13th International Conference on Copepoda
Pre-conference Workshop Course Content

1) Introduction to Copepod Morphology, Ordinal Classification and Phylogeny
Tutor: Rony Huys

This session will provide a brief overview of copepod morphology and diversity and introduce participants to the impressive range of body forms and limb types across the Copepoda. Trainees will be introduced to the standardized terminology used in the description and identification of free-living and symbiotic copepods. An overview of the basic functional morphology of the reproductive, locomotory and feeding systems will be presented, and the importance of the various sensory structures encountered in copepods will be discussed. Finally, a brief synopsis of the current ordinal classification system will be presented, including some recent developments in our phylogenetic understanding of the group.

2) Taxonomic Techniques for the Study of Copepods
Tutor: Rony Huys with assistance from other tutors

This lecture aims at students becoming familiar with the basic methods used in taxonomic studies of copepods. The presentation will demonstrate how to produce adequate equipment to manipulate and dissect copepods and how to prepare temporary and semi-permanent slides, focusing especially on the clearing, staining, mounting and dissecting techniques. The information content of taxonomic illustrations will be discussed, and detailed information on preparing line drawings, inking techniques and image editing will be provided.

3) Diversity of Copepod Life Cycles
Tutor: Rony Huys

The ecological adaptability displayed by copepods is reflected in their tremendous morphological plasticity which makes it difficult to formulate a rigorous diagnosis of the subclass Copepoda that is both informative yet sufficiently comprehensive to cover the bizarre parasites as well as the free-living forms. However, virtually all copepods have a stage in their life cycle, either the adult or one of the copepodid instars, exhibiting a cephalosome into which the maxilliped-bearing, first thoracic somite is incorporated and possessing at least two pairs of swimming legs, the members of which are linked by an intercoxal sclerite. The postembryonic development of copepods is divided into a naupliar phase and a copepodid phase. Primitively, each phase comprises six stages but larval development and life cycles are highly variable and can be significantly abbreviated (0–6 nauplii; 1–6 copepodids). Most copepods hatch at the (ortho)nauplius stage, a simple larval form. Occasionally the first stage in the life cycle is a metanauplius and some parasitic species are known to hatch as a copepodid. Typically, after six naupliar instars (often designated as NI, NII, NIII, etc.), the final nauplius stage moults into a copepodid stage, which resembles the adult but has a simple, unsegmented abdomen and only three pairs of thoracic limbs (maxillipeds and legs 1–2). Copepodid stages are often referred to as CoI, CoII, etc. (or CI, CII, etc.). In some parasitic groups a stage following the infective copepodid (or one of the copepodid stages) is called the chalimus; it differs from the copepodid in its possession of a frontal filament that aids in attachment to the host. There are significant changes in body size, shape and appendages in the moult from NVI to CoI, collectively known as metamorphosis. Intermoult stages are important for tracing the origin and homology of larval structures between naupliar and copepodid stages. Some parasitic copepods have an onychopodium or (transient) pupal stages in their life cycle. Participants will be introduced to the different larval types and the major differences between life cycles of free-living and symbiotic/parasitic copepods.

4) Marine Plankton I: Systematics and Morphology of Calanoid Copepods
Tutor: Mark Ohman and Janet Bradford-Grieve

Calanoid copepods have radiated throughout the ocean water column, into fresh water, brackish estuaries and even hypersaline lakes. They extend from abyssal and hadal depths in the deep sea to the sea-air interface, and some taxa have taken refuge in marginal environments such as marine caves. They usually dominate zooplankton biomass in oceanic pelagic regions and are key elements of ocean food webs and biogeochemical cycles. We will illustrate the calanoid body plan, internal anatomy, ontogenetic changes, sexual dimorphism, loss of functionality in some male feeding appendages, mating behavior, sex ratios, and the significance of presence or absence of seminal receptacles in the female. We will introduce calanoid diversity including characteristics of major families and superfamilies. We will touch on the evolutionary history of the Calanoida and their relationship to bentho-pelagic ancestors. We will introduce life history traits including developmental delays (diapause or other suspended development), different spawning modes, and aspects of sensory biology, including chemoreception, mechanoreception, and the evolutionary significance of myelination of nerve axons in some families. Laboratory work will include diverse specimens from the Scripps Pelagic Invertebrate Collection, including a variety of calanoids ranging across diverse ocean regions and bathymetric provinces. Where possible, these activities will be supplemented with live copepods collected from local waters. An introduction will be given to the use of identification keys.

5) Marine Plankton II: Systematics and Morphology of non-calanoid planktonic Copepods
Tutor: Ruth Böttger-Schnack

This lecture will provide an introduction to the highly diverse group of non-calanoid marine planktonic copepods. The various form types included in this group will be presented for comparison and the occurrence in various marine habitats will be contrasted for the different orders and families. The most abundant non-calanoid families will be considered in more detail, including ecological and reproductive characteristics in addition to morphological and taxonomic aspects. Particular attention will be paid to planktonic microcopepods of the family Oncaeidae, which is one is one of the most abundant and speciose non-calanoid copepod families in oceanic areas. Gaps in the current state of knowledge of this family will be highlighted, related especially to sampling and identification problems. Specific methods for handling and identifying the small species on morphological basis will be presented. The opportunities and drawbacks of genetic methods for identification will be discussed and the advantage of combining both approaches be explained. An interactive identification key for female Oncaeidae in the world ocean has been developped and will be presented in the lecture. The key is available on the internet and can be used by the participants during the practical session.

6) Marine Benthos: Morphology and Systematics of Harpacticoida
Tutor: Samuel Gómez

Marine meiofauna is well known for its high abundance in relatively small samples, for its close relationship with the sediment (where most pollutants are found), for its lack of planktonic larvae, for its limited dispersal capacity, and for being a very important source of food and energy for crustaceans and (larval) fish. Despite its ecological role, studies about the ecology of meiofauna in some regions wordlwide are very scarce. The lack of a long-standing tradition in the study of meiofauna in these regions has led to a scarcity of researchers interested in the study of these communities, a genuine reflection of the difficulties faced when working with meiofauna. This is particularly symptomatic for the study of harpacticoid copepods, the most numerically important meiofaunal group after the nematodes. Analysis of temporal and spatial variation in copepod abundance and taxonomic composition has proven to be a reliable tool for the assessment of the health of marine and brackish ecosystems. However, the difficult taxonomy of harpacticoids has traditionally been viewed as a serious impediment to such assessments, particularly in regions where adequate taxonomic expertise and guidance are lacking. In this workshop, the importance, advantages and problems in the study of meiofauna will be presented, and students will be introduced to the taxonomy of harpacticoid copepods, its second most abundant component.

7) Copepods in fresh water: diversity, ecology and evolution
Tutor: Diana Galassi

Copepods colonized virtually all the freshwater habitats world-wide, from glaciers to deserts, and from planktonic to benthic habitats. Benthic freshwater habitats are the most diverse, offering different environmental conditions and allowing copepod species diversification. Surface fresh water is also connected with ground water, where frequently unique phylogenetic lineages are still preserved, having disappeared elsewhere. Lakes, ponds, rivers, ground water and related ecotones (GDEs) harbour high abundances and a species richness of benthic Cyclopoida and Harpacticoida, frequently outnumbering other meiofaunal groups. The order Gelyelloida is very rare and currently known from two groundwater sites in southern Europe and a hyporheic habitat in North America. Students will be introduced to (1) freshwater colonization pathways; (2) habitat preferences of the most common copepod families and genera, as exemplified by some flag species; (3) the Linnaean shortfall: morphological features discriminating families, genera and model species; (4) the role of freshwater copepods as indicators in water quality assessment and conservation issues.

8) Symbiotic Copepods Using Invertebrate Hosts: Diversity and Adaptation
Tutor: Rony Huys

Copepods utilise a spectacular variety of invertebrate metazoans as hosts, from sponges to urochordates. Relatively few species of copepods make use of host groups such as the Nemertea, Platyhelminthes, Bryozoa, Phoronida, Brachiopoda, Hemichordata and Sipuncula. However, they are very commonly associated with sponges, the entire range of cnidarian groups from the hard corals and sea anemones to the medusae and siphonophores, most echinoderm and molluscan groups, both solitary and colonial tunicates, and to a lesser extent, crustaceans and annelids (including the former phyla Echiura and Vestimentifera). The main families utilising particular invertebrate host phyla will be introduced and their usage of host microhabitats reviewed. The body form of copepods parasitic on marine invertebrates is astonishingly varied. Many retain the basic cyclopiform body but some of the most extreme examples of secondary reduction in body segmentation combined with the loss of paired limbs are found in copepods from invertebrate hosts. A surprising variety of species also possess a system of rootlets which penetrate host tissues. Students will be introduced to where to find symbiotic copepods, their adaptations to the parasitic mode of life, and the characters that are most useful in their identification. Key aspects of the biology of a selection of the most important taxa and methods of collecting and extracting copepods from their invertebrate hosts will also be summarised.

9) Symbiotic Copepods Using Fish as Hosts: an Overview
Tutor: Danny Tang

Copepods are common parasites of marine and freshwater fishes and are known to cause diseases in finfish aquaculture. They may also serve as useful bioindicators of host dispersal, host phylogeny and host population structure. Students will be introduced to the life history strategies, morphological diversity and economic importance of piscicolous copepods, with emphasis on poecilostome and siphonostome taxa. In addition, the microhabitats and modes of attachment of piscicolous copepods will be discussed. Techniques for extracting copepods from fish hosts will also be presented.

10) An Introduction to the Principles of Zoological Nomenclature
Tutor: Rony Huys

The International Code of Zoological Nomenclature (ICZN or The Code) is a widely accepted convention in zoology that rules the formal scientific naming of organisms treated as animals. The rules principally regulate (1) How names are correctly established in the frame of binominal nomenclature, (2) Which name must be used in case of name conflicts, and (3) How scientific literature must cite names. The rules and recommendations have one fundamental aim: to provide the maximum universality and continuity in the naming of all animals, except where taxonomic judgment dictates otherwise. The Code is meant to guide only the nomenclature of animals, while leaving zoologists freedom in classifying new taxa. Students will be introduced to the basic principles of zoological nomenclature including availability, validity, priority, synonymy and homonymy of taxomonic names.