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Linnaeus tercentenary and invertebrate taxonomy: an introduction*

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"The beginning of wisdom is to call things by their right names."—Chinese proverb

A tribute to Linnaeus

Carl Linnaeus (1707–1778) is the founding father of modern taxonomy. The binominal nomenclatural system for species and the principles of biological classification that he developed in the 18th century provide the basis on which we name and group organisms today. The tenth edition of his monumental *Systema Naturae* (Linnaeus 1758) marks the beginning of zoological nomenclature (ICZN 1999) and zoology as a modern branch of the natural sciences. Linnaeus' genius was to see and understand what others had not: the requirement for a simple, easily applied, and consistent system of classification. That the fundamental principles of his work have survived two and a half centuries of repeated challenges stands as a tribute to that genius.

In the 25 decades that have passed since this founding document was published, taxonomy has undergone extraordinary changes. The theory of relationship by descent introduced by Darwin (1859) was quickly adopted as a rationale for the nested system of taxonomic categories already put in place by Linnaeus a century earlier. The 20th century saw the development of cladistics (e.g. Hennig 1966) and integration of information from many areas of biology into taxonomy, with an increasing emphasis on understanding evolutionary relationships. Today, taxonomy, or systematic biology, can truly be said to encompass two great goals: the creation of a catalog of life that can be used to access all available information about it, and the development of a universal tree of life that will embody the relationships of all organisms.

As we complete 250 years of zoological nomenclature and taxonomy, it is timely that we present this special issue of *Zootaxa* on invertebrate taxonomy in celebration of the tercentenary of Linnaeus.

A focus on invertebrate taxonomy

The Linnaean era is characterised by an ambition to name, catalogue and classify all species of the natural world. This huge task is far from complete 300 years after Linnaeus' birth. In the last 250 years, zoological

taxonomists have made significant achievements in defining the animal fauna of the world, having named and described over a million species of animals. However, the vast majority of the world's animal species are yet to be discovered, named and described—estimates of the total number vary from 5 to 30 million. The invertebrates comprise about 97% of the total and thus present the largest gap in our knowledge. It is for this reason that we focus on invertebrates in this special issue of *Zootaxa*.

An introduction to this special issue

Structure

In this volume, we collect 30 essays and reviews by 57 authors from around the world. This book consists of two parts. Part I is an overview of several major initiatives, projects or areas of research that are of fundamental importance to taxonomy and are transforming and rejuvenating the science in the present era. Part II is the major section, and includes review papers focused on the state of the taxonomy of particular invertebrate taxa. In a single issue with limited space, it is obviously not possible to cover all invertebrate taxa. The selection reviewed here mainly reflects the significance of the taxa and, as importantly, the availability of authors who were able to contribute to this commemorative issue in a timely manner.

Overviews

The development of cyberinfrastructure, digital technology, information science, and computer engineering has had a huge impact on taxonomy. Wheeler (2007: 11–18) defines cybertaxonomy and elaborates on how it will help to accelerate species discovery, description and revision. He forcefully argues that taxonomy as a science driven by hypothesis testing must reassert its unique position among the biological sciences, and taxonomists must speak with a unified voice to develop three levels of leadership to assure that its missions, goals and needs are met.

One of the earliest and most significant taxonomic projects on the internet is the Tree of Life Web Project. Maddison et al. (2007: 19–40) review its early history, growth in contents, successes in presenting information to researchers and the general public, and the challenges it must face in the future. The National Science Foundation of the United States has taken the lead in addressing the decline in available expertise in taxonomy with its PEET (Partnerships for Enhancing Expertise in Taxonomy) program of generous grants, aimed at producing monographic studies of previously neglected groups of organisms and at training a new generation of taxonomists. The program is described here by James Rodman (2007: 41–47), a former PEET director.

Winston (2007: 47–54) addresses the subject of collections-based research from the viewpoint of a former Director of Research and Collections at a modest-size, state-supported museum, and concludes that if the rich resources available in collections are to be preserved and used to extend our knowledge of biodiversity, significant increases in funding and the attention of governments at all levels will be necessary.

An important phenomenon of the late 20th century has been the integration of molecular biology, genetics and developmental biology with taxonomy and phylogenetics. A substantial number of invertebrate taxa have proven to be crucial in developing an understanding of common developmental pathways in all animals. At the same time, evolutionary developmental biology (evo-devo) sharpens the picture of both taxonomy and animal phylogeny. A leading figure in the field, Alessandro Minelli, analyses in his chapter the contributions that taxonomy can make to evo-devo and *vice versa* (Minelli 2007: 55–60).

Taxonomy

The taxonomic part starts with two general papers: one provides a phylogenetic (Giribet et al. 2007) and another a taxonomic/nomenclatural framework (Dubois 2007) for the invertebrate taxa treated in this special volume. Giribet et al. (2007: 61–79) summarize the current state of knowledge of high-level animal

phylogeny, and describe how new techniques from molecular biology, advances in the study of morphology (such as confocal laser microscopy), and the discovery of new aspects of biodiversity have allowed us to arrive at our present understanding. Dubois (2007: 81–106) provides a complete survey of the classification of the 5222 animal taxa that were recognized and diagnosed in Linnaeus (1758)'s tenth edition of the *Systema Naturae*. Of the 4383 species included in Linnaeus (1758), 3049 are invertebrates.

Specialist taxonomic reviews cover a wide range of invertebrate taxa and at different ranks. Five papers deal with the higher taxonomy and phylogeny of phyla Porifera (Erpenbeck & Wörheide 2007: 107–126), Cnidaria (Daly et al. 207: 127–182), Annelida (Rouse & Pleijel 2007: 245–264), Nematoda (Hodda 2007: 265–293) and Echinodermata (Pawson, 2007: 749–764). They review the classifications and relationships of these animals at class, order and down to family levels within each phylum. At a lower taxonomic level, Fautin et al. (2007: 183–244) provide a list of genera of cnidarian orders Actiniaria and Corallimorpharia.

The majority of the papers cover the Arthropoda, the largest and most diverse of all phyla, with reviews on the taxonomy of sea spiders (Bamber 2007: 295–312), crustaceans (Boxshall 2007: 313–325), millipeds (Shelley 2007: 343–362), centipeds (Edgecombe 2007: 327–341), small arachnid orders (Harvey 2007: 363–380) and last, but not least, many groups of insects. The entomological section is by far the largest portion of this book, consisting of twelve reviews in 396 pages (just over 50% of all the pages). Six of these review the higher taxonomy of ordinal-level taxa: Odonata (Trueman 2007: 381–394), Thysanoptera (Mound & Morris 2007: 395–411), Diptera (Yeates et al. 2007: 565–590), Hymenoptera (Sharkey 2007: 521–548), Trichoptera (Holzenthal et al. 2007: 639–698), and Lepidoptera (Kristensen et al. 2007: 699–747), whereas another four deal with the taxonomy and phylogeny of interesting and important family-group taxa such as ants (Ward 2007: 549–563), weevils (Oberprieler et al. 2007: 491–520), mosquitoes (Harbach 2007: 591–638), and scale insects (Gullan & Cook 2007: 413–425). The only paper dealing with species-level taxonomy is a revision of Linnaeus' scale insects. Williams (2007: 427–490) reviews all species of scale insects described by Linnaeus, summarises the history of Linnaeus' collection, redescribes all the species in modern standards, translates Linnaeus' original descriptions of scale insects into English, and lists all the references to scale insect literature cited by Linnaeus in bibliographical form, with annotations.

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