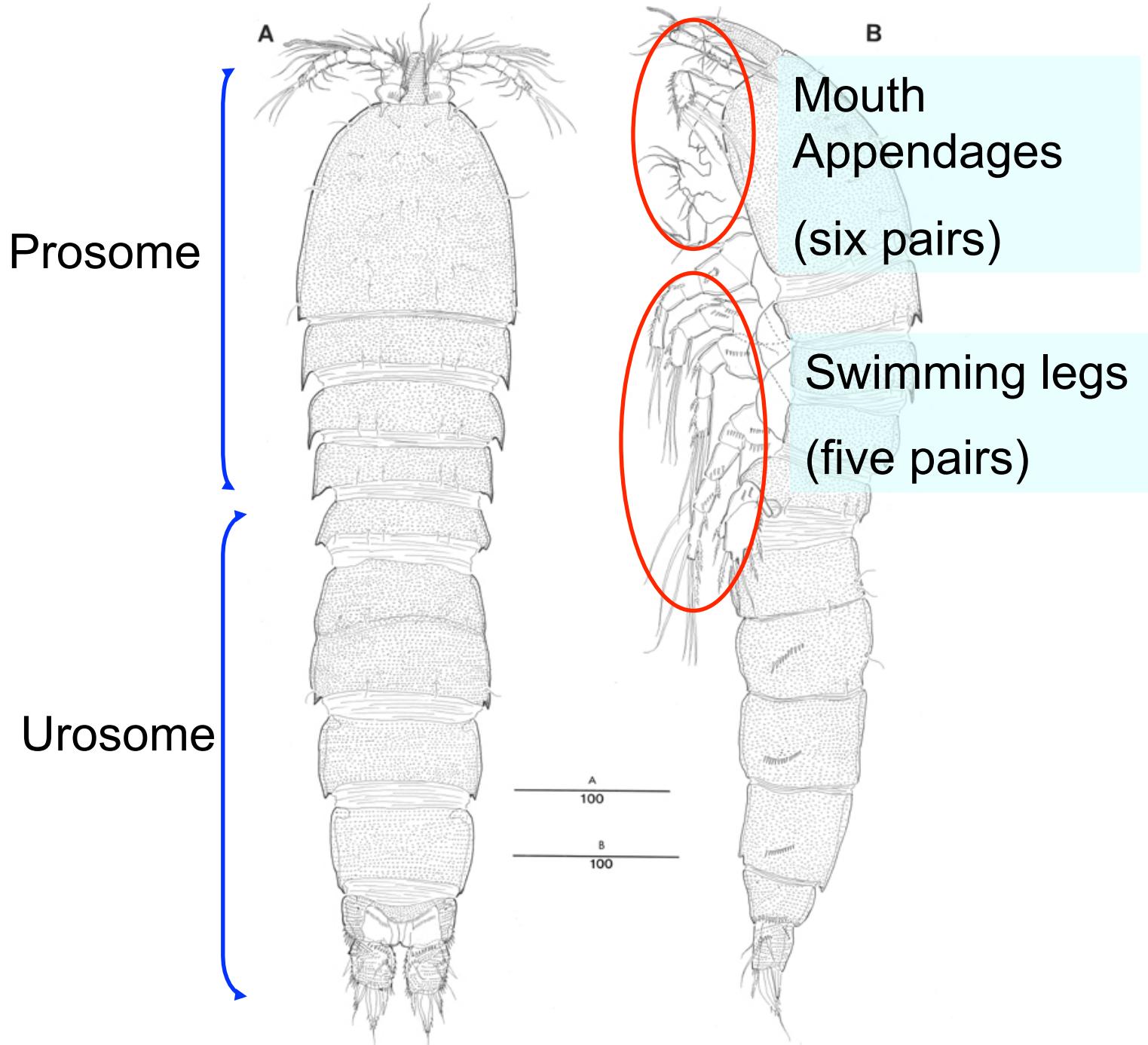
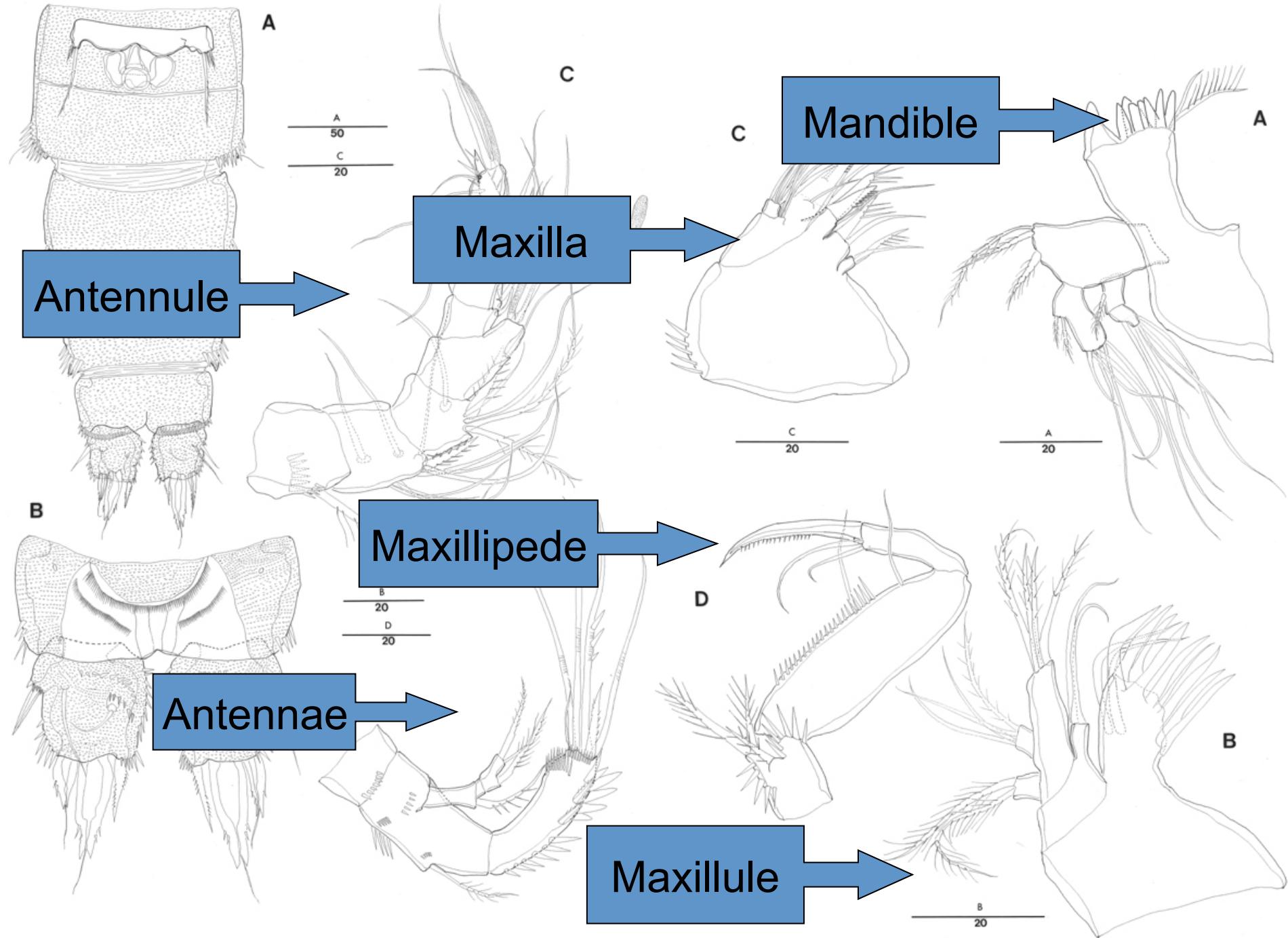
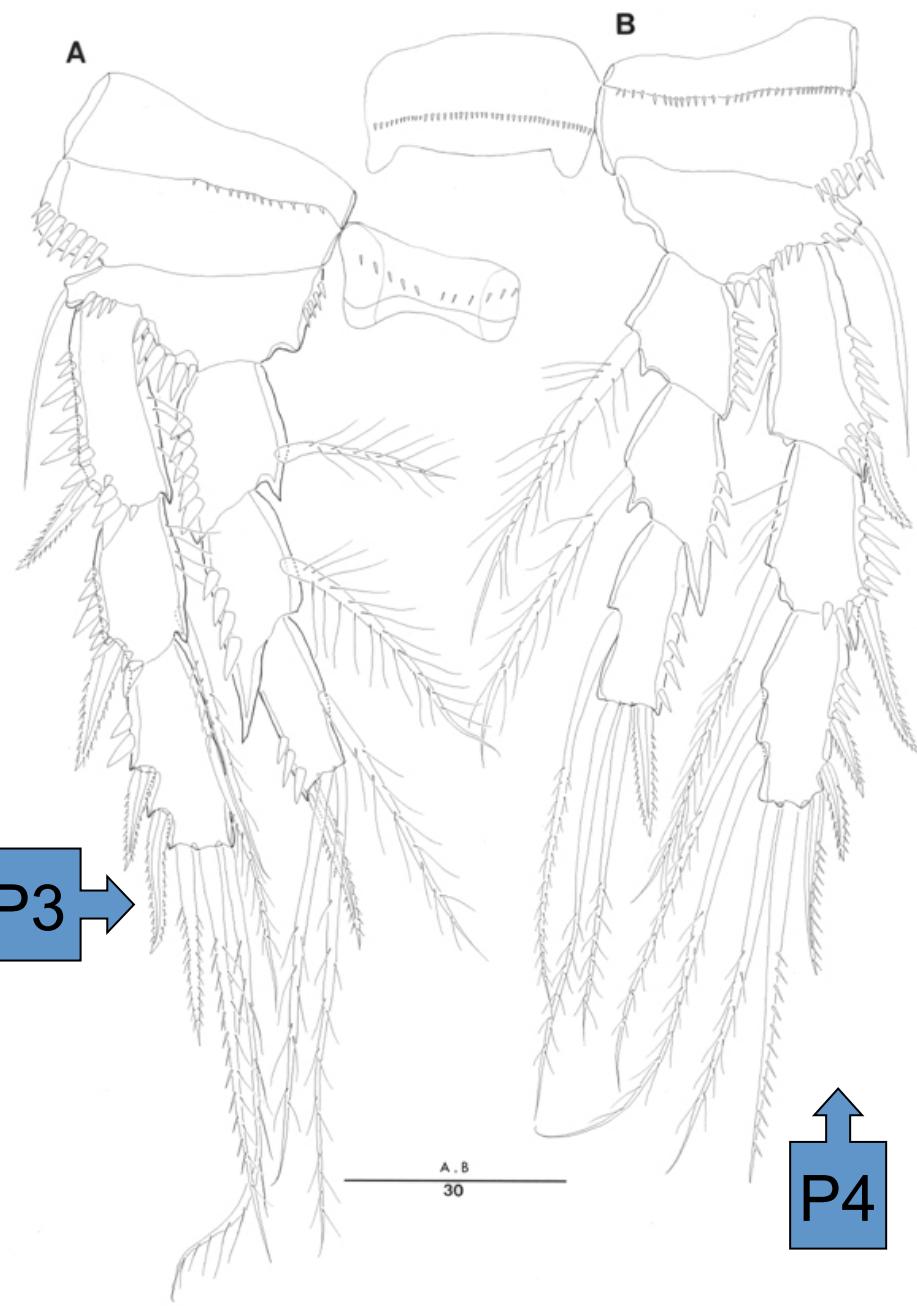
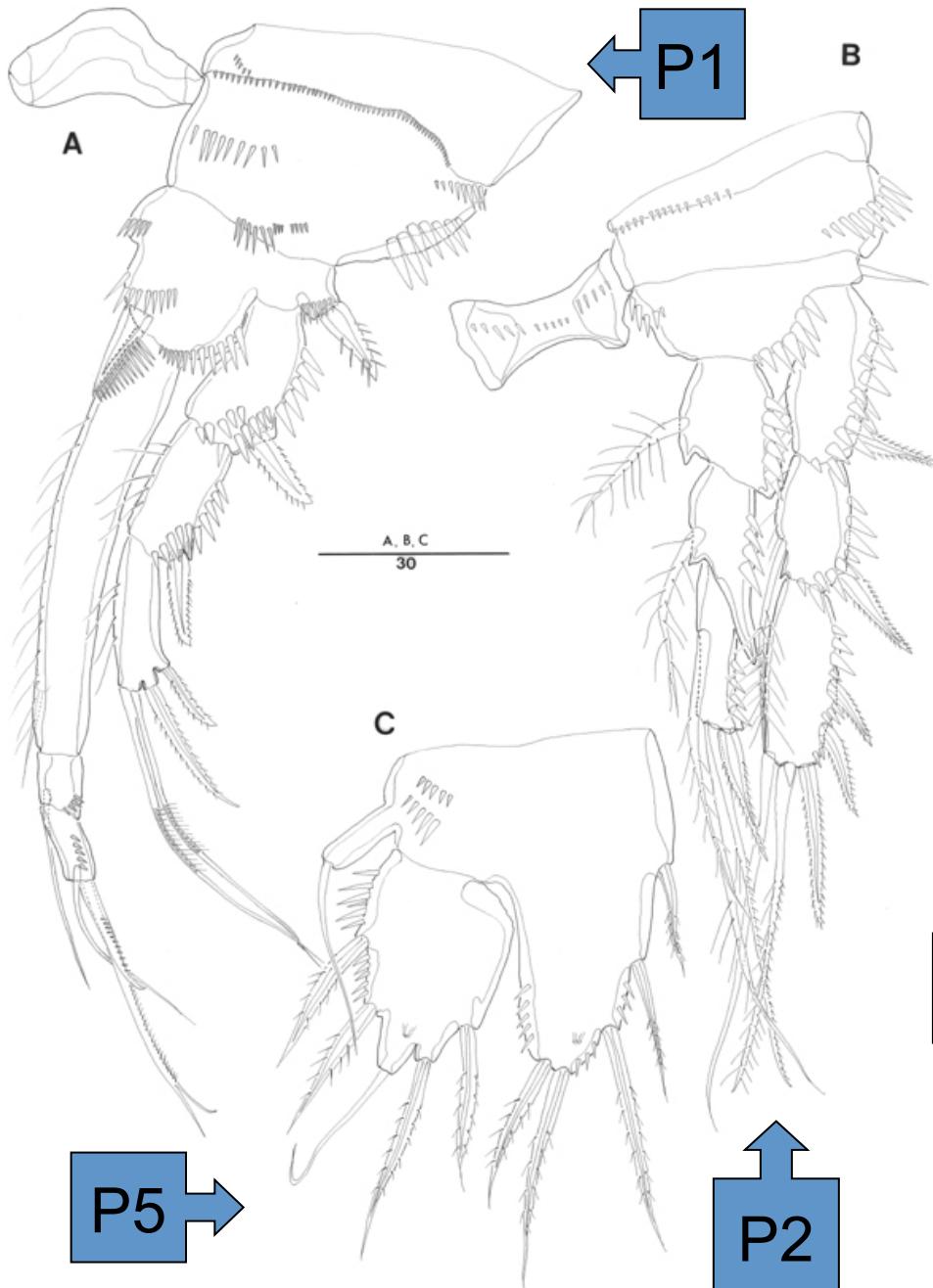


Fig. 1. General structure of harpacticoid copepod.







P5 →

↑ P2

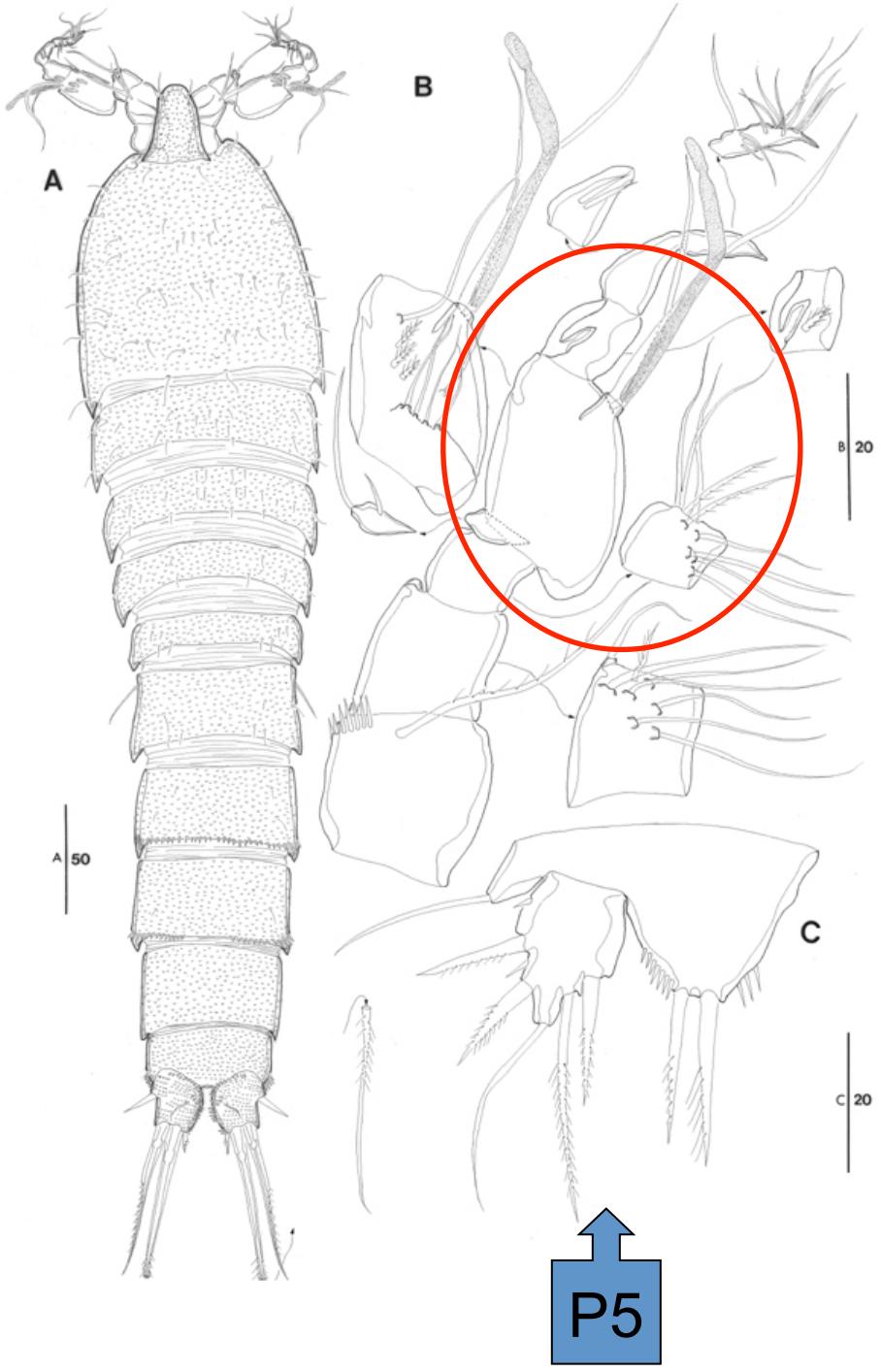
← P1

↑ P4

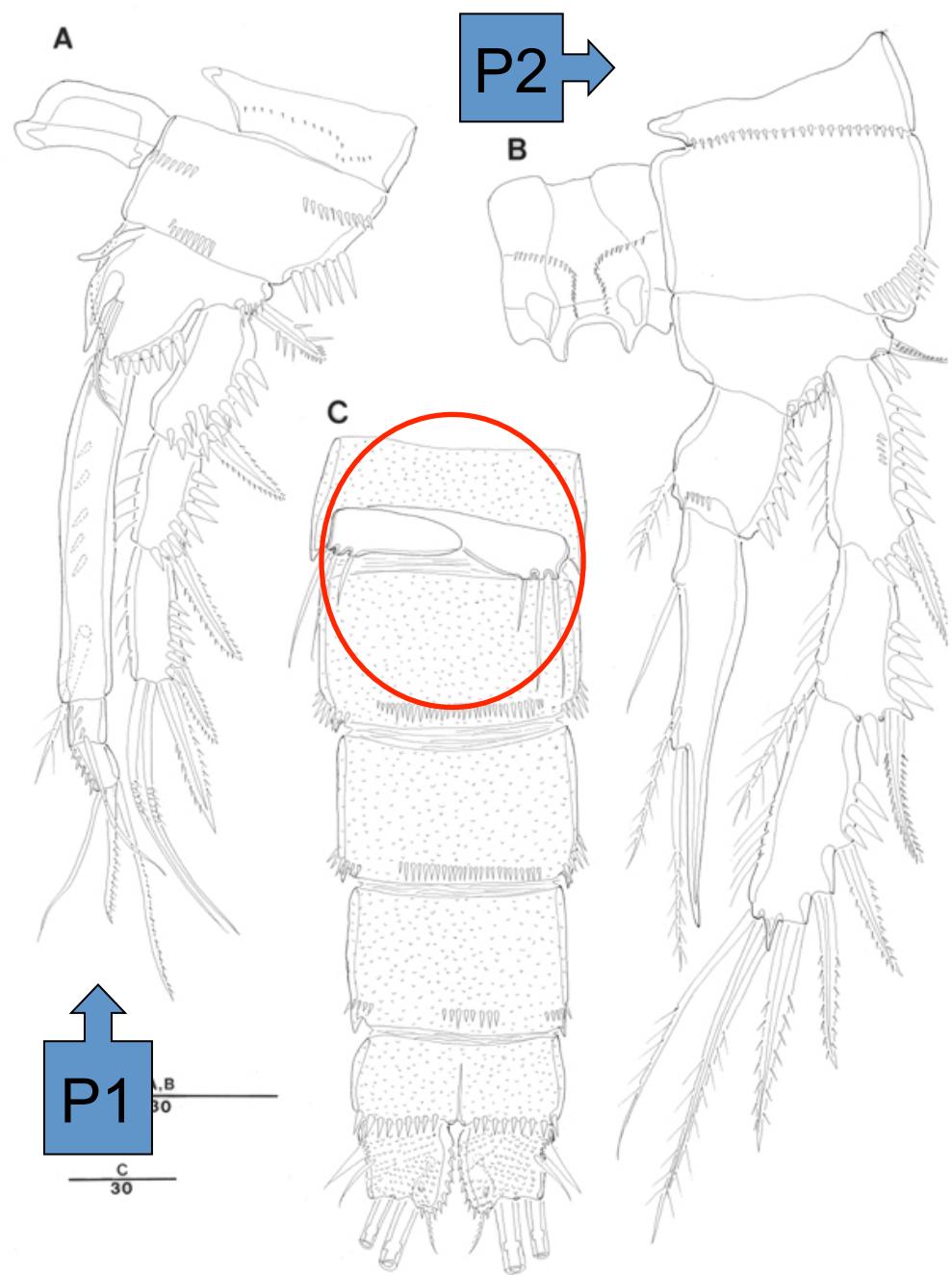
→ P3

# Sexual dimorphism

- Related to reproduction
  - Antennule
  - P1 - P5
  - Genital field
  - Size
  - Mouth parts



P5



P1

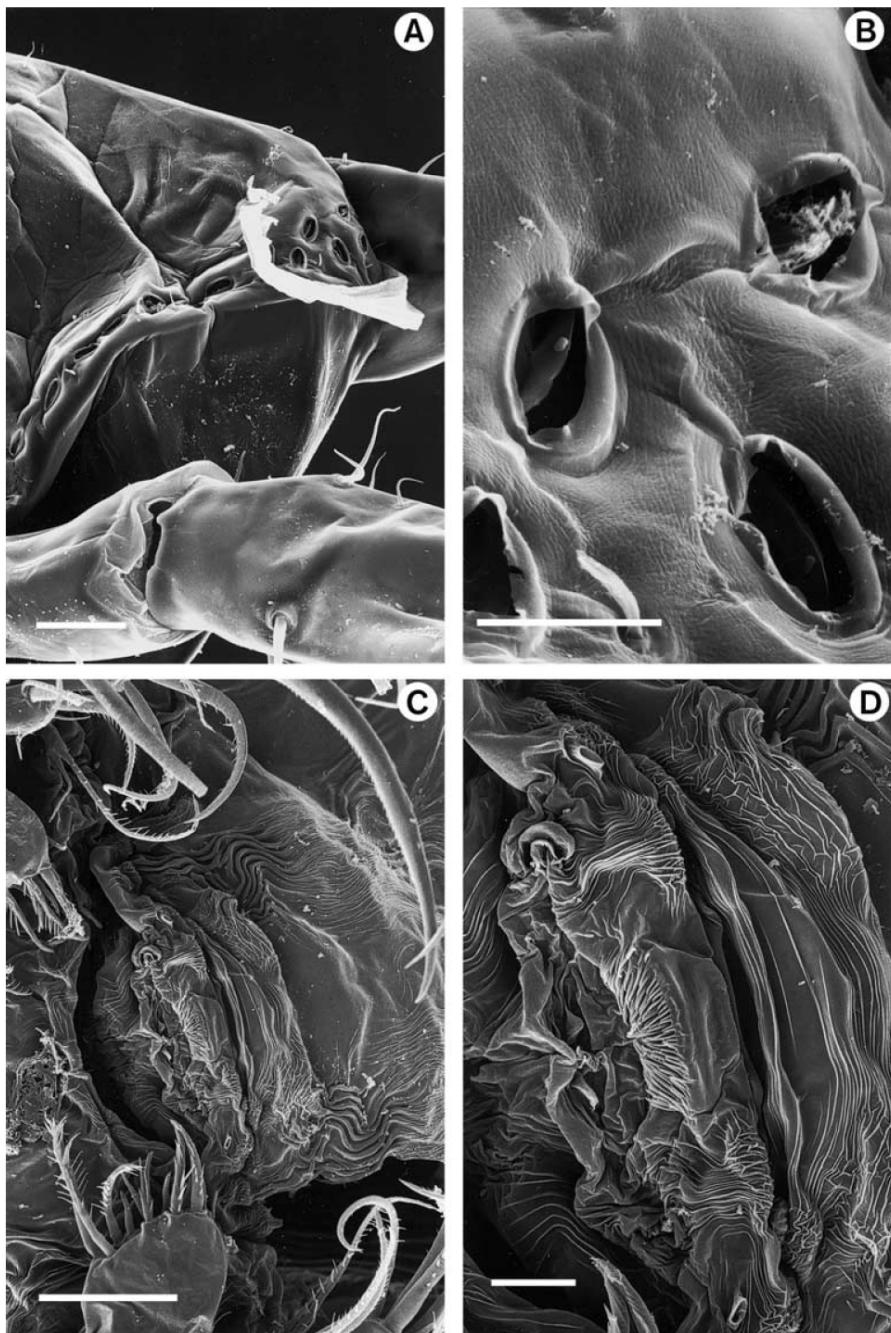
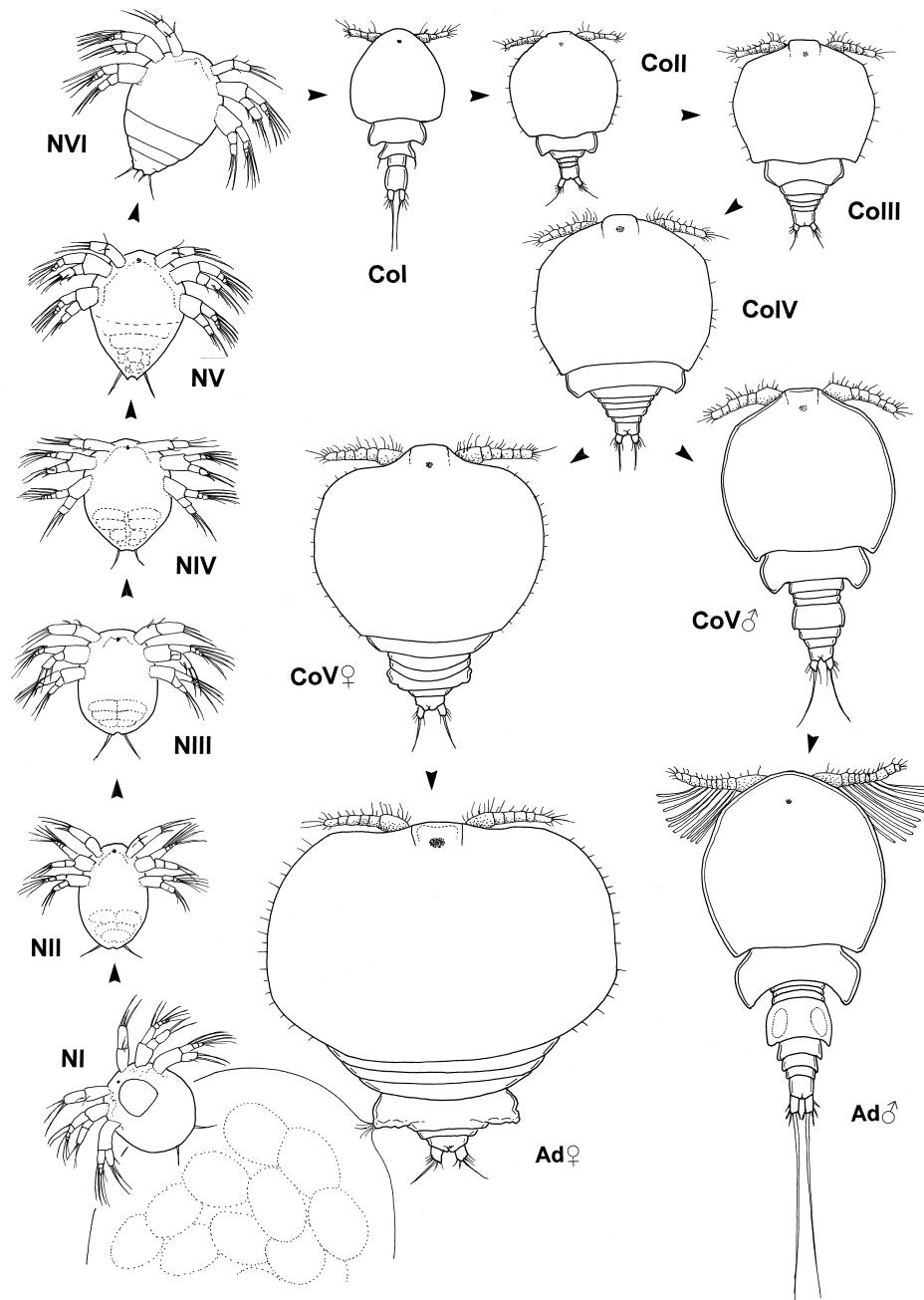


Figure 13. *Nudivorax todai* gen. et sp. nov. (♂). A, lateral view of cephalosome showing pore; B, detail of cephalosomal pores; C, oral area; D, detail of labrum. Scale bars: 20 µm (A, C), 5 µm (B), 10 µm (D).

***Nudivorax* males  
are non-feeding  
with atrophied  
mouthparts  
  
mandibular coxal  
gnathobase,  
maxillary  
endites and  
maxilla are all  
vestigial in adult  
male**



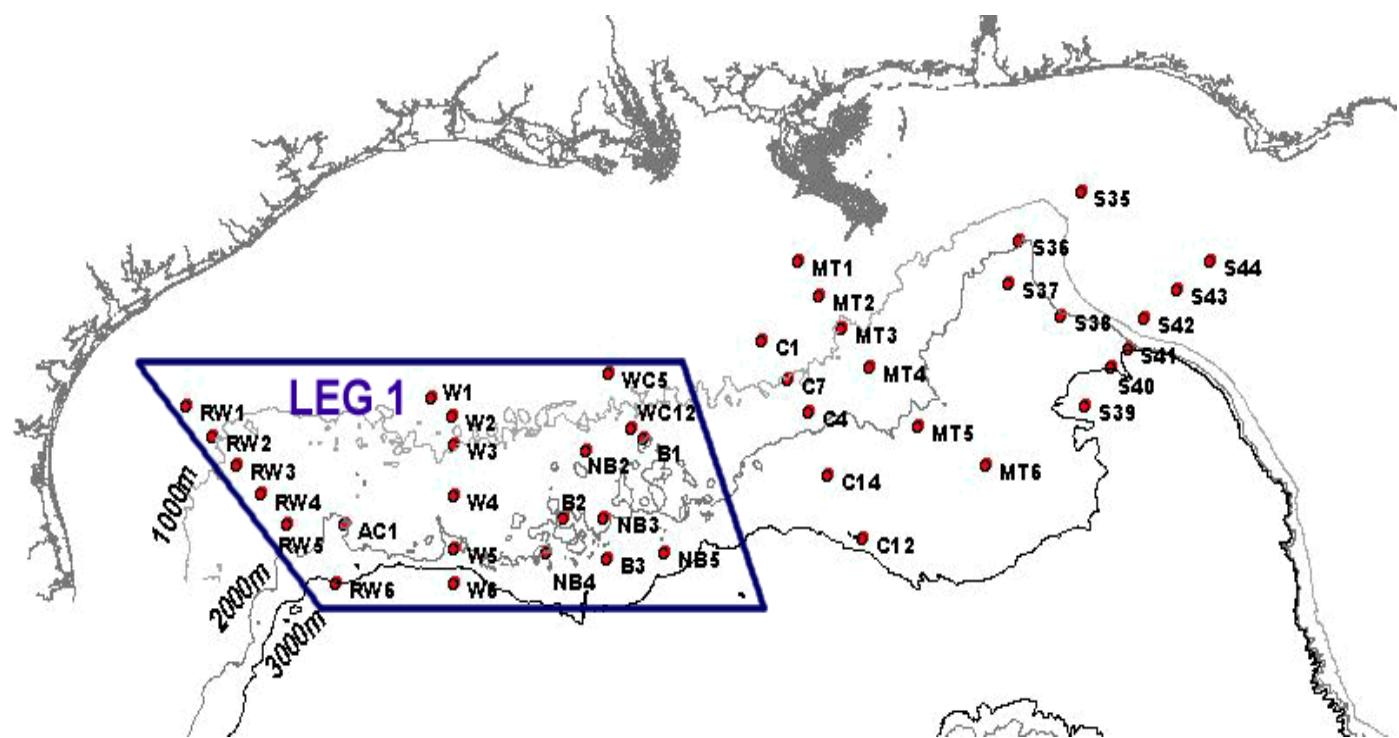
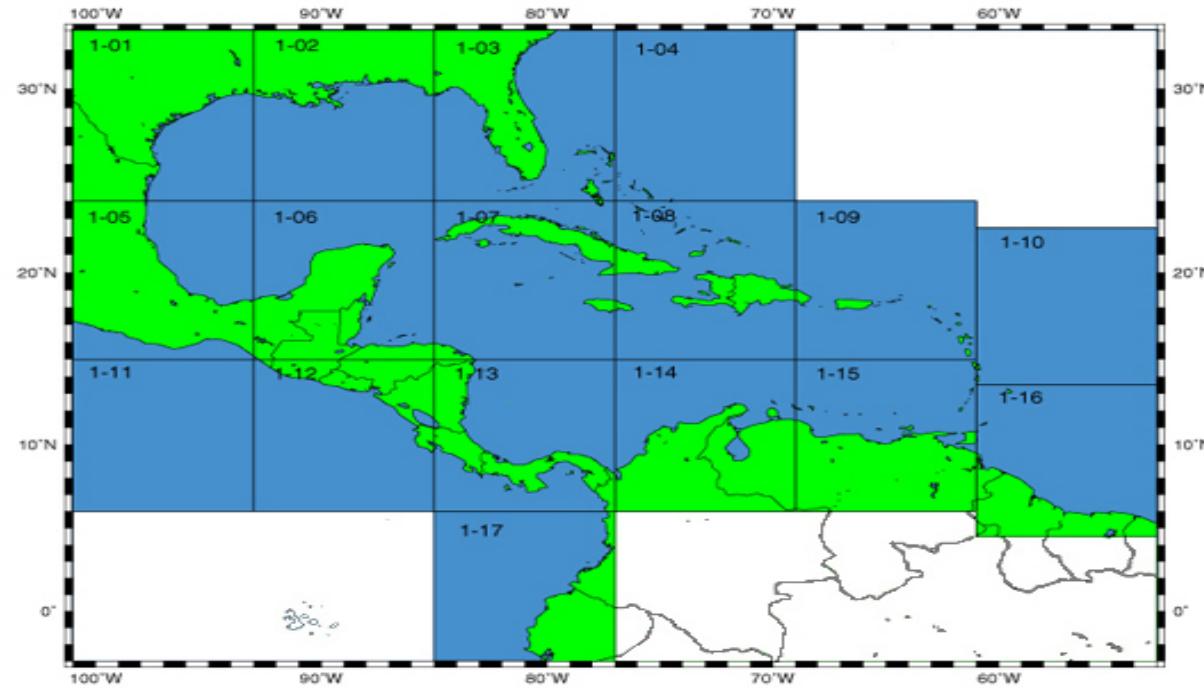
**Typical copepod life cycle comprises two phases: naupliar and copepodid**

**Each phase primitively has six stages:**

**Nauplius 1 to VI and copepodid I-VI, of which the sixth is the adult**

# Identification of Harpacticoids from the Gulf of Mexico

- To reveal the energy flux in the northern Gulf of Mexico (DeGOM)
- Survey on the community structure in the region (May - July 2000)
- Diversity of harpacticoids









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EXPERIMENTAL  
MARINE BIOLOGY  
AND ECOLOGY**

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[www.elsevier.com/locate/jembe](http://www.elsevier.com/locate/jembe)

## Spatial and bathymetric trends in Harpacticoida (Copepoda) community structure in the Northern Gulf of Mexico deep-sea

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Received 27 May 2005; received in revised form 25 November 2005; accepted 15 December 2005

**Table 1**  
Percent contribution of Harpacticoida families to total harpacticoid abundance

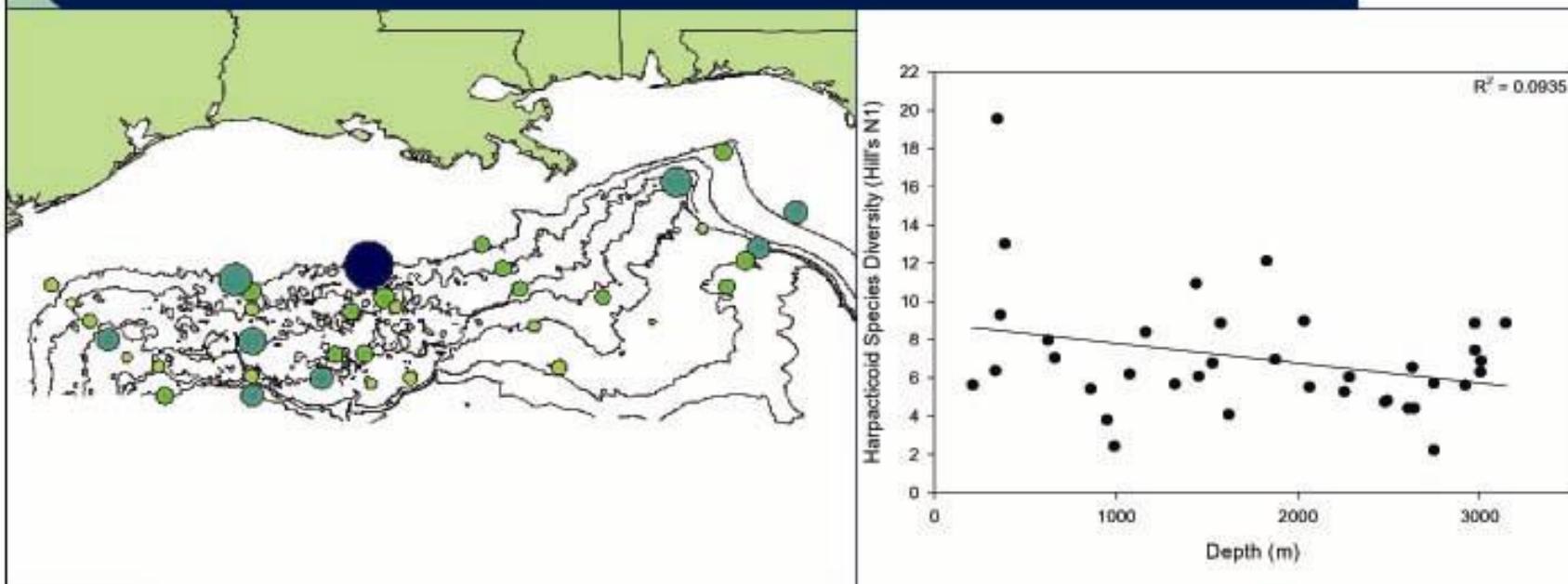
Family	AA	Contrib.%	T%
Tisbidae	40.19	32.98	32.98
Ectinosomatidae	24.12	13.27	46.24
Diosaccidae	19.74	9.84	56.09
Ameiriidae	15.71	8.24	64.33
Argestidae	11.00	8.08	72.41
Paranannopidae	9.15	6.50	78.91
Canthocamptidae	12.38	6.03	84.95
Paramesochriidae	6.73	4.15	89.10
Cletodidae	6.62	3.42	92.52
Neobradyidae	2.73	1.39	93.91
Thalestridae	2.34	1.09	95.00
Normanellidae	2.41	1.09	96.08
Cerviniidae	2.55	1.05	97.13
Danielssenidae	3.55	0.93	98.06
Huntemannidae	1.70	0.93	98.99
Unid. family	1.79	0.61	99.60
Ancorabolidae	1.21	0.32	99.93
Laophontidae	0.42	0.03	99.96
Canuellidae	0.28	0.03	99.99
Darcythompsonidae	0.19	0.01	100.0
Longipedidae	0.16	0.00	100.0
Euterpinidae	0.05	0.00	100.0

AA=Average abundance, Contrib.%=percent contribution of family,  
T% =cumulative percent contribution of families.

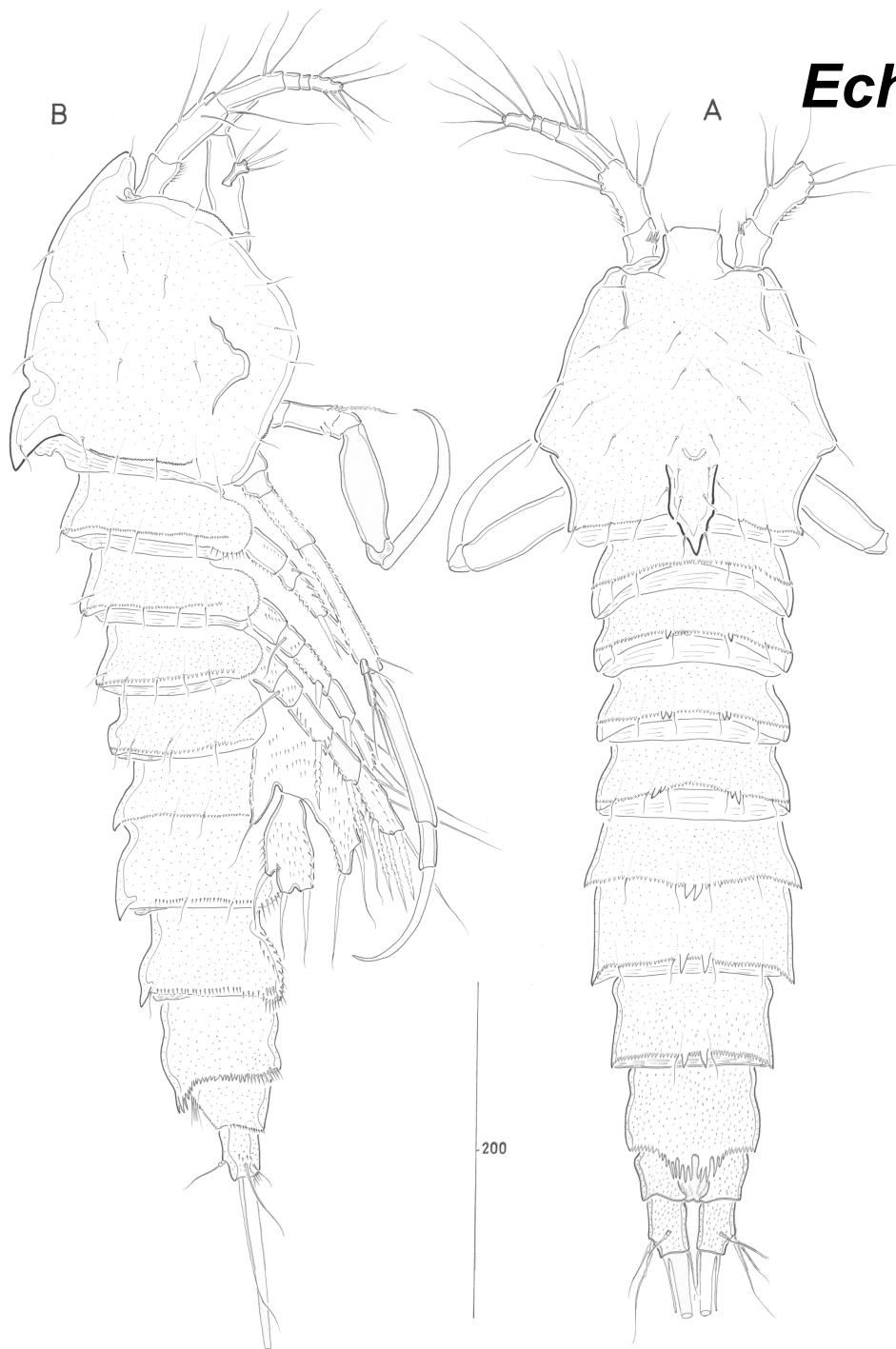
**696 species  
175 Genera  
22 Families**

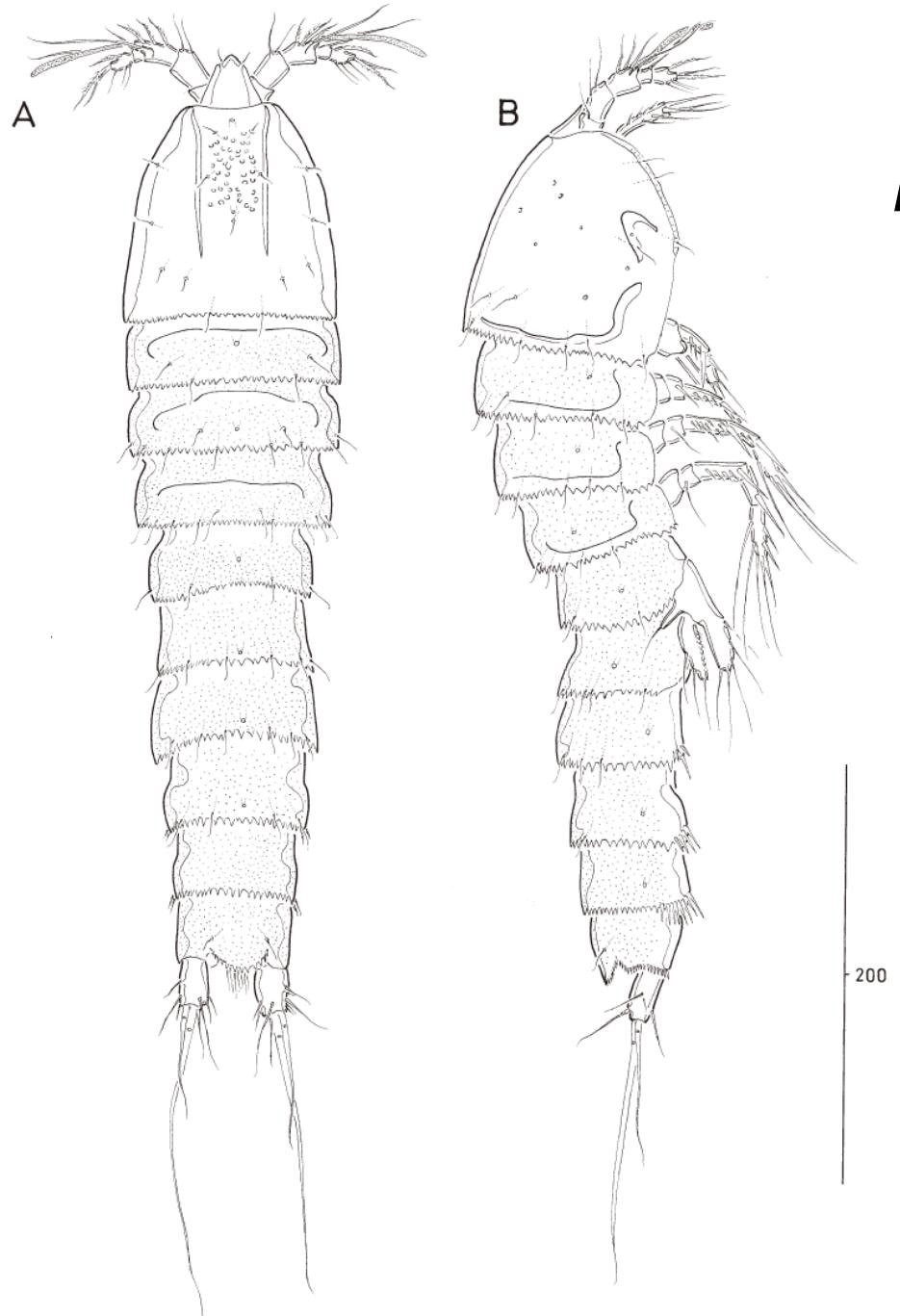
**The most  
abundant  
group:  
Tisbidae →  
Zosimidae**

# Harpacticoid Species Diversity (N1)



***Echinolaophonte armiger***

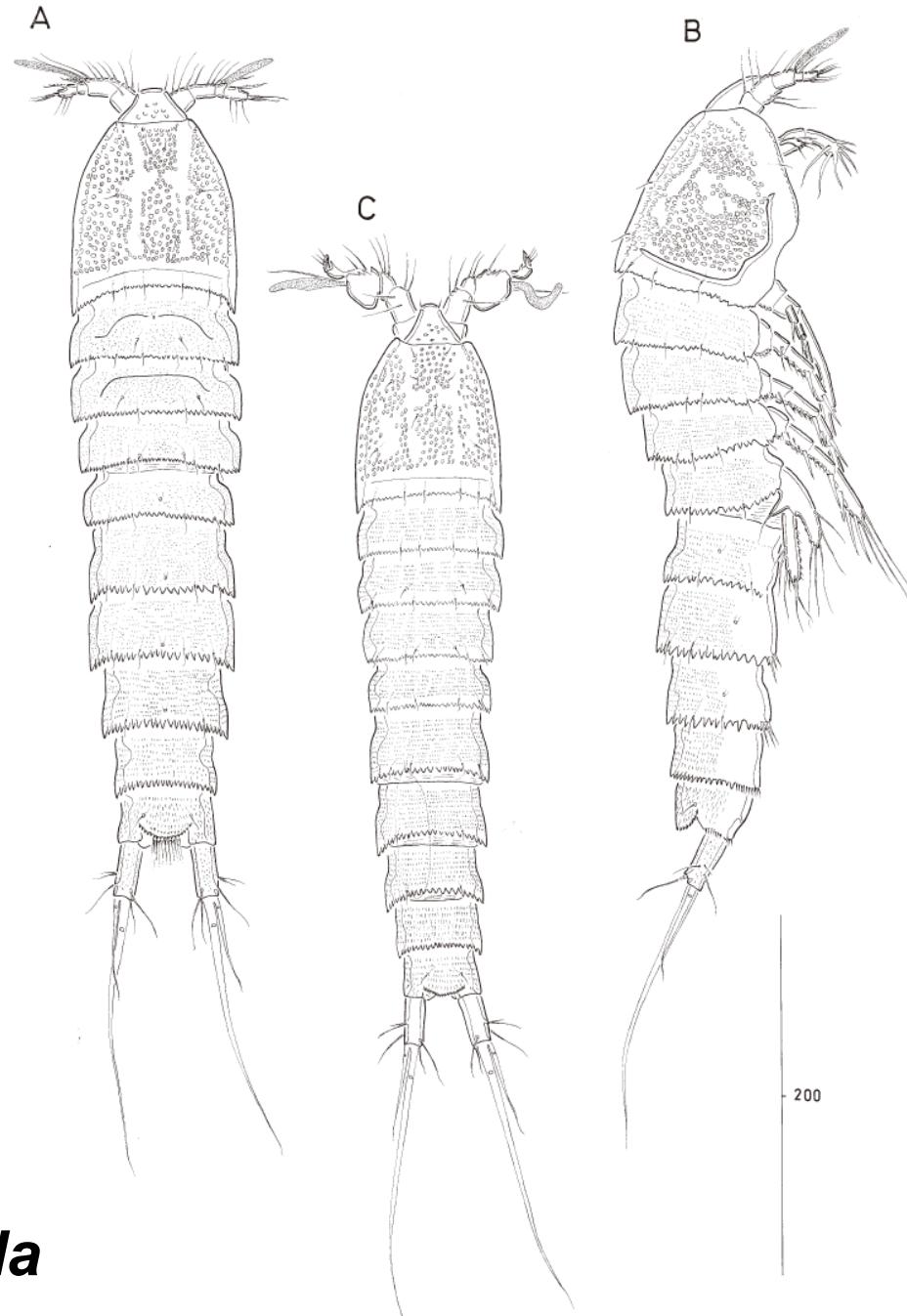




## ***Normanella texana***

200

FIG. 1. *Normanella texana* sp. nov. (♀). (A) Habitus, dorsal; (B) habitus, lateral.



## ***Normanella brevicauda***

FIG. 7. *Normanella brevispina* sp. nov. (♀). (A) Habitus, dorsal; (B) habitus, lateral; (C) habitus, dorsal (♂).

## ***Normanella chanhoi***

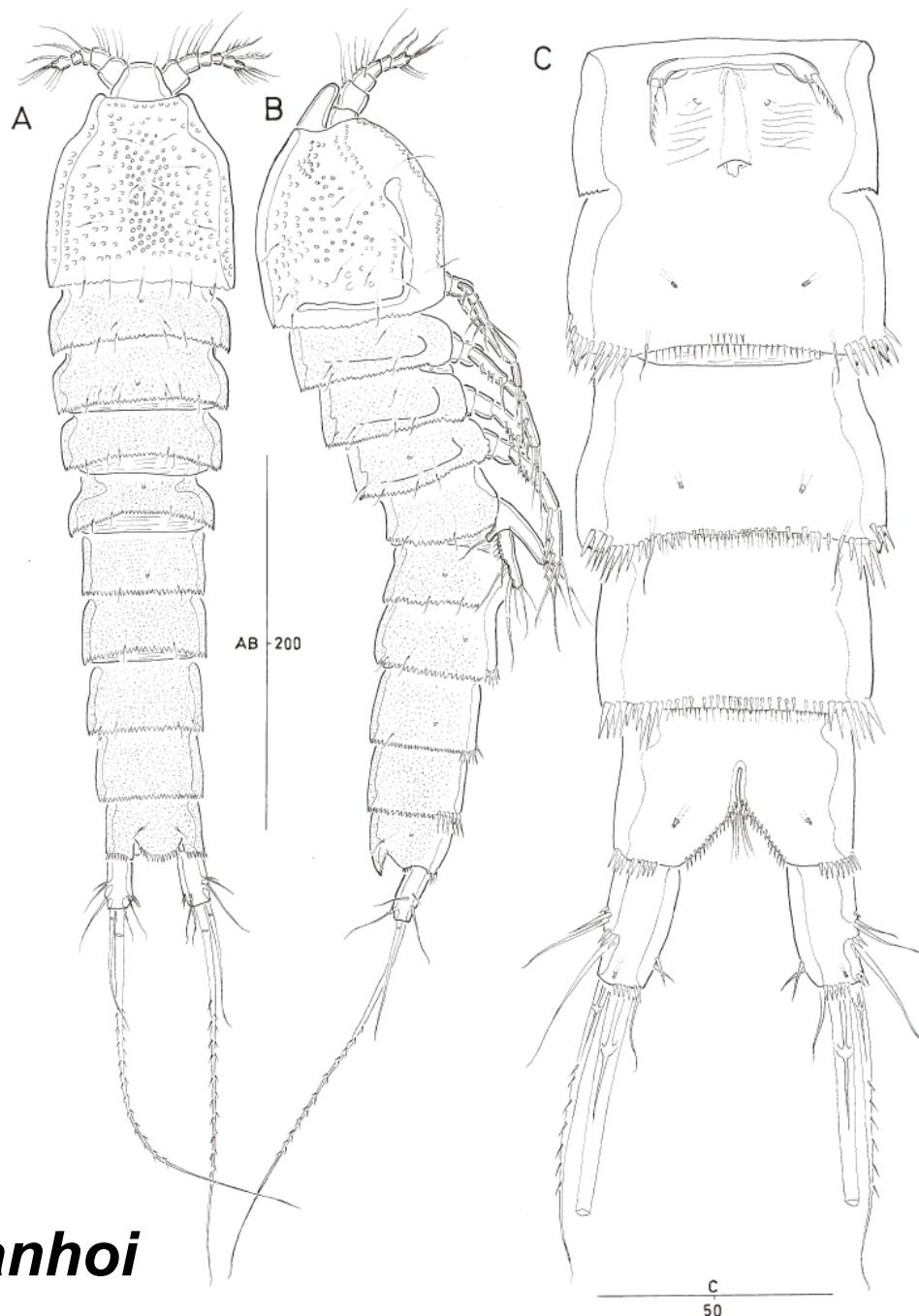


FIG. 11. *Normanella chanhoi* sp. nov. (♀). (A) Habitus, dorsal; (B) habitus, lateral; (C) urosome (excluding P5-bearing somite), ventral.

# *Pseudostenhelia wellsi*

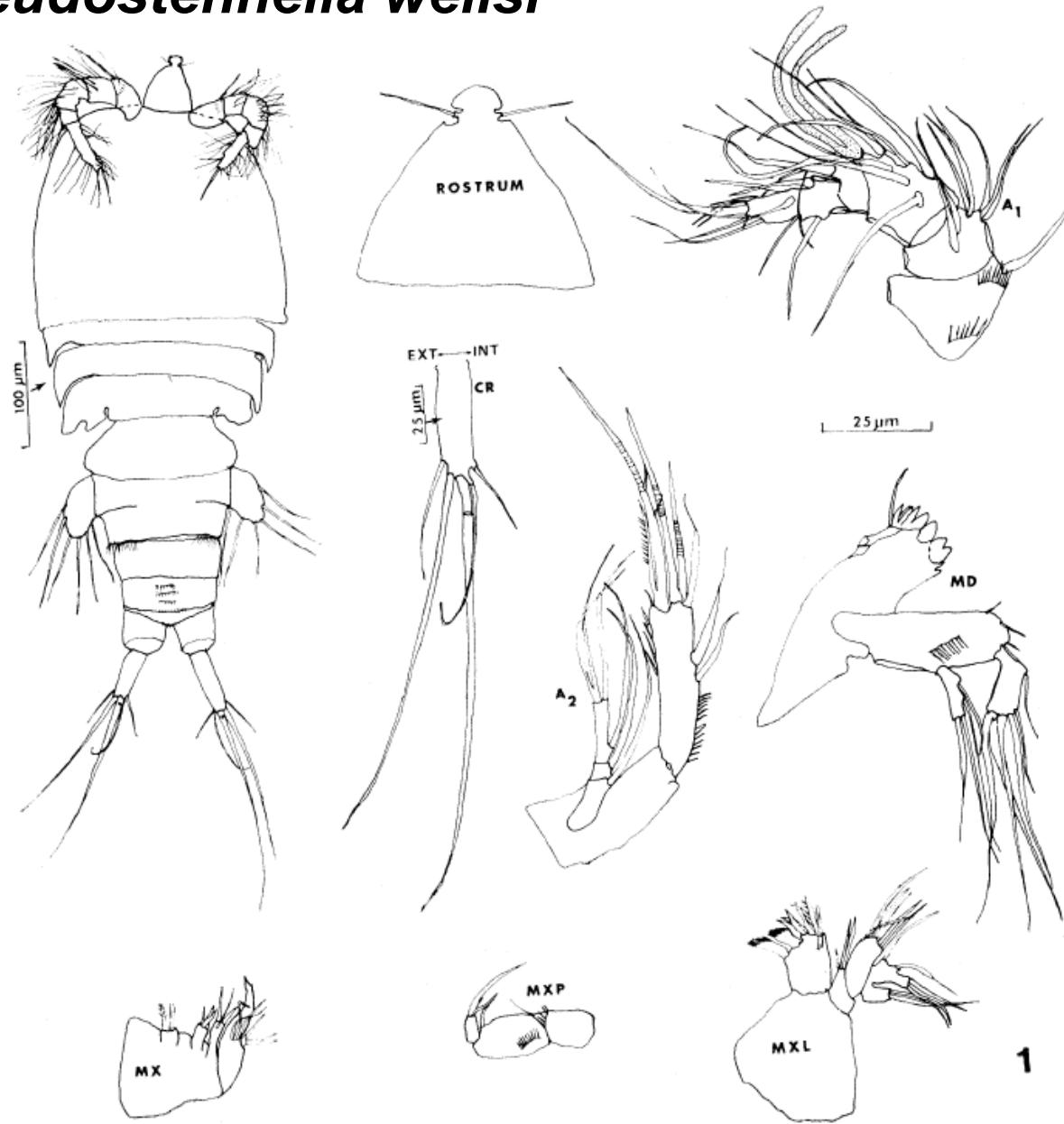
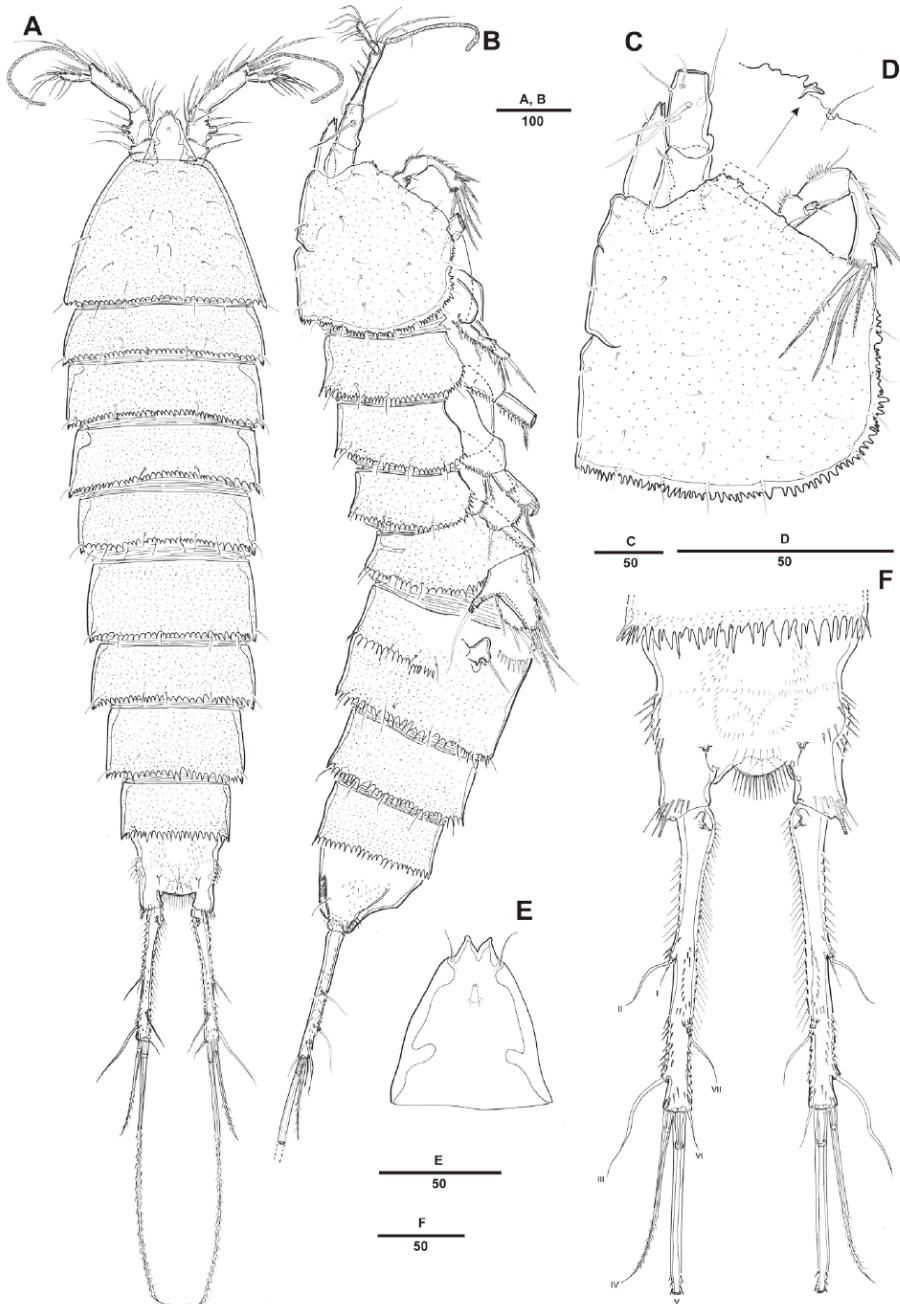


FIG. 1. *Pseudostenhelia wellsi* n. sp.: ♀.

Coull & Fleeger, 1977



## *Peptacleptopsyllus montagni*

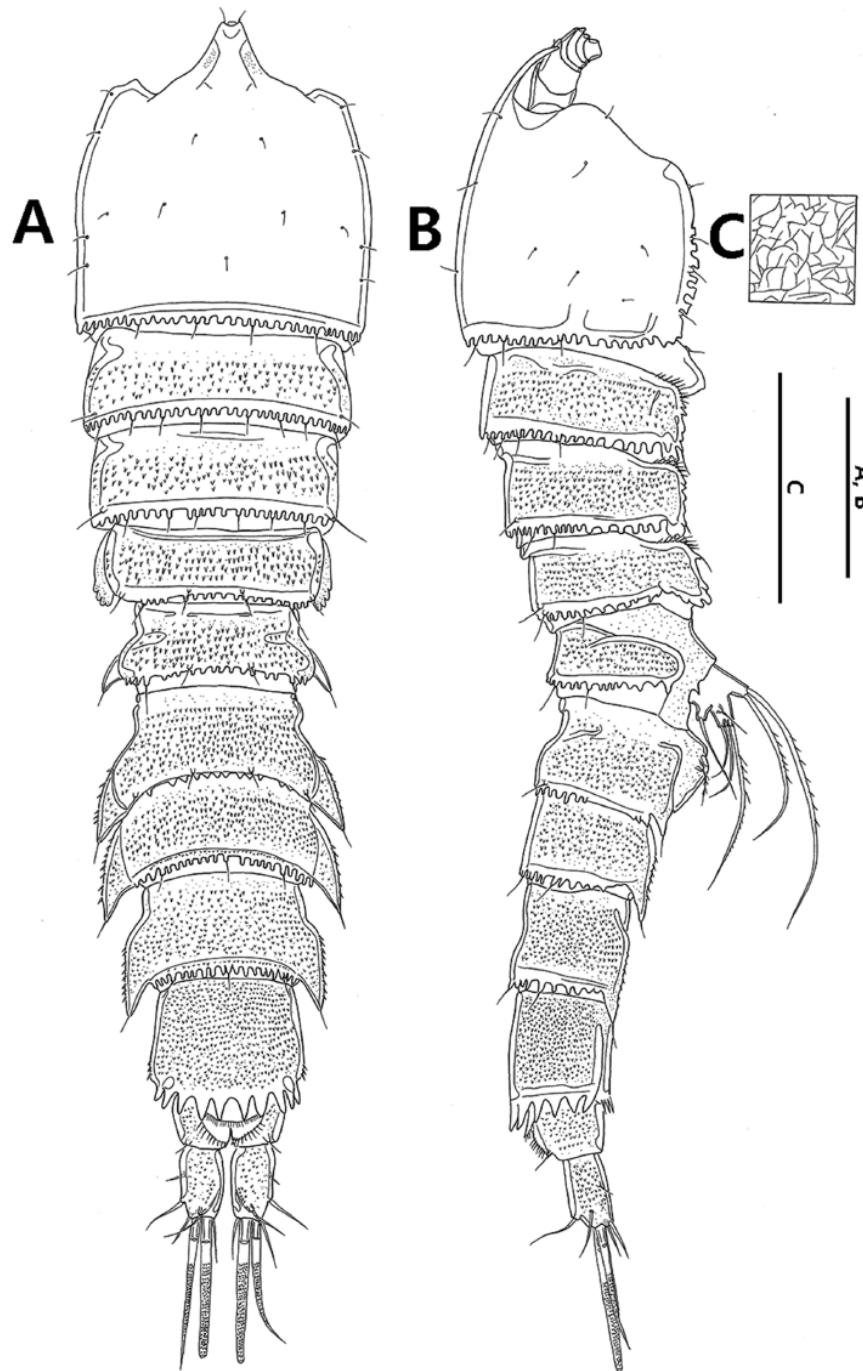
-1590m

**Figure 1.** *Pentacleptopsyllus montagni* gen. et sp. n. female: **A** habitus, dorsal **B** habitus, lateral **C** cephalothorax, lateral **D** tooth-like process of cephalothorax lateral anterior margin **E** rostrum, dorsal **F** caudal ramus, dorsal.



## ***Nannopus palustris***

Fig. 1. *Nannopus ganghwaensis*. Female. CLSM images. A, habitus, dorsal; B, habitus, ventral. Male C, habitus, ventral.



## Zosimiidae

**Zosime spp. ~10 species**

Suarez-Morales, E., Fleeger, J.W. & Montagna, P.A. 2006. Free-living copepods of the Gulf of Mexico. *In*: Gulf of Mexico Biota. University of Texas.

Copepoda 406 species

**Harpacticoida 71 species 54 genera 21 families**



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## A checklist of the marine Harpacticoida (Copepoda) of the Caribbean Sea

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**178 species 94 genera 33 families  
Dominant taxa: Miraciidae, Laophontidae, Tisibidae**

**Thank you very much for your attention!**



**FiftIMCo**

**Special thanks to:**  
**Paul A Montagna**  
**& Organizing committee**