1. INTRODUCTION

Not many scholars increased our knowledge of the Badenian (middle Miocene) decapod crustaceans so profoundly as Pál Müller (1935–2015) did. Pál studied decapods with great enthusiasm in the field, in the laboratory and at home. His brilliant and sparkling mind was never short of new hypotheses regarding their taxonomy, palaeoenvironmental context, stratigraphic range and evolutionary patterns, but never mixed facts with fiction, so to speak. When it comes to testing his ideas, he was always thorough and highly critical. By himself, or in collaboration with colleagues abroad, Pál described over 100 species of extinct decapod crustaceans (summarised by Hyžný et al., 2014a). His fellow (palaeo)carcinologists named a number of decapod taxa after him.

Pál Mihály Müller (Fig. 1) was born in Budapest on 14 July 1935. In 1958 he received a master's (MSc) degree in geology at the Eötvös Loránd University (ELTE, Budapest). As a young graduate he worked as a geologist for the Bauxite Exploration Company (1958–1959), and later (1959–1967) for an agricultural planning company, Agroterv. His free time, however, was already devoted to decapod crustaceans and he visited different localities to collect their fossil remains. Pál's first papers on fossil decapods appeared in print when he was employed by the water research company VITUKI (1967–1976). In 1975 he became a candidate of the Hungarian Academy of Sciences. Almost twenty-five years later, in 1999, this degree was accepted as a PhD, and he was appointed as Doctor of the Hungarian Academy of Sciences in 2003 based on a thesis on fossil decapod crustaceans. For the remainder of his professional career since 1976, Pál was affiliated with the Geological Institute of Hungary / Magyar Állami Földtani Intézet (merged in 2017 with the Hungarian Office for Mining and Geology to become the Mining and Geological Survey of Hungary / Magyar Bányászati és Földtani Szolgálat). He was also a member of the Committee of Palaeontology of the Hungarian Academy of Sciences, and chairman of the Palaeontology and Stratigraphy Division of the Hungarian Geological Society (1994–1997). Although he officially retired in 1995, he participated in various projects at the Geological Institute of Hungary until 2010. Sadly, in 2012 Pál was diagnosed with a progressive loss of brain function, making him unable to participate any longer in the scientific projects he so loved. On 13 September 2015 Pál Müller died in Budapest.

Numerous of Pál's field trips were dedicated to the collection of fossil decapod crustaceans. He was very persistent and occasionally visited a single locality over a hundred times to be certain that all, or nearly all, decapod crustacean taxa were represented in his collections. He started his studies at the classic localities of Imre Lőrenthey (1867–1917), one of the great palaeocarcinol-

ogists of his time. Pál's first papers focused on taxa from the Miocene of the Budapest area (Müller, 1974a, 1974b, 1975a, 1975b, 1976, 1978), in particular from the Badenian Stage in the Central Paratethys. In 1984 his *magnum opus*, a monograph on all decapod taxa then known from Badenian strata, was published (Müller, 1984a). Although much new material has been discovered since, this work still remains a major reference. It was published as volume 42 of *Geologica Hungarica*, *Series Palaeontologica*, which is very fitting because 55 years earlier in the same series, the grand monograph by Imre Lőrenthey came out (Lőrenthey, Beurlen, 1929). These two tomes constitute the classic literature sources for any scholar who works on fossil decapod crustaceans from central Europe.

It was Pál's wish that his entire private collection of decapod crustaceans should ultimately be deposited in the Hungarian Natural History Museum (HNHM). Shortly after the publication of his "Badenian monograph", the extensive material of Badenian decapod crustaceans of Hungary was donated by Pál to the HNHM. At that time, an even larger portion of the collection remained in his private flat. His collection of fossil decapod crustaceans was always kept in great order, with every single piece of cheliped or tiny carapace in its own small box and accompanied by a reference number matching the database in his computer. Moreover, all boxes were hand made of cardboard by Pál himself and arranged in larger boxes holding colour codes for specific stratigraphic levels which yielded the material. After Pál passed

Fig. 1 – Pál Müller at the exposure of Rákos, Budapest, in November 2008 (Photo: M. Hyžný)

away, this collection was transferred to the HNHM and is open for further scientific studies (Hyžný et al., 2015a).

This book is based on the examination of both parts of the decapod collection of Pál Müller. The systematic part dedicated to Badenian decapods of Hungary (Chapter 7) not only includes new photos of the type material but also documents the newly processed material from the remaining part of Pál's private collection, which became available only recently. Together with the systematic overview of decapod species, a synopsis of all Hungarian localities yielding Badenian decapod crustaceans is provided (Chapter 4). Selected localities are presented in greater detail showing decapod assemblages from distinct strata in separate photographic plates. The systematic part is introduced with an identification key to all discussed taxa (Chapter 6). The hope is that this work will be useful to enthusiastic fossil decapod hunters and professionals alike.

For the inspiration, the authors of *Badenian decapods of Hungary* are grateful to their deceased friend and colleague Pál Müller. This book is dedicated to his memory.

Studied material and repositories

Several thousands of decapod specimens from the Badenian of Hungary were studied, mostly deposited in HNHM. Since this book is intended to reach a wider audience, the exhaustive listing of the studied material is not presented herein (for the listing of type specimens, see Pálfy et al., 2008 and Dulai et al., 2019). However, each figured specimen is shown together with its repository number. In some instances, comparative material, fossil or extant, is presented as well. The repositories of these specimens are following:

GBA – Geologische Bundesanstalt (Geological Survey), Wien, Austria;
HNHM – Magyar Természettudományi Múzeum (Hungarian Natural History Museum), Budapest, Hungary;
NHMW – Naturhistorisches Museum Wien (Natural History Museum Vienna), Austria;
MBFSZ – Magyar Bányászati és Földtani Szolgálat (Mining and Geological Survey of Hungary), Budapest, Hungary;
USNM – Smithsonian Institution, National Museum of Natural History, Washington D.C., USA;
SMF – Forschungsinstitut und Naturmuseum Senckenberg (Naturmuseum Senckenberg), Frankfurt, Germany;
MNHN.F – Muséum national d'Histoire naturelle (National Museum of Natural History), Paris, France;
ZIN – Zoological Institute of Russian Academy of Sciences, St. Petersburg, Russia;
ZRC – Zoological Reference Collection of the Lee Kong Chian Natural History Museum, National University of Singapore.

Anatomical abbreviations

P1–P5 = pereiopods (walking legs) 1–5
L = left
R = right