Contents

Preface

A Systematic Summary of the Phanerozoic Brachiopods of China

(in Chinese)

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中国显生宙腕足动物的一次系统总结

（中文代前言）

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这是一本用英文编撰的中国腕足动物化石属志，是门类古生物研究的学术参考书，也是专业性很强的学术工具书。全志涉及的化石记录，来自显生宙的古生代（寒武纪、奥陶纪、志留纪、泥盆纪、石炭纪和二叠纪）和中生代（三叠纪、侏罗纪和白垩纪）共9个纪的海相地层中，跨越地质历史约4.5亿年，涵盖了从1883年至2015年间、根据中国材料创建的757个属（含6个亚属，归于15个目、191个科及若干不确定的分类单元）。

本志书对所收录的属不是只进行简单的汇编，而是本着“一个都不能少”的原则，以纪（period）为单位，从文献中把所有符合条件的属（或亚属）都搜录进来，不管属的有效性如何，都逐个编号、按规范记录并展示其模式种的图影。我们对这些分类单元进行系统厘定和分类取舍，提出我们最新的观点；在最新年代地层框架基础上，确定各个属的地层历程和地理分布；在梳理其他腕足动物属的基础上，论述各个时期腕足动物的组合或动物群、生态和生物地理特征。因此，这是现阶段对中国显生宙腕足动物的一次全面而系统的总结。

在编撰中，我们保留原始信息的真实性，体现具体资料的可靠性，注重问题诠释的科学性；尤其鼓励各纪作者依据自己的理解和经验，对系统分类与归属提出最新认识，旨在提高志书的质量和水平，以经得起后人的查询和时间的考验。

那些曾经置于腕足动物门、厘定后被排除的属和虽未归于腕足动物门、确实属于本门类的属，也被包括进来。至于与上述中国的属共生、数量更多的属（如耳熟能详的泥盆纪的喙石燕属 *Rostrospirifer* Grabau, 1931 和弓石燕属 *Cyrtospirifer* Nalivkin *in* Fredericks, 1924）以及由中国学者创建的或名称赠与中国学者的属，因其模式种的模式标本不产自中国者，均不在本志书记录的范围内。

现就我国腕足动物的研究简史，本志书编撰的目的意义，主要内容，系统分类厘定结果，编撰过程，模式标本等阐述于下。

一、中国腕足动物研究简史述评

我国腕足动物的研究历史，在本书概论部分将详细叙述，这里只做简单的回顾与评论。

最早记载的中国腕足动物是比利时古生物学家康宁克（de Koninck, 1846）描记的两种华南泥盆纪化石（*Terebratula yunnanensis* 和 *Spirifer cheehiel*）。最早以中国材料为模式标本建立的腕足动物属是二叠系标准化石、形态特化的蕉叶贝（*Leptodus*），系德国地质地理学家李希霍芬（von Richthofen）采集、古生物学家凯瑟（Kayser, 1883）描述的。十九、二十世纪之交，远道来华考察的欧洲古生物学家根据野外采集或药铺收购的化石材料，描记了一些中国常见的属种，所建的中国的新属不到10个。

上世纪 20 年代开始，中国学者或在中国工作的外籍专家的研究完成了本领域早期里程碑式的成果，其中有孙云铸先生（1924）、葛利普先生（如 1926, 1931, 1933, 1934, 1936）对寒武纪、志留纪、泥盆纪和二叠纪，赵亚曾（1927, 1928, 1929）和黄汲清（1932, 1933）两位先生对华北和华南的石炭纪和二叠纪，田奇璵先生（1938）对华南的泥盆纪等有关腕足动物的著作。葛利普先生不仅对古生代腕足动物研究造诣很深、成果丰硕，还指导多名青年古生物学家，使他们较早地达到了一个很高的水平。赵亚曾先生就是其中突出的一位，他所做的工作赢得了中国学者在国际学术界的声誉；不幸的是，1931 年，他在云南昭通野外考察途中被土匪残害，英年早逝，把短暂的生命奉献给了腕足动物及相关地质事业。他的执着、聪颖和勤奋成为后辈学习的楷模。

上世纪 50 年代初起，中国的地层与古生物研究进入了一个新纪元。其中，王钰先生和杨遵仪先生对腕足动物等无脊椎动物的研究起到了引领和指导的作用。他们在上世纪三四十年代专程去美国学习，深得库珀（G.A. Cooper）等地质古生物学家的真传，认为中国不同时期的古生物群，既丰富、又独特，一定会有许多新的分类单元。为应对社会经济建设的迫切需要，地质矿产部着力开展大范围的区域地质填图工作，中国地质科学院及各省区都增添了一批新的研究力量，成立了古生物工作站，实属重要的战略部署。王钰、杨遵仪、乐森璕等老一辈古生物学家积极指导年轻科研人员、教师或学生，一方面继续晚古生代化石的研究，另一方面开拓早古生代和中生代的新领域。他们带领年轻人鉴定野外队标本、写论文、编教材、办短训班、讲授专题课、接纳各省区人员进修。王钰先生领衔编著的两本腕足动物专业研究工具书［《中国的腕足动物化石》（王钰等，1964）和《腕足动物化石》（王钰等，1966）］，杨遵仪先生等（1957）编撰的范围更宽广的《古生物学教程》，对科研、教学和生产部门的初学者均有突出的参考价值，也为提高研究水平和壮大队伍起到了重要作用。

腕足动物的生物地层意义较大，在野外工作中实用有效。各地同行长年坚持考察和标本采集，为确定含腕足动物化石的地层时代及其对比、揭示各期动物群的性质，发表了大批论文，创建了很多新属（见本志书概论和其他各纪的参考文献）。这一情况突出地体现在上世纪七八十年代出版的、由数十位学者参与的各省区古生物图册中。来自于高校、地质科学和石油煤田院所、区域地质测量大队的腕足类学者，我大多有过接触，其中不乏我的老师和同行。那个年代，野外工作艰苦，政治运动频繁，室内设备简陋，更不用说借用电脑写作了。但是，大家本着对腕足动物研究的浓厚兴趣和真情挚爱，使同行之间的交流成为一件愉快的事情。1980 年秋，“文革”结束不久，在杭州召开了第一次全国腕足动物会议，王钰、杨遵仪等近百位来自全国各地的学者出席，一度传为佳话。尽管国内很多学者不是本志书的作者，但长期以来他们勤奋敬业，发表了大批相关成果，为本次总结提供了资料和图影。从这个意义上说，本志书也包含了他们的辛劳和贡献。上世纪 90 年代，正当我国社会发展到一个新阶段的时候，许多老同志因年龄关系淡出了专业领域，但仍有学者坚守阵地，如侯鸿飞、孙东立等老师，都为本志书的编写做出了重要的贡献。

同时，我也欣喜地看到国内有一批基础扎实、训练有素的中青年学者已经成长起来。从某种意义上说，“文革”后的这代人是幸运的，因为他们赶上了国家发展的好时光，得到了多方面的条件保障和经费支持。面对来自社会的各种诱惑，他们在日常工作中执着坚毅，在野外考察中开拓积累，在国际合作中增长才干，成果喜人（如 Shi, 1991；Shi and Grant, 1993；Shen and Shi, 1996；Zhan and Cocks, 1998；Shen *et al*., 2003；Zhan *et al*., 2013, 2014；Zhang *et al*., 2014）。写到这里，我想起了 2015 年在沈树忠、詹仁斌（共同主席）和黄冰（秘书长）的组织下，在孙元林、何卫红、张志飞等老师的共同努力下，第七届

国际腕足动物大会在南京举办，受到了参会各国学者的好评，实现了中国学者数代人的夙愿。我想，今后也许不会再有像上世纪那么多的学者专家了，但腕足类研究在中国的拓宽和深化定将薪火相传，年轻人的贡献令人期待。

中国的腕足动物属的创建过程，既有高峰期，又有低谷期。高峰期是在上世纪七八十年代，这是与国家开展大规模区域地质填图和采集到大量化石标本密切相关的；尤其是在 1975 年至 1985 年这段时间里，新建中国的属多达 378 个，占总数的一半。低谷是在上世纪 40 年代，建立 7 个新属，这无疑与日本军国主义发动罪恶的侵华战争密切相关。上述状况在文献实录中也有反映。上世纪 60 年代出版的《腕足动物论丛》（Moore, 1965）共包括 1716 属，含中国的属 64 个，仅占总数的 3.7%；到世纪之交，新修订的《腕足动物论丛》（Kaesler, 1997–2006；Selden, 2007）共记载近 4800 属，中国的属 600 余个。前后相隔 40 余年，中国的属占全球总数的百分比猛增。

就高级分类阶元而言，中国的腕足动物属以长身贝目（173 个）、石燕大类（含石燕目 104、准石燕目 29）和小嘴贝目（99）分列前三位，共占总数的 53.5%；随后依次为穿孔贝目（74）、扭月贝目（51）、无窗贝目（43）、正形贝目（38）、无洞贝目（34）、直形贝目（31）和五房贝目（26）；剩下 10 个目的属很少。这与这些属的繁盛程度、历程长短和标本采集有关。

从地理区域上看，中国的腕足类属以贵州（88）和广西（86）的最多，浙江（71）和西藏（70）的次之；少数如海南省、京、津、沪等则缺失记录。这从一个侧面反映了实际状况，显示了这些属在空间分布上的一大特点。

腕足动物化石标本来自多种岩石类型，最引人注目的有两类：一类是特异埋藏、软躯体保存的材料，如寒武纪的澄江动物群，其科学价值与众不同、弥足珍贵；另一类是灰岩中的硅化标本（已在我国奥陶纪、泥盆纪、石炭纪、二叠纪和三叠纪地层中报道），对深入了解属种、构造特征、居群（population）、群落、多样性等甚为重要，尽管已知材料有限，但颇受同行关注。

二、编撰的目的和意义

本志书的编撰旨在全面查考并厘定以中国材料所建立的腕足动物属的名称、模式种和鉴别特征，确认它们的有效性。每个纪都是独立的，篇幅最大的是系统古生物学部分。然而，本志书不啻探讨属的分类，还在国际最新年代地层框架基础上论述各时期、各块体腕足动物群及其生态特征和古生物地理意义，提出国内外对比的新认识。本志书所拥有的资料丰富翔实，编写时尽量做到规范规整，尽量使读者使用时感到方便快捷。

腕足动物门（Phylum Brachiopoda）是一类海洋中营底栖固着方式的无脊椎动物，其幼虫可在海水中漂浮 1 至 2 个星期；几丁磷灰质或钙质壳的两瓣大小和凸度多不一样，包围纤毛环（即“腕”）。最早的学者误以为这个“腕”（brachion）与软体动物门的运动器官“足”（所有格 podos）相当而误称其为 Brachiopoda（中文译成“腕足动物”）。事实上，这个“腕”是起呼吸和摄食作用的，与身体运动无关。问题已经明晰，但原先“名不符实”的称谓却一直沿用至今。

在近 3 亿年的古生代历程中，腕足动物经历了多次盛衰变化。在海域深约 200 m 内的陆表海、斜坡或盆地平坦海底（level bottom）上，它经常是个体最丰富、分布最广的优势类群之一。在经受了奥陶纪末和弗拉-法门交界期两次大灭绝后，它又遭遇了二叠纪末（2.52 亿年前）大灾变，原有的优势不复存在。新生代开始，腕足动物的丰度和多样性锐减，分布范围已然碎片化和边缘化，与古生代的繁盛相比，判若两类。今日海洋里，腕足类只剩下 110 属、近 400 种，部分属种被迫向深海迁移（最深逾 6000 m），零星的

分布使其成为海洋无脊椎动物中的稀有代表，民众对它十分陌生。相反，软体动物全面替代了腕足动物而成为常见生物类群，还是百姓所喜爱的舌尖上的食品。可以说，腕足类兴衰史是地球生物宏演化过程的一个缩影。

腕足动物在海相地层中易于发现和采集，动物群演替频繁，在地层划分对比、盆地分析、环境推测和矿产勘探上意义很大。中国是腕足动物化石赋存的大国，从寒武纪到新生代都有化石记录。我国广袤的大地由地质时期离散在不同海域、后拼合在一起的很多板块（plate）、地体（terrane）或岛屿组成。各时期、不同块体孕育着相似或不同的腕足动物群和特征的土著属种。世界性分子有助于远距离对比，地方性属种有益于地理区系分析，以揭示同时期、不同动物群之间的亲疏关系；再根据洋流运移方向、古气候、古地磁等因素，推断出不同块体的远近和古纬度。因此，在全球古地理再造上，腕足动物也有着不可替代的作用。

以中国化石为模式种建立的大量腕足动物属，散见于成百种出版物里，短时间内查寻到所需资料实非易事，尤其是在地区性很强的专著、图册及专业或非专业会议论文集中寻觅起来，就更困难了。对外国学者而言，难度还要大，他们即使找到了文献，也会因只用中文撰写而导致语言障碍，难以精准理解属种的关键特征；若请非专业人士翻译难免隔行如隔山，译出似懂非懂的句子来。有些论文，虽附有英文摘要，也难以如愿。凡此种种，既给研究者增添烦恼，又使材料价值大打折扣。因此，出版一本用英文综述中国腕足动物的属志，符合中外学者的共同愿望，方便学者交流使用，对于掌握这些属的科学意义，不无裨益。

三、志书的主要内容

如上所述，对中国的属及其所含物种进行查考和系统古生物学再研究是本志书的主要内容，包括属的分类、异名关系、词源、模式种、特征、比较或讨论、种的归属、地层历程和地理分布等。各纪还附有模式种的插图、图影和参考文献。

这些属（未经厘定时）的多样性变化显示，显生宙 9 个纪的差异十分显著，以二叠纪的属最多（208 个），泥盆纪（180）和奥陶纪（113）的居后，侏罗纪（12）和白垩纪（13）的压阵。中生代的三个纪，特别是三叠纪（88 属）引人注目，因为上世纪 60 年代前资料还十分零星，随着中国学者在祁连山（杨遵仪等，1962）、贵州（杨遵仪、徐桂荣，1966）和青藏高原科学考察（金玉玕等，1976, 1979；刘第墉，1976；孙东立，1981，1990；Shi, 1991, 1992；Shi and Grant, 1993），有关它们的生物地层、组合概貌、地理区系的成果在国际上均占有重要的一席之地。

若以期为单位，中国的属（经厘定后）的峰值出现在泥盆纪埃姆斯期（Emsian：49 属），紧接着的依次是奥陶纪凯迪期（Katian：38）、三叠纪安尼期（Anisian：38）与诺利期（Norian：30）、泥盆纪吉维特期（Givetian：27）、二叠纪长兴期（Changhsingian：25）和吴家坪期（Wuchiapingian：24）。当然，这些数字不包括与它们共生的其他腕足类，但也正是在这些时期里，腕足动物出现了演化辐射事件。

中国各时期的腕足动物群中，既有土著或区域属，也含广布属。前者是中国及其相邻国家或地区特有的，历程短暂，形态特征。如奥陶纪的扬子贝（*Yangtzeella*），志留纪的肋房贝（*Pleurodium*），泥盆纪的准无窗贝（*Athyrisina*），石炭纪的甘肃贝（*Kansuella*）和二叠纪的二叠隐石燕（*Permocryptospirifer*）。

我国也发育世界广布的腕足动物群，最典型的是奥陶纪末赫南特贝动物群（*Hirnantia* Fauna），全球冰川时期的特殊产物，历程不足百万年，是地质历史时期里已知分布最广泛的一个腕足动物群，无论是生物地层、地理区系，还是古气候和古环境研究，都有重

要的科学意义（Rong and Harper, 1988）。

本志书对其他与中国的属相伴的腕足类所作的初步梳理，也成为本志书的一个重要内容。各纪作者讨论了不同地区和时期的化石组合（assemblage）、群落（community）或动物群（fauna 或 faunule）以及同期、不同板块（或地体）腕足类的共性和差异性，识别和/或确认共 220 余个腕足动物组合、群落或动物群，阐释它们的生物地层意义，确立它们在世界同期生物地理区系中的位置。这些内容在各纪概论中均做了综述和归纳。

本志书的概论部分以中国资料为基础，简要探讨了腕足动物在显生宙多次重大宏演化事件中所扮演的角色。这些事件包括寒武纪大爆发、奥陶纪大辐射、奥陶纪末大灭绝、泥盆纪弗拉期与法门期交界的大灭绝、二叠纪末大灭绝和中三叠世大辐射。根据中国材料探索腕足动物的起源和演化（如张志飞等对澄江动物群中腕足动物珍贵材料的研究），取得了可喜的成果。研究表明，中国可能是全球腕足动物一些较高级别分类单元，如石燕目（spiriferides）、扭月贝族（strophomenoids）、德姆贝族（dalmanelloids）、多房贝族（polytoechioids）、具疹小嘴贝族（rhynchoporoids）等的发祥地；小嘴贝型腕足动物已知最早代表顾脱贝属（*Kutorgina*）与奥陶纪叶月贝动物群（*Foliomena* Fauna）已知最早代表，都已在华南记载（Rong *et al*., 1994；Rong and Zhan, 1996；戎嘉余等，1999；Zhan *et al.*, 2013, 2014；Rong *et al.*, 2014；Liang *et al*., 2014）。我相信，随着新材料的不断发现，中国腕足动物研究将越来越受到国际同行的关注和重视。

腕足类最大个体在地质时期的发育和变化是一个饶有兴味的话题，尽管它们的数量有限，在化石群中却异常醒目。更有甚者，它们的存亡与环境变化关系很大。中国的材料丰富，但尚未深入研究，不妨在此略费笔墨，以引起关注。寒武纪腕足类个体通常在 10 mm 以下。据张志飞面告，他采获的一枚磷酸盐质腕足类，长、宽分别接近 30 mm 和 25 mm，可能是国内寒武纪已知最大的标本。早奥陶世的壳体大都小于 20 mm；中奥陶世最大的贝体属于共凸贝亚目（曾庆銮，1977），壳长可达 45 mm；晚奥陶世最大个体系三分贝目（徐桂荣、李罗照，2002），长、宽接近 50 mm、75 mm，华南腕足类大型化【本文定义：壳长或壳宽在 50–100 mm 为大型化，超过 100 mm 为特大型化，即 gigantism】在此时首次出现。上述个体变大的趋势，也在双壳类（Isozaki and Aljinovic, 2009）中出现。

奥陶纪末大灭绝后，腕足类个体出现了特大型化。志留纪的特大型壳体属于五房贝目（Rong *et al*., 2005），第一次出现在中兰多维列世，后见于罗德洛世（张梓歆、戎嘉余，2001）；早中泥盆世出现了石燕类、五房贝类和穿孔贝类（侯鸿飞、鲜思远，1975；鲜思远、江宗龙，1978；王钰、朱瑞芳，1979；王钰、戎嘉余，1986）。晚泥盆世 F/F 大灭绝前后，特大型腕足类均未在国内记载。

泥盆-石炭纪交界期灭绝发生后，早石炭世特大型腕足类复又出现，如长身贝类（Qiao and Shen, 2015）和石燕类（杨式溥，1964）。到石炭-二叠纪大冰期早中期消失，进入晚期及以后，特大型化石在萨克马尔期（如石燕类）、瓜德鲁普世（Guadalupian）（如无窗贝目，王国平等，1982；Shen in this book）和乐平世（Lopingian）（如网格贝目，廖卓庭, 1983）又出现了。

二叠纪末大灭绝后，情况发生了根本改变。三叠纪残存期里腕足类出现小型化（miniatism，个体小于 5–10 mm）（He *et al*., 2007）。随后开始常态化，但一直到早白垩世，才又出现大型化的报道（侯鸿飞、王金星, 1984），而特大型个体在我国一直销声匿迹。

大型个体的存亡与什么因素有关，是大家很感兴趣的问题。它是否与全球温度变化有关？已知多数特大型个体的出现与凉水似乎关系不大，但也有少数大个体出现在大冰期晚期（如早二叠世晚期的 *Choristites*，沈树忠面告，2016）。无论怎样，温度太高（如

二叠纪末及早三叠世）或者太冷（如奥陶纪末期），可能都对大型个体生存不利。这里还有其他问题，如为什么特大型腕足类的首现发生在奥陶纪大灭绝之后？为什么特大型腕足类几乎是古生代的专利，而在二叠纪末大灭绝后消失了？这是否还受制于和软体动物门竞争的失败？生物受环境影响的因素甚多，除温度外，还有海水营养优化与可溶解氧浓度变化，生物摄食机制的适应等等，内因与外因都可能起作用，哪个更重要？这些问题都值得今后进一步探索。

四、系统分类的厘定结果

本志书采用了国际上广泛认可的腕足动物分类系统全新格架（Popov *et al*., 1993；Williams *et al.*, 2000）。这个新格架是根据现生腕足动物的壳质、解剖、发育和生理，得益于分子生物学和电子显微技术并采用分支系统学（cladistics）的方法提出的（Kaesler, 1997–2006; Selden, 2007）。据此，腕足动物门囊括 3 个亚门：舌形贝型亚门（Linguliformea）、髑髅贝型亚门（Craniiformea）和小嘴贝型亚门（Rhynchonelliformea）；后者包括原归于有铰纲（Articulata）的扭月贝纲（Strophomenata）和小嘴贝纲（Rhynchonellata）和原归于无铰纲（Inarticulata）的奇里贝纲（Chileata）、小圆货贝纲（Obolellata）和库脱贝纲（Kutorginata）（参见戎嘉余、李荣玉，1997）。笔者对以壳质是否具疹作为主要依据把石燕分成两大目尚有异议，因为有疹和无疹可在同一目（如正形贝目和小嘴贝目）中出现。

统计表明，创建中国的腕足动物属的第一作者，共有 116 位，中、外学者分别为 92 和 24 位。这些属在创建时的繁简、精粗和规范程度是参差不齐的。如果试图用作者的意志平衡这样的状况，既不切合实际、也无必要。各纪作者在挖掘原始信息、增补新资料后，对命名、异名等问题进行了梳理，做出了判断和处置。

本志书共识别出以下合格（available name）或不合格，有效（valid name）或无效名称，包括异名或同名、同义或非同义的属名关系。需要指出的是，有效名必定是合格的，但合格名不一定有效；凡遇到命名混乱时，最早的合格名称（符合优先率）才是可用的。

（1）异模异名（*synonymum heterotypicum*）或主观异名（*synonymum subjectivum*）系属名不同、模式种亦不同者，只因研究者有不同的意见而导致，所以称主观的或人为的异名。全书共有晚出主观同义名（junior subjective synonym）130 个、可能同义名 20 个，两者占总数的 19.8%。

（2）同模异名（*synonym homotypicum*）或客观异名（*synonymum objectivum*）系属名不同、模式种相同者，共 17 个。

（3）【异物】同名（*homonymum*）系属名相同、模式种不同者，可分为首同名或早出同名（*homonymum senius*，创建属名在前）和次同名或晚出同名（*homonymum junius*，创建属名在后）两种，共 14 个。

（4）疑难名（*nomen dubium*）系已发表的属，创建时证据不足或条件不充分，分类归属难以确定，共 80 个，占总数的 10.6%。

（5）裸记名（*nomen nudum*）系已命名的属，但不符合国际动物命名法所规定的合格发表条件，无描记、未指定模式种等，或没有图片，共 26 个。唯有名（*nomen solum*）也属于此类，发表时只有名称，其他任何条件都不具备。这些属名，因为其发表是不合格的，为命名法所不允许，必定是无效名，得不到优先率的保护。

（6）新名（*nomen novum*）系首次在本志书内发表的，5 个。

（7）禁用名（*nomen vetitum*）系 1930 年后发表的、位于属或亚属级以下的分类名称，共 8 个。

（8）重复名（*nomen duplicum*）系同名属不适当地正式发表了两次，共 9 属。

（9）无用名（*nomen nullum*）系对一属名原始拼缀无意地做出不正确的更改，属于疏忽性错误（如抄写、打字、印刷过程中发生的），不同于妄改名（*nomen vanum*）（系有意地进行不正确改变）。

（10）排除名，在创建时曾归于腕足动物门，本志确证，它们应从本门类中排除掉，共 18 属，包括寒武纪的 16 属，志留纪和泥盆纪的各 1 属。

（11）曾被归入其他门类、后证实宜归于腕足动物，仅 1 属，即 *Heliomedusa* Sun and Hou, 1989（最初被归于腔肠动物门）。

在全部 757 个属中，本志书确立有效属 466 个（含 5 新属），约占总数的 61.6%；主观与客观同义名以及异物同名的属，占总数的 23.9%。该数字与中国三叶虫属的异名和同名记录（Zhou and Zhen, 2008），甚为接近。

从大的分类阶元看，本志书确定次同义名属最多的是长身贝目（175 属中有 83 属，占 47.4%）；石燕目和小嘴贝目（106 和 99 属中，分别有 37 和 33 属，占 34.9%和 33.3%）跟随其后。从地质时期看，寒武纪早期小壳动物中，曾归于腕足类的 18 属中只承认 2 个；二叠纪卡匹敦期和空谷期中的 42 属和 19 属，分别有 17 属和 10 属被确认，次同义名（各占 59.5% 和 47.4%）的比例也是很高的。还有二叠纪吴家坪期（38.5%）、石炭纪杜内期（31.6%）、泥盆纪埃姆斯期（27.9%）和奥陶纪凯迪期（25.5%），次同义名均超过同期属数的 1/4。

上述表明，以往在建属过程中，存在以下问题：1）材料不足；2）内部构造揭示不充分；3）对属的关键特征理解不深；4）重要构造分类意义把握不到位；5）没能与关系最亲近的属比较；6）未能查阅到必要的文献资料；7）未能尊崇现代生物学区分物种、居群和表型（phenotype）的理念等。此外，还出现未能遵守国际动物命名法规的实例。

五、编撰的过程和体会

《中国显生宙腕足动物属志》（英文版）有一个值得记述的编写过程。编撰想法最初是已故金玉玕先生于 1986 年提出的。他邀我协助草拟提纲和参与组织队伍，并于次年向国家自然科学基金委员会申请“编写中国腕足动物属志”项目。该项目批准后，开始分工写作，部分文稿于 1994 年初步完成。然而，对照编写要求，这些初稿离最终付印距离较大。后来，金先生为担任“现代古生物学和地层学开放实验室”主任工作、执行新疆油气地层大项目、建立国际二叠纪年代地层框架及乐平统和长兴阶底界层型而全力以赴，故属志编写被搁置下来。但他的设计和思路受到国内外学者的赞许。

大致同时，由英国古生物学家威廉斯（A. Williams）领衔和组织，诚邀国际相关专家开展《腕足动物论丛》修订版的超大型编撰工作。因为这是全球范围的，中国材料必不可少。金玉玕、侯鸿飞、孙东立和我分别应邀参加部分类群的编写，还分别向其他类群的负责者提供了中国属的文字和图片。现在看来，当时整理的资料只包括 1990 年前发表的，有些属的特征表述得不确切，时空分布资料已显陈旧，甚至还有少量误录的情况。但不管怎样，该论丛搜录了全球约 4800 个属，于世纪之交、分 6 卷先后出版（Kaesler, 1997–2006；Selden, 2007），称得上是价值非凡的历史巨著。但囿于篇幅，《腕足动物论丛》中属的描记过于简单，分类阶元未到种级，讨论注释欠缺，更多信息资料与切面图影未能容纳；同时，这恰恰给本志书的编写留下了较大的增补、完善和提高的空间。

后来，金玉玕先生因重病缠身，不幸于 2006 年过早辞世，令人十分惋惜。为使这项摸清家底的工作能够完成，在中断 10 余年之后，我从 2008 年开始聚焦本志书的编写。

鉴于时过境迁，情况多变，既要考虑原有基础，又要跟上国际步伐，我们须调整计划、充实队伍、启用新生力量、开展新的分工合作；增加新框架下生物地层划分与对比，动物群时空分布与演替，群落生态和生物地理区系等内容；重新统一设计图版；邀请乔丽创建本志书的数据库、黄冰参与整理参考文献。按新的要求，大部分纪的主要作者重新撰写文稿，少部分则在原稿基础上做了很大的修改。

新稿初步完成后，我对各纪、沈树忠和詹仁斌对相关时代文稿分别进行了修改。科学出版社胡晓春编审对各纪文稿前后作了两次编改，提出了详细的意见，于 2016 年春夏之交，将编改稿陆续反馈给作者，再行修改后陆续发还给胡晓春再改。终于在 2017 年下厂付印。若包括前期工作，整部书稿的撰写与编改，前后历时长达 16 年。

从设计、组织、编写到完成，本志保持全书统一是目标确定后最重要、也是最麻烦的一件事。我们前后遇到过许多问题，大的如各纪涵盖的主要内容，系统分类框架，构造名词，各属涉及范围；小的如文献的编法，图版的贴法，插图和图版说明的写法；还有更小的如字符的选定等。其中，不乏事先没有料到和考虑不周的。有人说，当目标确定之后，细节决定成败；也有人说，决定成败的是做好关键环节的工作。这些说法都是对的。编著本志书，对细节的核查，不容小觑。为确保完整统一，我们按照“严格、严密、严谨”的精神，尽可能滴水穿石般地把繁琐细节工作做好。

六、其他

1. 插图

本志各纪共配有插图 446 幅。除产地分布、地层历程等外，绝大多数均展示模式或其他标本的外部形态或内部构造（以系统切面图为主）。每个纪的插图均单独编号、自成系统。志留纪、泥盆纪和中生代的化石多两壳铰合，要花费大量时间和精力做好系统切面、以揭示内部构造。记得上世纪 70 年代初，与我同一办公室的叶松龄为磨制侏罗纪标本，竟把一块 3 mm 厚的玻璃板给磨穿了，印象极深。做模型、绘制切面图、恢复内部构造，成为当时研究的一个基本功。随着技术进步和条件改善，现在的年轻学者采用稀盐酸浸润化石、制作撕片，清晰揭示微细结构，切面亦可永久保存。本志书少数切面图就是重新绘制的。为保持老图原样，多数图面内数字未作更改；但为了简洁美观，删除了过多的切面图、构造变化不大或存有疑问的图。全部切面图都把背壳朝上放置。

2. 文献

参考文献体现了科研活动的历史，是记录科学知识的过程，是对科学家劳动成果的继承、借鉴与尊重，亦是本志书不可或缺的组成部分。中国腕足动物研究到了今天这个阶段，是四五代人共创的结果。全书共引述了近两千篇文献。为方便国际学者，文献用英语表述，直接列于各纪的系统分类之后。所有条目按作者姓氏字母顺序排列；当第一作者相同时，按第二作者排序，以此类推。1950 年前的作者按韦氏音标、以后的用汉语拼音标注，如 Chan（詹）、Ching（金）和 Ting（丁），分别改为 Zhan、Jin 和 Ding。

3. 图版

全书总共附图版 125 帧，分别置于每个纪的最后，而不是集中置于全书的末尾，以方便读者。除寒武纪和白垩纪外，各纪图版以该纪英文词首字母为前缀，单独编号。在同一图版内，不同模式种的模式标本用细实线分开，以便读者查找。背壳一律朝上放置。许多模式种图影从原始文献中拷贝，有不够清晰的，找到标本重新照相；但仍有标本未能找到，无法重照，成一憾事。在 9 个纪中，以二叠纪和泥盆纪的图版数最多（34 帧和 28 帧），侏罗纪和白垩纪的最少（1 帧和 2 帧）。

4. 模式标本

化石标本镌刻着生命演化的痕迹，模式标本更是古生物学研究的重点对象，也是本属志的根基。因此，对模式标本的规范化处理，是古生物学的基本要求。凡本属志承认的和识别为次同义名的属，都无遗漏地被记录编号，并附其模式种的模式标本图影，旨在让读者独立辨识。全书共展示 604 个中国腕足动物属模式种的正模（holotype），还有少数副模（paratype）、地模（topotype）和非模式种的正模。原作者若只标注共模（syntype）的，则为其指定了选模（lectotype），有些还包括副选模（paralectotype）。有些作者专程赴模式标本收藏地拍摄照片，或赴模式产地采集地模标本进行再研究；与国外博物馆联系、寻找中国属模式种标本的下落。有一定数量的模式种及其标本，本次未能再作研究，主要有两个原因，一是模式标本现今的存放地不明，二是受时间或条件限制不能前往模式产地采集新材料进行再研究。

5. 标本存放

全书涉及的模式标本，绝大多数散见于国内数十家单位，个别老标本则保存在英、德、意、日、澳、美等国家。由于客观（如“文化大革命”、机构变化、单位改名）和主观（如管理不慎、人员流动）原因，标本存放状况差别很大，有些单位把大量信息录入数据库，查找简易便捷；有些缺乏规范整理或把标本转给其他单位，查找难度很大；有些因搬家转移，标本积压，石沉大海；有些还在个人手中，前途堪忧。因此，总体上看，标本保存现状不容乐观。做好规范管理是一件大事，但已远远超出本志书力所能及的范围。希望从国家层面上立法，无论是单位还是个人，都宜从长计议，精准地做好模式标本的规范保存与管理。标本是自然和科学遗产，是全人类的宝贵财富，一旦毁坏或丢失，损失难以估量。

七、展望

为更好地发挥中国腕足类化石的价值，强化野外采集，提高研究水平，重视穿越大事件过程厘米级的地层和化石研究，描述新动物群、补充厘定老动物群，尤为重要。以下是我对化石材料处理的一些期许。

1. 野外采集的充分度

在化石采集上应下更大的功夫，以体现化石在生命演化中的价值和中国材料在国际上的重要位置。化石采集量的多少，与该化石点生物多样性密切相关。多样性越高，采集的化石应越多。用定量方法（如 rarefaction）检验所获材料是否充分，值得提倡（黄冰，2012）。探讨大灭绝过程时，采集最大量标本以探究灭绝期间变成稀有、甚至一度消失的属种。研究大辐射事件中的化石也需要这样做，但方法有所不同。

2. 重视居群和群落的研究

以往常规工作中，存在着两种理应避免的做法：一是在化石量不足时仓促建立新属种，二是化石量虽多，却把同地、同层、同类标本鉴定为不同的属种。借鉴现代生物学概念，重视居群个体形态和变异，十分重要。变异是成种的基础和演化的灵魂，没有变异，何谈演化？从这个意义上说，研究群落埋藏和环境恢复，还有很大的提升空间。

3. 寻找和使用新方法

有条件、快捷地使用定量方法和统计软件是一个必然的趋势，但是，方法是为研究服务的，采用现代生物学新方法，旨在对深时生命过程有更深的了解（黄冰等，2013）。对属种及其以上级别进行分支系统分析（cladistic analysis），将能较合理地挖掘化石资料

的科学潜能。

4. 重视标本的清理和整理

对保存在全国各地的化石，尤其是模式标本，需花时间和耐心进行规范整理。那些对分类或演化极为重要的珍稀化石，是可遇而不可求的宝贵财富，它们被发现的机会也许只有一次，一旦化石丢失了，就再也找不回来了。

5. 建好数据库、强化厘定工作

化石多样性的统计，量大而繁琐；建立数据库，十分必要。为此，须先做好顶层设计，尤其要重视对浩瀚资料数据的厘定及其产地层位的再确定和精细化。它们是数据库的基础，若没有厘定或厘定有误，就会让隐匿的错误潜伏进研究的结论中去。

八、致谢与怀念

本志书是一项集体成果，由来自 10 个单位、24 位学者参与完成（名单见后）。在作者群体中，既有老同志（前期工作为主），又有中青年（多参与后期编写）。西安地质矿产研究所的张研老师，曾应金玉玕先生之邀，多次来宁参加晚古生代和中生代各纪的前期编写任务；北京大学马学平老师和中国地质科学院地质研究所的宗普博士为泥盆纪的最终完稿，乔丽为整个数据库的创建与操作及中生代三个纪的后期完稿，黄冰为全书文献的编校，沈树忠和詹仁斌为全书的统编，都付出了精力和辛劳。上述后四位也对本文初稿提出了宝贵意见。

本志书得到国家自然科学基金委[1988–1990 面上项目（金玉玕）；创新群体项目早古生代重大生物事件及其环境背景 41221001, 41521061（詹仁斌）；重大项目古生代重大海洋生物事件及其背景机制 41290260（沈树忠）]，科技部基础性研究专项中国各门类化石系统总结与志书编研 2006FY120400（沙金庚），国家出版基金（2016）及现代古生物学和地层学国家重点实验室的资助。周志炎老师和周忠和老师为本书向国家出版基金规划办公室申请基金给予热情的推荐。

中国科学院南京地质古生物研究所提供研究支撑。科学出版社胡晓春编审在编辑出版的各个阶段，认真细致、一丝不苟。我所马振刚借阅文献和处理杂务；张小萍寻找稀缺、疑难文献；任玉皋清绘插图；袁道俊助借模式标本，均不厌其烦、耐心尽力。我们还得到过张汝玫、邓龙华与栾晓聪、周航行的帮助。对支持我们工作的其他中外学者已在本志书的概论中一一列举，此处恕不赘述。

没有上述老师、同事和同仁的通力合作和帮助，没有相关单位的长期支持，本志书的完成是不可能的。

本志书的出版也与老前辈和同仁的长期工作密不可分。葛利普、赵亚曾、黄汲清、田奇璩、乐森琄、王钰、杨遵仪等诸位先生及杨式溥、陈源仁等老师亲历亲为、教书育人，都为中国腕足动物的研究付出了大量的心血，至今我们仍常常怀念他们。

金玉玕先生是本志书的设计者和前期工作的组织者，为本志编写费尽了心力，十分可惜的是他未能亲眼见到这部志书的最终出版。陈秀琴女士近年来罹患重病，仍十分认真地编写泥盆纪部分，不厌其烦地修改文稿，没想到无情的病魔竟使她的生命定格在本志书的编写之中。借此机会，特向他们表达深切的怀念。

本志书的疏漏、问题和错误在所难免，敬请读者不吝批评指正。

附录

1.《中国显生宙腕足动物属志》（英文版）编著单位及人员

北京大学（马学平、孙元林）
中国地质科学院地质研究所（侯鸿飞、宗　普）
中国地质调查中心西安地质矿产研究所（张　研、傅力浦）、沈阳地质矿产研究所（苏养正）、成都地质矿产研究所（鲜思远）
西北大学（张志飞）
中国地质大学（北京）（徐桂荣、史晓颖）
中国科学院南京地质古生物研究所（其他编著者）
澳大利亚 Deakin 大学（伊丽莎白·韦尔登）（E.A. Weldon）
加拿大 Brandon 大学（李荣玉）

2.《中国显生宙腕足动物属志》（英文版）各纪编撰人员名单

中国显生宙腕足动物的一次系统总结（中文代前言） 戎嘉余
概　论 戎嘉余、沈树忠、詹仁斌、乔　丽、黄　冰、金玉玕
中国寒武纪腕足动物属志 李国祥、张志飞、戎嘉余、刘第墉
中国奥陶纪腕足动物属志 戎嘉余、詹仁斌、黄　冰、许汉奎、傅力浦、李荣玉
中国志留纪腕足动物属志 戎嘉余、黄　冰、詹仁斌、傅力浦
中国泥盆纪腕足动物属志 侯鸿飞、陈秀琴、戎嘉余、马学平、张　研、许汉奎、苏养正、鲜思远、宗　普
中国石炭纪腕足动物属志 沈树忠、乔　丽、张　研、孙元林、金玉玕
中国二叠纪腕足动物属志 沈树忠、金玉玕、张　研、伊丽莎白·韦尔登（E.A. Weldon）
中国三叠纪腕足动物属志 孙东立、徐桂荣、乔　丽
中国侏罗纪腕足动物属志 孙东立、史晓颖、张　研、乔　丽
中国白垩纪腕足动物属志 孙东立、张　研、乔　丽

3.《中国显生宙腕足动物属志》（英文版）各纪所含属数、图版数、插图数及模式标本数

	属数	图版数	插图数	正型数	选型数
概论			18		
中国寒武纪腕足动物属志	32	7	6	16	
中国奥陶纪腕足动物属志	113	18	67	93	12
中国志留纪腕足动物属志	52	10	44	44	3
中国泥盆纪腕足动物属志	180	28	105	148	16
中国石炭纪腕足动物属志	59	13	23	44	5
中国二叠纪腕足动物属志	208	34	54	158	38
中国三叠纪腕足动物属志	88	12	92	77	10
中国侏罗纪腕足动物属志	12	1	20	12	
中国白垩纪腕足动物属志	13	2	17	12	1
总计	757	125	446	604	85

4. 根据中国模式材料创建中国腕足动物属的第一作者名录（括号内为建属数目）

白顺良 (2)	常美丽 (2)	陈秀琴 (1)	陈永明 (4)	陈源仁 (13)
陈中强 (14)	丁培榛 (3)	段承华 (2)	范炳恒 (1)	傅力浦 (26)
郭　文 (1)	韩乃仁 (1)	韩同相 (1)	何廷贵 (1)	何卫红 (2)
何锡林 (6)	侯鸿飞 (15)	侯先光 (1)	胡昌明 (2)	黄汲清 (2)
江宗龙 (5)	蒋志文 (3)	金小赤 (1)	金玉玕 (50)	靳吉锁 (1)
李　莉 (18)	李国祥 (1)	李罗照 (8)	梁定益 (7)	梁文平 (39)
梁演林 (1)	廖卓庭 (17)	刘　发 (4)	刘第墉 (21)	吕彤臣 (1)
马家骏 (3)	马学平 (4)	梅仕龙 (3)	牟崇建 (1)	倪世钊 (1)
彭元桥 (2)	齐文同 (1)	戎嘉余 (28)	单惠珍 (1)	沈树忠 (20)
盛怀斌 (1)	石光荣 (2)	史晓颖 (7)	苏养正 (20)	孙　特 (2)
孙东立 (28)	孙卫国 (1)	孙元林 (3)	谭正修 (3)	田奇璠 (2)
佟正祥 (6)	王　钰 (31)	王　智 (2)	王成文 (4)	王海洲 (1)
王化羽 (1)	王淑敏 (1)	吴　岐 (2)	鲜思远 (25)	熊　斌 (1)
徐桂荣 (26)	许汉奎 (26)	许庆健 (15)	阎国顺 (2)	杨德骊 (16)
杨式溥 (7)	杨学长 (3)	杨遵仪 (18)	姚守民 (1)	姚肇贵 (1)
尹仲科 (1)	岳　昭 (2)	曾　勇 (1)	曾庆銮 (20)	詹立培 (5)
詹仁斌 (19)	张　川 (3)	张　研 (16)	张志飞 (3)	张梓歆 (1)
赵汝旋 (4)	赵亚曾 (2)	中华(陈孟莪) (1)	朱　森 (1)	朱　彤 (1)
朱慈英 (5)	朱湘水 (2)	Baliński A. (2)	Campi M.J. (1)	Copper P. (2)
Frech F. (1)	Fredericks G.N. (1)	Gatinaud G. (6)	Grabau A.W. (25)	Hamada T. (1)
Havlíček V. (1)	Hayasaka I. (1)	Jahnke H. (1)	Kayser E. (1)	Kolarova F.N. (1)
Licharew B.K. (3)	Muir-Wood H.M. (2)	Ozaki K. (2)	Popov L.E. (1)	Racheboeuf P.R. (1)
Reed F.R.C. (1)	Sartenaer P. (3)	Schischkina G.R. (1)	Vogel K. (1)	Waterhouse J.B. (11)
Wirth E. (1)				

以下为参与创建中国腕足动物属或为研究中国腕足类化石做出贡献的其他中外学者名录

陈爱林	陈鹏飞	程金辉	程立人	邸巧玲	丁　惠
丁雅玲	范嘉松	方炳兴	方大卫	方瑞濂	方润森
冯儒林	冯向红	傅英琪	高金汉	古鸿信	谷　峰
关世桥	韩　健	韩立刚	郝维诚	洪祖寅	胡世学
胡世忠	黄　冰	黄沪芳	江能人	江新胜	邝国敦
李贵鹏	李宏英	李荣玉	李汝宁	李社高	李守军
李文国	李文忠	李志宏	李柞文	梁　艳	刘春莲
刘广才	刘清昭	刘渭洲	刘锡兴	刘亚光	柳祖汉
罗惠麟	罗克钰	孟逢源	孟令凯	闵永明	区元任
潘云唐	乔　丽	覃兆松	饶荣标	时　言	苏一保
孙昌谟	孙全英	孙云铸	万正权	王　雪	王德友
王国平	王海峰	王敏成	席与华	薛春汀	杨暹和
姚益民	叶松龄	殷鸿福	俞国华	乐森璔	曾德敏
曾鼎泉	曾书明	张　宁	张风鸣	张康富	张鸣韶
张守信	张以春	张宇波	张志亮	赵泽国	赵治信
钟石兰	周铁民	朱梅丽	朱瑞芳	朱学剑	宗　普
邹定邦	Afanasjeva G.A.	Alekseeva R.E.	Alvarez F.	Archbold N.W.	Bergström J.
Boucot A.J.	Cocks L.R.M.	Day J.	Ghobadi Pour M.	Grant R.E.	Grunt T.A.
Harper D.A.T.	Holmer L.E.	Kebria-Ee Zadeh M.-R.	Manceñido M.O.	Modzalevskaya T.L. 等	

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Introduction

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Contents

It has been one hundred and thirty-three years since the first fossil brachiopod genus: *Leptodus* erected based on a Chinese species: *L. richthofeni* was established by Kayser in 1883. Since then, there have been 757 brachiopod genera named with their type species from China. During the same period, stratigraphical correlation and brachiopod classification have also undergone great changes, all of which have prompted the radical revision of all the brachiopod genera of China presented in this book. Thus, we revise all the brachiopod genera based on the type species and type localities from China. The Chinese genera are treated as valid taxa or various synonyms, homonyms, *nomina dubia*, *nomina nuda*, *nomina nulla*, *nomina veta* or others. In addition, 18 genera are excluded from Brachiopoda.

This work began with a project from the Natural Science Foundation of China (NSFC) in 1988 that was led by late Professor Jin Yugan. Preliminary revision on

some 400 genera was carried out in which related basic data were sent to individual authors of many major brachiopod groups for the new edition of the *Treatise on Invertebrate Paleontology*, *Part H*, *Brachiopoda*. The latter was led by Sir Alwyn Williams, and was published in six volumes between 1997 and 2007. Some of the authors of this book (Hou H.F., Jin Y.G., Rong J.Y. and Sun D.L.) were invited to participate in the fundamental and comprehensive work, which enhanced our expertise and also afforded us with a substantial amount of new data.

Our revision on the Chinese brachiopod genera was interrupted between 1995 and 2007. The main reason for that pause is that there were two major successive research projects respectively on 'The origin, radiation, extinction and recovery of biota' (led by Rong J.Y. from 2000 to 2005) and 'Biodiversity changes through geological time' (by Shen S. Z. from 2006 to 2011), both sponsored by the Ministry of Science and Technology of the People's Republic of China, which absorbed significant resources from us and thus the present work was deferred.

Since 2008, however, we have again been able to focus on this work, which was organised and coordinated by the senior author (Rong J.Y.), who has been responsible for merging all the contributions. A fruitful combination of the older generation of brachiopod workers and also younger experts were invited to join our team, and a substantial amount of new data has been identified and included here. In the middle of 2016, this work was finally accomplished after almost nine years of extensive arduous work and has presented a golden opportunity for a fine investigation of the Chinese brachiopod genera with precise designations that have never been achieved previously. A thorough survey of the occurrences of fossil brachiopods has made it possible to deliver an overall view on these genera and related faunas of all ages in many regions of China.

This book deals with 757 generic names which are based on type specimens from China. It provides a substantial amount of new/revised information about their diagnosed characters, their temporal and spatial distributions, and all the holotype and/or paratypes (if any) of the type species restudied and/or re-illustrated (if possible). A few neotypes are designated and some type specimens are illustrated for the first time. Some genera, including these previously frequently cited in Chinese literature (e.g., the Devonian *Cyrtospirifer* Nalivkin *in* Fredericks, 1924, *Rostrospirifer* Grabau, 1931 and *Tenticospirifer* Tien, 1938), or those established by Chinese scholars (e.g., the Ordovician *Paromalomena* Rong, 1984, the Triassic *Tulungospirifer* Jin and Sun *in* Jin *et al*., 1976, and the Jurassic *Obsoletirhynchia* Shi, 1992), or named for Chinese scholars (such as the Lower Permian genus *Liufaia* Waterhouse, 2004, in honour of the late Professor Liu Fa), or critically revised on Chinese material (e.g., *Planovatirostrum* Sartenaer, 1970; see Sartenaer and Xu, 1989), are not included here because their type species were derived from outside China.

As well as this introduction, there are separate sections for each geological period, Cambrian, Ordovician, Silurian, Devonian, Carboniferous, Permian, Triassic, Jurassic, and Cretaceous. Each period includes a review of geographical distribution, stratigraphical correlation, faunal succession, palaeobiogeography, and systematic palaeontology of brachiopods. The systematic part of this book includes the type species, etymology, diagnosis, comparison (or discussion), species assigned and rejected, and the stratigraphical range and geographical distribution.

This book aims at putting together all the available information on Chinese brachiopod genera which has hitherto been distributed in a heterogeneous spectrum of publications, such as palaeontological atlases, journals, proceedings, monographs, and others. Many atlases were published in Chinese, although with an English abstract, and are difficult for foreigners to peruse. Many came out in various journals within China which were printed by local presses and are poorly represented in international libraries and have thus proved inconvenient for *non*-Chinese researchers to access. In addition, despite some atlases having a short English summary, many of the original genera and species were inadequately presented within them, and it has often proved difficult to properly understand the generic concepts used by the original authors. Furthermore, the rules of nomenclature required by the *International Code of Zoological Nomenclature* (ICZN, 4th Edition) were not always strictly obeyed, and they are followed herein. We anticipate that this book should greatly facilitate evaluation of the existing genera for researchers in China and elsewhere who are interested in fossil brachiopods and can thus be able to access the Chinese data with ease from now on.

I. Historical review

Fossil brachiopods have been traditionally popular medi-

cal material and have thus been well known for ages in China. Their earliest record in Chinese essays dates back to the 7th Century as indicated by a collection of annotations on 'shiyan' (Chinese Pinyin for 'stony swallows' in English, and mostly Devonian spiriferides) by Lee Shihchen (now Li Shizhen), one of the most famous physicians and pharmacologists in the history of China in his classic work on Chinese medicinal materials in the 16th Century. He recorded that 'Li Zhi (7th Century) said that many shiyans occur in Linlin, Hunan. Gun (9th Century) stated that they are small, clam-like, heavy-like stone, found from a low hill twelve li (about 6 km) north-west of Qiyang, Hunan. Local people said that shiyan comes out of the rock pits after raining, but what they told is not true that shiyan drops down with rain. It is impossible for them to fly out as they have no wings.' Based on his own observation, Li Shizhen pointed out that 'two things are both called shiyan, one is stony, swallow-shaped and striated, and another refers to swallows nesting in the cavern with stalactites ...' However, no further discussion was given on their true origin as he was mainly interested in the medical effects of these enigmatic 'pebbles' rather than their scientific origins. As part of modern science, taxonomic study on fossil brachiopods of China was first conducted by de Koninck (1846). The studies on Chinese fossil brachiopods may be divided into four stages.

1. The first stage (1846–1923)

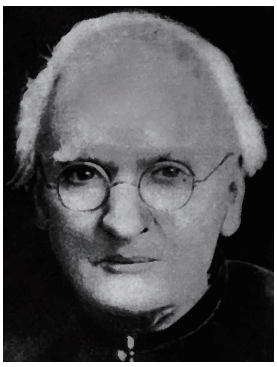
This was a pioneering period when foreign specialists published their monographs and papers on Chinese brachiopods ranging from Cambrian to Eocene in age. A majority of them were collected by various exploration teams from numerous localities, while some of the fossils were purchased from Chinese drug stores.

Fossil brachiopods from China were first described by de Koninck (1846) with two new species *Terebratula yunnanensis* and *Spirifer cheehiel* which are the two earliest known invertebrate fossil species in China, by Strachey (1851) with *Productus*, *Spirifer*, ?*Chonetes* and *Terebratula* possibly from the Carboniferous of Xizang (Tibet) and Davidson (1853) with *Crania*, *Productus*, *Spirifer* and *Cyrtia* from the Devonian of South China. Since then, more works include Cambrian brachiopods from eastern Liaoning, Silurian ones from northern Sichuan, and Permian ones (such as *Leptodus* Kayser, 1883, a widely-distributed genus in Permian and the first genus established with a type species of China) from northern Jiangxi, collected by von Richthofen in 1870s and described by Kayser (1883, 1884) and Frech (1901); Palaeozoic brachiopods from Sichuan collected and documented by von Loczy (1894); Carboniferous brachiopods from northeastern Xinjiang found by Klementz and described by Tschernyschew (1893), and from western Xinjiang collected by Merzbacher and systematically studied by Gröber (1908) and Krenkel (1913); a number of Permian brachiopod genera from the Himalaya, southern Xizang collected by Krafft and published by Diener (1897, 1903); Silurian and Devonian brachiopods from Shaanxi recorded by Martelli (1901, 1902) and Pellizari (1913); Cambrian, Ordovician and Upper Palaeozoic brachiopods from North China collected by Willis and Blackwelder and described by Walcott (1906–1914), Weller (1906) and Girty (1913) respectively; Cambrian, Devonian and Carboniferous brachiopods from eastern Yunnan collected by Deprat and reported by Mansuy (1912–1916); and Palaeozoic brachiopods from Northeast and South China reported by Hayasaka (1917) and Yabe and Hayasaka (1920). To sum up, 62 well-known European or North American genera (e.g., *Productus* and *Spirifer*) were recorded in China, but only three genera (*Leptodus* Kayser, 1883; *Loczyella* Frech, 1901; and *Athyrisina* Hayasaka, 1922) were established based on type specimens and species of China.

2. The second stage (1924–1950)

No Chinese palaeontologists published any papers on fossil brachiopods until Sun Y.C. (Sun Y.Z.) (1924) reported six genera from the Cambrian of Shandong Province. Subsequently, abundant Palaeozoic brachiopod fossils from South and North China attracted much attention from Chinese scholars, in particular Chao Y.T. (Zhao Y.Z) (1927, 1928, 1929) (Text-fig. 1), Chu S. (Zhu S.) (1933) and Huang T.K. (Huang J.Q.) (1932, 1933) completed a series of monographic works on Devonian, Carboniferous and Permian brachiopods. Tien C.C. (Tian Q.J.) (1938) published a comprehensive study on Devonian brachiopods of Hunan. Most of the collections he studied were collected by Ting W.K. (Ding W.J.) during his expeditions in Southwest China between 1914 and 1917. In addition, Lower Palaeozoic brachiopods from Guizhou and Hubei were studied by Chang M.S. (Zhang M.S.) (1934) and from western Yunnan by Yin T.S. (Yin Z.X.) (1937). It should be noted that the study on Chinese brachiopod fossils was substantially disturbed by the Japanese military invasion in 1931–1945. Not only were the basic researches seriously

Text-fig. 1. Prof. Chao Yatseng (Zhao Y.Z. 1898–1929). He was killed by bandits at Zhaxinchang, Zhaotong City, northeastern Yunnan Province during his field work in November, 1929.



Text-fig. 2. Prof. A.W. Grabau (1870–1946).

interrupted, but also some preliminary results were destroyed. For example, the manuscripts dealing with the Carboniferous brachiopod fossils collected by Ting and described by Grabau and Tien were unfortunately lost by the publisher during this time interval; consequently, such genera as *Neoproductella* in their manuscripts became a *nomen nudum*.

Grabau A.W., an American who had a job as professor in Peking University, was a most respected supervisor for earlier Chinese geological and palaeontological students, and made substantial contributions to both education and research on the Palaeozoic brachiopods of China (Text-fig. 2). He was very productive, including professional monographs on the Ordovician brachiopods of North China in 1922, the Silurian brachiopods of South China in 1925–1926, the Permian brachiopods of Inner Mongolia in 1931a and the Devonian brachiopods of China in 1931–1933, an introduction to selected brachiopod genera in 1931 and 1932, and the Lower Permian brachiopods, bivalves and gastropods of Guangxi and Guizhou in 1934 and 1936. These important contributions represent earlier milestones of the investigation of the Palaeozoic brachiopods of China in which there are many common genera established based on the type species of China.

Brachiopods from areas other than South and North China were recorded by the following scientists. For example, some Devonian brachiopods from eastern Yunnan and Carboniferous and Jurassic ones from western Yunnan (Reed, 1925, 1927), some Cambrian, Carboniferous and Permian ones from the Karakorum Mountains (de Terra H., 1932; Gortani and Melar, 1934), and some Carboniferous and Permian brachiopods from northeastern Xijiang (Yang, 1948). In addition, Japanese scholars described brachiopods from the Cambrian and Ordovician of Liaoning (Kobayashi, 1931, 1934, 1936; Endo, 1932, 1935, 1939; Endo and Resser, 1937; Yabe and Sugiyama, 1942a, b), the Lower Devonian of Heilongjiang, the Carboniferous of Hunan and the Permian of North China (Ozaki, 1931, 1939) and Jilin (Minato, 1943a, b), and the Cenozoic of Taiwan (Hayasaka, 1938, 1943, 1946).

3. The third stage (1951–1990)

After 1950, owing to a rapid development of the new economic construction in China, it was urgent to carry out geological mapping on a large scale in many provinces. As brachiopod fossils in field are usually the most common marine invertebrates in Palaeozoic rocks, a huge number of fossil specimens were collected by regional geological teams to help decipher the stratigraphy. Many institutes, like the Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences (CAS), Institute of Geology, Chinese Academy of Geological Sciences (CAGS), and Institutes of Geology and Mineral Resources in Chengdu, Nanjing, Shenyang, Xi'an, Yichang and elsewhere, were asked to identify the fossils and to send stratigraphical reports to those regional geological surveys. Having recognised new provinciality within Chinese brachiopods, a number of new taxa chiefly from the Ordovician and Silurian (Wang, 1955, 1956; Wang and Xu, 1966), Devonian (Wang, 1956; Yoh, 1957; Hou, 1959, 1963, 1965; Hou and Xian, 1964; Hou and Xu, 1964), Carboniferous (Yang, 1959, 1964; Jin, 1961; Hou, 1965), Permian (Zhang and Jin, 1961; Zhan and Li, 1962; Jin, 1963), and Triassic rocks (Yang *et al*., 1962; Yang and Xu, 1966) were established in various regions of China. Meanwhile, the Carboniferous, Permian and Triassic brachiopods were described based on the material from Kunlun (Ustritsky *et al*., 1960) and Qilian Mountains (Yang *et al*., 1962), West China.

Two senior professors, Wang Yu (Text-fig. 3) and Yang Zunyi (Text-fig. 4) agreed with their American colleague, G.A. Cooper, that China was a virgin kingdom for brachiopod fossils with many potential new genera. That further encouraged younger Chinese colleagues to follow. After 1959, Profs. Wang and Yang organised workshops to educate young scientists or teachers and make them enthusiastic about brachiopods. Wang *et al*. (1964) compiled two comprehensive synopsis volumes of '*Brachiopod Fossils of China*' in Chinese, which reported 119 references before 1960, and a total of 1427 species and 253 genera, amongst which 42 new genera had been established on Chinese material (type specimens and type species). Subsequently, the textbook '*Brachiopod Fossils*' in Chinese, containing 471 genera (both endemic to China and common in the world) was compiled by Wang *et al*. (1966). Those publications provided a new generation with essential information concerning brachiopods and inspired a nation-wide geological survey lasting for about three decades (1960–1990). As a result, very large quantities of brachiopod fossils from rocks of various ages and regions of China were obtained, but a few of them had been published before the 'Cultural Revolution' of China (1966–1976).

The 'Cultural Revolution' lasted for a decade, and was a severe disturbance, since palaeontological and stratigraphical studies were almost stopped in China. Nevertheless, since the mid-1970s, there was a burst of new genera mostly in Chinese regional palaeontological atlases. The first of them was published by the Nanjing Institute of Geology and Palaeontology, CAS with the data from Cambrian (Rong, 1974), Ordovician (Xu *et al.*, 1974), Silurian (Rong *et al*., 1974), Devonian (Wang *et al*., 1974), Carboniferous (Jin and Liao, 1974), Permian (Jin *et al*., 1974), and Triassic (Liao and Sun, 1974). Then palaeontological atlases came out from many provincial geological units, including Yunnan (Fang and Zhu, 1974), Inner Mongolia (Su, 1976; Li and Gu, 1976), Central-south China (Zeng, 1977; Yang *et al*., 1977), Guizhou (Xian and Jiang, 1978; Feng and Jiang, 1978), Sichuan (Xu *et al*., 1978; Xu, 1978; Tong, 1978), Northwest China (Jin *et al*., 1979; Zhang and Zhang, 1981; Fu, 1982; Zhang *et al*., 1983; Zhang and Fu, 1983; Ding and Qi, 1983), Northeast China (Su, 1980; Li *et al*., 1980), Xizang (Jin and Sun, 1981; Sun, 1981), East China (Wang *et al*., 1982; Liu *et al*., 1983), Hunan (Liu *et al*., 1982), Hubei (Wang, 1984) and North China (Li and Duan, 1985). There were more than 50 palaeontologists who were involved to work on these major tasks.

Text-fig. 3. Prof. Wang Yu (1907–1984).

Text-fig. 4. Prof. Yang Zunyi (1908–2009).

Meanwhile, a number of papers and monographs dealing with brachiopods of various periods of Palaeozoic and Mesozoic were also published.

For example, there were many on the Cambrian (Liu D.Y., 1979, 1987), Ordovician (Rong, 1979, 1984; Chang, 1981, 1983; Zeng, 1983, 1986; Xu and Liu, 1984) and Silurian brachiopods (Fu *in* Li *et al*., 1975; Rong and Yang, 1978, 1980, 1981; Wang *et al*., 1980; Yang and Rong, 1982; Jones and Rong, 1982; Jiang, 1989) from Southwest China; the Ordovician and/or Silurian brachiopods of western Hubei (Zeng, 1987), western Qinling (Fu, 1982, 1984; Rong *et al*., 1987), Ningxia (Fu, 1985), the Greater and Lesser Hinggan Mountains, Heilongjiang (Su, 1981; Zhu, 1982, 1985; Liu *et al*., 1985), Altay, Kunlun and Altun Mountains, Xinjiang (Rong and Zhang, 1982, 1988; Zhang *et al.*, 1983; Liu *et al*., 1984), and Inner Mongolia (Rong *et al*., 1985; Su *et al*., 1985).

There occurred a large number of papers dealing with the Upper Palaeozoic brachiopods, including 1) the Devonian brachiopods of Guangxi and Guizhou (Hou and Xian, 1975; Xu, 1977, 1979; Wang and Zhu, 1979; Wan, 1980; Wang *et al*., 1981, 1983; Chen X.Q., 1983; Xu and Yao, 1984, 1986; Wang and Rong, 1986; Jin, 1988; Chen *et al.*, 1989; Chen, 1990; Xian, 1990), Hubei (Yang, 1984), Sichuan (Chen Y.R., 1979, 1983, 1984;

Tong, 1982; Hou, 1988), western Qinling (Fu, 1983; Zhang, 1983, 1985, 1987; Zhang and Fu, 1983; Rong *et al*., 1987), Inner Mongolia (Zhang, 1981, 1985), Liaoning (Liu F., 1987), Jiling (Liu, 1988), and Xizang (Copper and Hou, 1986); 2) the Carboniferous brachiopods of Guizhou (Yang, 1978; Liao, 1979; Yin, 1981), Hunan (Shan and Zhao, 1981), Yunnan (Jin and Fang, 1983), Sichuan (Tong, 1986), Anhui (Liao and Qi, 1989), Xizang (Yang and Zhang, 1982; Yang and Fan, 1983; Hu, 1985; Jin *et al*., 1985; Liu and Wang, 1990), and Xinjiang (Ding and Yao, 1985; Zhan and Wu, 1987); 3) the Permian fossils of South China (Jin and Hu, 1978; Zhan, 1979; Zhan and Li, 1979; He and Zhu, 1979, 1985; Liao, 1979, 1980, 1983, 1984, 1987; Zhao, 1984; Hu, 1985; Jin and Fang, 1985; Xu and Xie, 1985; Li *et al*., 1987; Chang, 1987; Mou and Liu, 1989; Liang, 1990; Zhu, 1990), Xizang (Jin, 1979; Zhan and Li, 1982), Xinjiang (Zhan and Li, 1987), and Inner Mongolia (Duan and Li, 1985).

The Mesozoic and Cenozoic brachiopods of West China were described from the Mts. Qomolangma and Hengduan regions (Jin *et al.*, 1976; Zhang and Jin, 1976; Jin and Fang, 1977; Sun, 1981; Sun and Ye, 1982; Ye and Yang, 1979; Li and Gu, 1982; Yang *et al.*, 1983; Hou and Wang, 1984; Sun, 1986, 1990; Shi, 1987; Sun and Li, 1990). Some monographs on the Ordovician to Palaeocene brachiopods of the Qinghai-Xizang Plateau were published (Liu, 1976; Zhang and Jin, 1976; Jin *et al.*, 1976; Jin and Sun, 1981; Yang and Zhang, 1985; Zhan and Wu, 1982, 1987). Late Palaeozoic and Triassic brachiopods were reported from east of Qinghai-Xizang Plateau (Jin *et al*., 1985), and the Carboniferous, Permian and Triassic brachiopods were from southern Qilian Mountains (Xu and Liu, 1985) mostly in Chinese. Moreover, it is remarkable that Cenozoic brachiopod fossils were systematically described by Fong (1987, 1989) from the Maanshan Mudstone and the Szekou Formation on the Hengchun Peninsula of Taiwan.

A great number of brachiopodologists gathered in the First and Second National Brachiopod Symposia in Hangzhou in 1980 and in Kunming in 1985 respectively (Text-figs 5 and 6). Many presentations, which were delayed by the 'Cultural Revolution', were warmly given in the meetings.

4. The fourth stage (1991 to the present)

Before 1990, investigations on Chinese brachiopods were mostly devoted to taxonomy and to the resolution of stratigraphical problems, but rarely to palaeoecology and palaeobiogeography. Later on, a great number of researchers of the old generation retired or nearly retired and the number of younger scholars also decreased synchronously compared with the 1980's. It was difficult to get ample funds to undertake study both in field and lab in the 1990's, and there were more urgent projects related to mining and oil and gas exploration, particularly in western China, such as Xinjiang, which involved many of us. Since 2000, a new generation has played a vital role, and the situation improved as more funds for basic scientific research were granted by national units, such as CAS, Natural Science Foundation of China (NSFC), and the Ministry of Science and Technology of the People's Republic of China.

Many new contributions are documented in the Lower Palaeozoic section. Jin *et al*. (1991, 1993) and Jin and

Text-fig. 5. Showing nearly 100 participants attending the First National Brachiopod Symposium held in Hangzhou City, Zhejiang Province in the autumn of 1980.

Text-fig. 6. Showing 50 participants in the Second National Brachiopod Symposium held in Kunming City, Yunnan Province in the spring of 1985.

Wang (1992) studied soft-bodied brachiopods in the Early Cambrian Chengjiang Biota and provided information on internal organs of the brachiopods for the first time. Subsequently, Zhang *et al*. (2003, 2004, 2006, 2007, 2009, 2010, 2011 and 2014) revised many genera with phosphatic shells representing six superfamilies, four classes and two subphyla. Besides, other Cambrian brachiopods were described from Hebei (Mei, 1993), southern Shaanxi (Li and Holmer, 2004), eastern Guizhou (Huang *et al*., 1994; Peng *et al*., 2011), and western Guangxi (Zhan *et al*., 2010). These investigations greatly expanded our knowledge of the Cambrian brachiopods of China, in particular for the origin and early evolution of the brachiopods in the light of the work by Zhang's team.

An Early Ordovician linguloid brachiopod with a three-dimentional, pyritised pedicle was discovered from western Hubei (Baliński and Sun, 2013). Brachiopods of the Dapingian and mostly Darriwilian rocks (Middle Ordovician) were probed from the Yangtze Region (Rong *et al*., 2005; Zhan *et al*., 2010), Karakorum-Kunlun (Xu and Sun, 1998), northern Yunnan (Indo-China Region) (Xu, 2012), western Yunnan (Sibumasu terrane) (Zhan *et al*., 2007; Xu, 2013), and southern Xizang (Lhasa Region) (Zhan *et al*., 2014). The Late Ordovician Sandbian-Katian deeper water *Foliomena* fauna was documented in many regions of China (Rong *et al*., 1994, 1999; Zhan *et al*., 2010, 2014; Zhan and Jin, 2014) and the late Katian shallower water *Altaethyrella* fauna from East China (Zhan and Rong, 1995; Zhan and Cocks, 1998; Li and Zhan, 1998; Zhan and Li, 1998; Xu and Li, 2002). Following the end-Ordovician mass extinction, the late Hirnantian (latest Ordovician) to early Rhuddanian (earliest Silurian) *Cathaysiorthis* fauna in South China were investigated and systematically studied (Zeng and Hu, 1997; Rong and Zhan, 2006; Rong *et al*., 2008, 2013; Huang, 2008; Huang *et al*., 2012, 2013; Huang and Harper, 2013). The latter enabled a much improved understanding of the turnover of Ordovician and Silurian brachiopod faunas. Moreover, some works and revisions of the Llandovery brachiopods from South China were made (Jiang, 1991; Rong *et al*., 2005, 2007; Jin *et al*., 2006; Zeng *et al*., 2015) and the Ludlow *Retziella* fauna in many regions of Asia and Australia were recognised based on the restudy of the genera *Molongia*, *Protathyrisina*, *Retziella* and others (Rong *et al*., 1994, 1995).

In the Upper Palaeozoic, the Devonian brachiopods were investigated for South China (Ma, 1993, 1995, 2009; Copper and Chen, 1995; Sun and Bai, 1995; Sartenaer, 1995; Chen, 1998; Chen and Yao, 1999; Sun and Boucot, 1999; Chen *et al*., 2001; Chen and Archbold, 2002; Chen X.Q., 2004; Chen and Boucot, 2004; Ma *et al*., 2006; Chen and Qiao, 2008; Guo *et al*., 2015), Karakorum (Sun and Chen, 1998; Xu, 1999), Tianshan (Chen and Xu, 2000; Chen and Liao, 2006), and Junggar regions, Xinjiang (Xu, 1999; Chen X.Q. *et al*., 2002; Zong and Ma, 2012; Zong *et al*., 2012), along with Hinggan region, Heilongjiang (Su and Hou, 1993). In particular, the spiriferides including cyrtospiriferids were revised in a great detail on the Late Devonian material of Hunan and Guizhou, South China (Hou *et al*., 1996; Ma and Day, 1999, 2000, 2003, 2007; Ma *et al*., 2002, 2003, 2006, 2009).

The Carboniferous brachiopod faunas and successions were researched in more detail in Xizang and Xinjiang, West China (Liu, 1991; Chen and Sun, 2000; Chen and Archbold, 2000; Chen and Shi, 2000, 2001, 2003; Chen *et al*., 2003; Chen Z.Q., 2004; Zhan L.P. *et al*., 2007), North China (Liu, 1992) and South China (Ding *et al*., 1991; Sun

et al., 2004; Baliński and Sun, 2005, 2008; Shi *et al*., 2005; Liao and Zhang, 2006; Qiao and Shen, 2012).

A large number of Permian brachiopods were described from Xizang and western Yunnan (Liu, 1991; Shen *et al*., 2000, 2001, 2002, 2003; Shi and Shen, 2001; Shi *et al*., 2002; Xu *et al*., 2005; Zhan L.P. *et al*., 2007). Systematic work on Permian brachiopods were presented mostly from South China (Yang, 1991; Shen *et al*., 1992; Xu and Grant, 1994; He X.L. *et al*., 1995; Zeng *et al*., 1995; Alvarez and Rong, 1995; Shen and Shi, 1999, 2007; Shen and Archbold, 2000; He W.H. *et al*., 2005, 2009, 2014; Shen and Zhang, 2008; Chen *et al*., 2009; Li *et al*., 2012; Zhang Y. *et al*., 2013, 2014, 2015), North China (Fan and He, 1999) and Northwest China (Chen Z.Q., 2004a).

The Mesozoic brachiopods of China are fewer than those from earlier rocks, chiefly because their outcrops are limited. A few papers on Chinese Triassic brachiopods (mainly Early Triassic) were published (e.g., Chen Z.Q. *et al*., 2002; He *et al*., 2006, 2015; Zeng, 2006; Peng and Shi, 2008). Monographic works on Mesozoic brachiopods of West China were completed by Shi (1991) and Shi and Grant (1993). The Jurassic brachiopods of West China were further studied by Shi (1990, 1992), Shi and Yang (1990, 1992), Yang and Shi (1990, 1994), and Sun and Zhang (1998), with some new genera established.

No new brachiopod genera have been erected from Cretaceous, Palaeogene, Neogene and Quaternary rocks of China in this stage.

It is noted that an important event for the world brachiopodologists, i.e. the 7th International Brachiopod Congress with a theme "The Brachiopod World" was held in Nanjing, Jiangsu in May, 2015 (Text-fig. 7). Our long-cherished dream of Chinese brachiopod experts was finally realised.

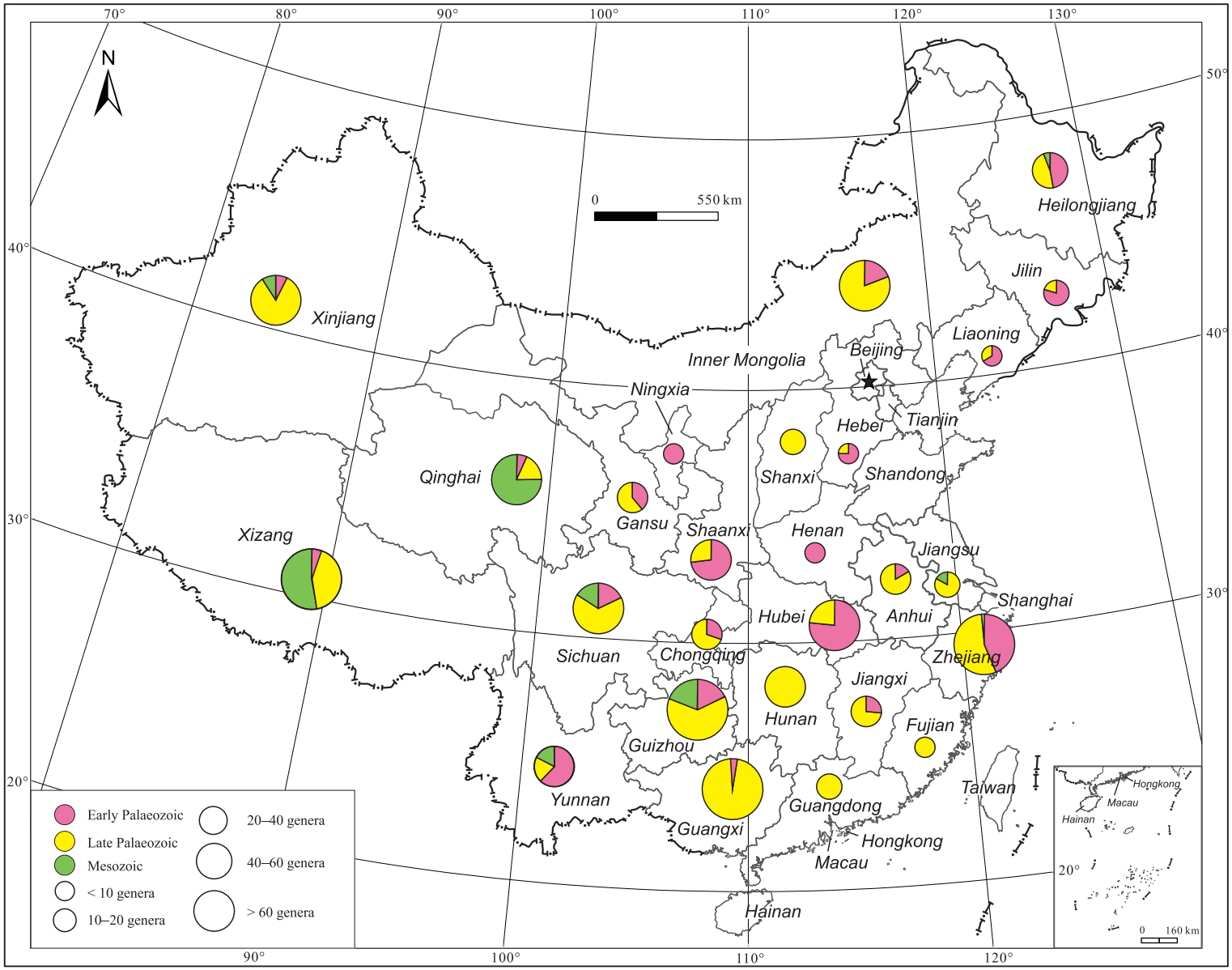
II. General features

Brachiopods in recent marine environments of China are represented only by a few taxa related to the genus *Lingula* along the shores of Liaoning, Shandong, Taiwan and Hongkong. However, brachiopods are abundant particularly in the Palaeozoic and Triassic rocks of many regions, in the Jurassic and Cretaceous rocks mostly of West China, and rarely in the Cenozoic strata of Taiwan (Text-fig. 8). They are of importance in studing brachiopod phylogeny, macroevolution, biostratigraphy, palaeoecology, palaeobiogeography, and geochemical proxies and their environmental implications.

Many of the brachiopod genera of China are quite distinctive or peculiar; some of them are very large, specialized, and even bizarre. A great majority of these genera are endemic with a short geological range and a limited geographical distribution. Some examples are shown in Text-fig. 9.

Based on the data in this book, among the various periods, the Ordovician has the most numerous orders (13), indicating a major signal of the Great Ordovician Biodiversification of brachiopods in China, whereas the Jurassic and Cretaceous have the fewest (only two respectively) (Text-fig. 10A). Within the nine periods, the Permian has the most genera established on the type species of China (208), followed by the Devonian (180) and Ordovician (113) respectively; whereas the Cretaceous

Text-fig. 7. Showing many participants attending the 7th International Brachiopod Congress which was held in Nanjing, Jiangsu Province in May, 2015.



Text-fig. 8. The numbers of Chinese brachiopod genera in various provinces.