The fossil Crustacea of China: their taxonomy, palaeobiology, biogeography and phylogenetic relationships
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Citation for published version (APA):
Taylor, R. S. (1999). The fossil Crustacea of China: their taxonomy, palaeobiology, biogeography and phylogenetic relationships Amsterdam: Fac. der Biologie

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Introduction

The study of fossils can have several objectives, among them the description of new taxa, the search for ancestors in biological history, considerations on the evolution of novel structures, or the search for phylogenetically informative characters. It can be a difficult science to work in, often misunderstood and sometimes even maligned by those who dislike its highly interpretational nature. There can be no question, however, regarding the importance of palaeontological studies to our understanding the evolution of life on the Earth.

Biology today is a fast-moving and rapidly growing, sometimes even controversial field. Modern studies such as those utilizing molecular clocks help to put life into a chronological framework. Developmental studies are making us aware of ways in which new animals may arise from old through such morphology-altering mechanisms as heterochrony. Genetic studies of controller genes such as homeobox genes are teaching us of the interconnections of life on the planet, the common bonds that are shared by all animals from limpets to llamas.

Such research is telling us much of the natural history of life on the Earth. They cannot, however, replace the importance of palaeontological work. Without the study of the remains of life from the past, approaches such as those mentioned above can provide little more than theoretical interpretations of the evolution of life on Earth. It is through the actual examination of fossils that we learn of the many forms of life that have inhabited this planet in the past. Only by looking at the morphological changes they have undergone, the environmental situations they occupy through time, and the floral and faunal associations they make can we attempt to understand the changes that have occurred during the history of life over the past several hundred million years.

This collection is the result of almost 4 years of work on the fossil Crustacea of China. The main goals of this project were: the description of new fossil taxa; the examination of phylogenetic relationships using both Recent and fossil taxa; the interpretation of biogeographic patterns as revealed by comparing the distributions of Recent and fossil taxa; and the reconstruction of their palaeobiology. Each of these topics is discussed throughout this volume, as well as other aspects of the palaeontology of these Chinese fossils.

Chapter 1 of this thesis serves as a general introduction to the biology of one specific group of Crustacea, commonly known loosely as the "crabs". It was written to be a book chapter dealing with functional morphology of the skeleton of the Meiura, which includes the
brachyuran and anomalan crabs. Included in this chapter are discussions of their general morphology, their adaptive types (general ‘mode-of-life’ categories), and their feeding strategies. This chapter concludes with a discussion of their fossil record, and how it is influenced by the morphological adaptations to the various modes of life they possess.

Chapter 2 provides the first true information regarding the Chinese crustaceans making up the bulk of this thesis. It takes up the Pygocephalomorpha, a group of shrimp-like animals that dominated near-shore marine and brackish habitats in the Permian and Carboniferous. Two new species, *Tylocaris asiaticus* and *Fujianocaris bifurcatus*, are described and placed in a new family, the Tylocarididae. This chapter also contains the first phylogenetic analysis of the Pygocephalomorpha, carried out in an attempt to clarify and update their taxonomy. This section also contains discussions as to the palaeobiology of these animals and the biogeographic patterns shown by the order as a whole.

Chapter 3 deals with a highly enigmatic group of Crustacea, the Spelaeogriphacea. There are few taxa known to date: 3 recent forms have been described, including one from Australia reported for the first time in 1998; and 3 fossil taxa, one of which (from the Cretaceous of Spain) has not yet been published. In this chapter, a new monospecific genus is described from the Upper Jurassic of China. The relationships between the members of this suborder are considered in this chapter, as well as their relationships to other peracaridan taxa, through a phylogenetic analysis based exclusively on morphological characters. The palaeoecology and biogeography of these animals are also considered.

Chapter 4 presents the results of work dealing with fossil crayfish from the Upper Jurassic of north eastern China. This chapter builds on work done in the 1920s and 1930s, in which two species of crayfish (*Astacus licenti* and *A. spinirostrius*) were described from the same localities and intervals. The collection and examination of new material, accompanied with a re-examination of the original material, has resulted in the synonymyzing of *A. spinirostrius* with *A. licenti*. It has also led to the erection of a new family, the Cricoidoscelosidae, for the new genus and species *Cricoidoscelosus aethus*. This is a highly unusual crayfish, in that it possesses a feature not seen in any other crayfish known (Recent or fossil): annulate pleopods. As with the previous chapters, a discussion covering such issues as biogeography, palaeoecology and taxonomy concludes this chapter.

In Chapter 5, each of the major crustacean groups found in China’s fossil record is discussed in terms of both their global biogeographic and temporal distributions. These same groups are then discussed in a more local context within China, allowing for comparisons of these Chinese taxa with their ‘relatives’ world-wide. This discussion is based largely in infor-
Appendix 1 provides a list of Chinese fossil crustacean taxa, their collection localities and their geological age. Unfortunately, this compilation is far from complete! It summarizes a great deal of the information that is currently widely dispersed, and is provided here as a starting point in data collection for interested readers.

The second appendix provides a data set to accompany that of Appendix 1. It includes information regarding the collection localities and geological age for the same crustacean groups known from China’s fossil record but on a global scale. A selected bibliography is provided at the end of this ‘chapter’, to serve as a starting point for any interested reader to investigate the natural histories of any of the groups mentioned here. The abbreviations used are from the Treatise on Invertebrate Paleontology, Part R, Arthropoda 4.

In reading this thesis, I hope that the reader will see the importance of palaeontological studies and will perhaps even share a little of the enthusiasm that I share for this work. There is no question as to the importance of fossils in the study of the history of life; I hope that this thesis will help to fill in a few of the gaps that currently exist in our understanding of where/when/why the Crustacea are where/when/why they are today!
Chapter 2 provides the first major theoretical backdrop to the exposition, setting up the context. It presents the theoretical framework for a group of studies that will form the basis for the subsequent discussions. This theoretical framework is designed to provide a comprehensive understanding of the phenomena under investigation. The theoretical stance adopted is rooted in an empirically driven approach, ensuring that the theoretical underpinnings are grounded in empirical evidence and data. This approach is characterized by a rigorous methodology that allows for a systematic analysis and interpretation of the data.

Chapter 3 presents the results of work dealing with fossil vertebrates from the late Cretaceous geologic period of central China. The chapter is structured around a detailed examination of the fauna and flora, which were captured by the geologic events of that period. The collection and examination of fossil material are augmented by re-examination of the original material, which resulted in the grouping of 14 new taxa with 5 new genera. This chapter also contributes to the creation of a new family, the Calpadianidae, and a new genus and species, Calpadianidae novae species. This chapter is highly critical, as it provides a new perspective that is not easily discernible in any other work known (Recent or fossil). This new taxonomic entity is discussed in detail, and the chapter concludes with a discussion of its implications for vertebrate paleontology and evolution.

In Chapter 4, each of the major faunal groupings identified is considered in terms of both their global geographic and temporal distributions. These groups are then discussed as a more local analysis within China, allowing for the comparison of their distinctiveness and their relative importance. This discussion is based largely in vertebrate paleontology.