

# 论志留纪王冠虫 *Coronocephalus* *Grabau*\*

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## 一、前 言

本文以简单的统计方法对属于王冠虫类的 34 种进行对比,结果表明,至少可以识别两个组合,第一组合称王冠虫亚属组合,第二组合称王冠盾壳虫亚属组合。其中 *Senticucullus* Xia, 1974, *Coronocephalus (Coronocephalina)* Wu, 1979 和 *Coronocephalus* Grabau, 1924, 3 属或亚属是同物异名,前两名应予废弃。本文新建一亚属 *Coronocephalus (Coronaspis)* Subgen. nov. (王冠盾壳虫),模式种为 *Coronocephalus changningensis*。这一亚属地质历程较长,在王冠虫亚属的种发生之前就已出现,并可延续到秀山“期”之后。

## 二、研究简史

在志留纪兰多维列世特列奇期,我国扬子地台的浅海海域,有一种具瘤刺、形态美观的三叶虫,它与腕足类等其它具壳的底栖生物,“统治”着这个海区的底域。由于这一三叶虫头部活动颊的边缘上发育有密集的瘤点,状似王冠,于是该类化石的第一批标本被发现时,就被 Grabau (1924) 命名为 *Encrinurus (Coronocephalus) rex*。最先发现该种标本的是刘季辰、谢家荣 (C. C. Lin 和 C. Y. Hsieh), 标本产于湖北阳新富池口镇去枫杨古道旁的富池页岩内。可惜当时葛利普没有描述,也没有留下图影,仅有一个可能包含彗星虫及王冠虫的综合素描图 (Grabau, 1924, p. 438, fig. 297)。在 Grabau (1925) 后来的著作中论及湖北的志留系时,也曾提及 *Encrinurus (Coronocephalus) rex* 一名,但仍然没有该种的描述和模式标本的图影。直到 1938 年,王钰在南京龙潭当时称高家边页岩上部(现称坟头组)发现一枚符合葛利普命名特征的完整标本,借此对该种进行补充描述,才使此种有了完整的概念。因当年葛利普研究的标本已告遗失,王钰 (1938, p. 9—30, pl. 1, fig. 1a—f) 重新选定上述南京龙潭的完整个体为新模标本 (neotype), 这就为我们识别 *rex* 种有了标准和依据。该标本一直完好地保存在南京地质古生物研究所的陈列厅内。应该指出,王钰 (1938) 描述 *rex* 种时,图示了两个较完整的标本,一枚是被他指定为新模的标本,产于南京龙潭的坟头组。另一枚是产于贵州铲山以东翁项的翁项群上部。贵州铲山翁项的标本是一个外模,当年王钰以此补充龙潭标本的不足,用以说明 *rex* 有两个很长的颊刺。但是,这两个标本有很大的差别,特别是龙潭的标本前头鞍叶为扁圆或横椭圆形,翁项的标本前头鞍叶相对圆凸;龙潭标本的尾部肋节末端尖

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(Wang Y., 1938, p. 28), 而翁项标本的尾肋节末端近似方钝形。鉴于这种差别, 翁项的标本最近被张文堂定为 *rex* 的新亚种 *Coronocephalus rex lushanensis* (Zhang, 1983, p. 229, pl. 6, figs. 4,5)。

本文选用了一些产自湖北省阳新县富池口的标本图象(图版 I, 图 1—10; 图版 II, 图 7—9)。它们是否就完全符合当年葛利普所定名的 *rex*, 无法肯定。但它们和王钰指定的那枚龙潭新模标本构造特征基本一致。

### 三、分类问题

相近 *Coronocephalus rex* Grabau 的种甚多, 仔细比较它们的特征, 可以发现, 有些种和 *rex* 种的新模接近, 如 *Coronocephalus ovatus*, *C. dentatus*; 另一些则和王钰描述的翁项的标本接近, 如 *C. qianjiangensis*。如前所述, 这类标本有的已被张文堂归于 *C. rex lushanensis* 和 *C. rex qianjiangensis*。过去比较王冠虫和其它彗星虫属的差别时, “王冠虫”的鉴别特征是建立在上述王钰描述的两个标本的综合基础上的, 有时甚至偏重于考虑翁项的标本形态(伍鸿基, 1979, 139 页)。本文认为, 王冠虫属应以王钰指定为 *rex* 新模、产自龙潭坟头组的标本作为有关种的对比标准。这样, 真正的王冠虫属的特征范围就相对地缩小了。原来 *rex* 的头鞍前叶特征定义从平凸到突起, 现在应限制在平凸特征上 (Wang Y., 1938, p.24); 原来 *rex* 尾肋节末端可包括圆钝, 无刺者(如翁项标本), 现在应修正为尾部肋节末端只限于尖锐者 (Wang Y., 1938, p. 28)。

如果按这一原则在对 *rex* 作出修正之后, 王冠虫属的特征就与 *Senticucullus* 和 *Coronocephalus (Coronocephalina)* 接近了。

但是有的种仍难于确定归属。如笔者创立的 *Coronocephalus granulatus* Wu 1979, 是建立在两个头盖标本的基础上(伍鸿基, 1979, 138 页, 图版 II, 图 2, 3), 笔者在创立此种时强调的是它的头鞍突起, 瘤点多而密集, 排列方式有异于王冠虫其它的种。后来, 经张文堂重新研究, 认为该种是王冠虫 *rex* 的一个亚种 (Zhang, 1983, p. 224)。但是 *granulatus* 属于 *Coronocephalus*, 且和 *rex* 相当接近是没有疑问的。另一方面, 笔者归于 *Coronocephalus (Coronocephalina)* 的 *C. (C.) orientalis*, 建立时仅以两个尾部和活动颊的标本为依据, 强调其活动颊边缘宽大, 边缘瘤点近似齿形(伍鸿基, 1979, 140 页, 图版 I, 图 6—8)。后来该种被张文堂 (1983, p. 213) 重新研究时, 将 *Coronocephalina* 亚属划归 *Senticucullus*, 并认为 *orientalis* 是否属于王冠虫还有疑问。但是近来, 在 *granulatus* 和 *orientalis* 的模式标本产地湖北宣恩高罗, 同一层位发现了大量具有个体发育的系列标本。发现 *granulatus*, *orientalis*, 是同一个个体的头部和尾部, 应是同种异名。该种的头部确实和 *C. rex* 的头部有些相近, 其相似率达 66% (见下面介绍的简单统计相似率的结果); 但其尾部和 “*Senticucullus*” 近似, 具长刺或短刺; 活动颊边缘的瘤呈齿状, 和 “*Coronocephalus (Coronocephalina)*” 亚属接近。而 *granulatus* 和 *orientalis* 合一之后, 究竟应置于何属之中, 是一个十分值得深究的问题。

### 四、*Senticucullus* 和 *Coronocephalus (Coronocephalina)* 的归属

如前所述, 王冠虫应以 *rex* 的新模式标本为准。从特征上来看, *Senticucullus* 及 *Coro-*

*nocephalus* (*Coronocephalina*) 所有种和 *Coronocephalus rex* 更为接近。迄今为止, 在我国发现的 *Coronocephalus* (*Coronocephalus*), *Coronocephalus* (*Coronocephalina*) 和 *Senticucullus* 中, 正式发表的有 34 种。为了澄清它们之间的关系, 兹将有关的种列表分析如下。曾归于王冠虫 *Coronocephalus* (*Coronocephalus*) 的种:

- 巴东王冠虫 *C. (Coronocephalus) badongensis* Chang, 张文堂, 1974, 184 页, 图版 84, 图 9; 图版 85, 图 10。不完整头盖, 活动颊。
- 长宁王冠虫 *C. (Coronocephalus) changningensis* Chang, 张文堂, 1974, 184 页, 图版 84, 图 10; 图版 85, 图 2—4。头盖, 口板, 活动颊, 尾部。
- 收缩王冠虫 *C. (Coronocephalus) constrictus* Wu, 伍鸿基, 1979, 136 页, 图版 2, 图 8。头盖。
- 德江王冠虫 *C. (Coronocephalus) dejiangensis* Yin, 尹恭正, 1978, 581 页, 图版 189, 图 9—11。不完整头盖, 尾部。
- 齿缘王冠虫 *C. (Coronocephalus) dentatus* Chang, 张文堂, 1974, 185 页, 图版 83, 图 1, 完整的个体。
- 坟头王冠虫 *C. (Coronocephalus) fentouensis* Lin, 林天瑞, 1982, 451 页, 图版 1, 图 7, 8。不完整头盖外模, 活动颊。
- 瘤点王冠虫 *C. (Coronocephalus) granulatus* Wu, 伍鸿基, 1979, 138 页, 图版 2, 图 2, 3; 两个头盖, 两个尾部, 一个活动颊。
- 广东王冠虫 *C. (Coronocephalus) guangdongensis* Zhou, 周天梅, 1977, 256 页, 图版 77, 图 8。头盖。
- 长刺王冠虫 *C. (Coronocephalus) longispinosus* Lee, 李善姬, 1978, 268 页, 图版 112, 图 5—7。不完整头盖, 带胸节的尾部。
- 南京王冠虫 *C. (Coronocephalus) nanjingensis* Lin, 林天瑞, 1982, 450 页, 图版 2, 图 1—3。完整的个体, 头部, 尾部。
- 卵形王冠虫 *C. (Coronocephalus) ovatus* Chang, 张文堂, 1974, 185 页, 图版 83, 图 2。不完整个体。
- 黔江王冠虫 *C. (Coronocephalus) qianjiangensis* Wu, 伍鸿基, 1979, 137 页, 图版 2, 图 10—13。3 个头盖, 1 个尾部。
- 霸王王冠虫 *C. (Coronocephalus) rex* Grabau emend. Wang, 王钰, 1938, 9—30 页, 图版 1, 图 1 a—f。完整的个体。
- 溶溪王冠虫 *C. (Coronocephalus) rongxiensis* Chang, 张文堂, 1974, 185 页, 图版 85, 图 6—8。头盖, 两个活动颊。
- 简单王冠虫 *C. (Coronocephalus) simplex* Zhou, 周天梅, 1977, 257 页, 图版 77, 图 6, 7。不完整头盖, 活动颊。
- 尖形王冠虫 *C. (Coronocephalus) spiculum* Wu, 伍鸿基, 1979, 137 页, 图版 2, 图 19。不完整头盖。
- 窄沟王冠虫 *C. (Coronocephalus) tenuisulcatus* Chang, 张文堂, 1974, 185 页, 图版 85, 图 5。不完整头盖。
- 横宽王冠虫 *C. (Coronocephalus) transversus* Wu, 伍鸿基, 1979, 137 页, 图版 2, 图

16. 不完整头盖。

乌兰察布王冠虫 *C. (Coronocephalus) ulanqabensis* Nan, 南润善, 1976, 347 页, 图版 198, 图 13—16。两个不完整头盖及两个尾部。

武宁王冠虫 *C. (Coronocephalus) wuningensis* Zhang, 张全忠, 1983, 245 页, 图版 84, 图 8, 9。不完整头盖, 活动颊, 尾部。

宣恩王冠虫 *C. (Coronocephalus) xuanenensis* Zhou, 周天梅, 1977, 257 页, 图版 77, 图 9。不完整头盖。

殷汇王冠虫 *C. (Coronocephalus) yinhuiensis* Zhang, 张全忠, 1983, 245 页, 图版 84, 图 2, 3。不完整头盖及尾部。

寨山王冠虫 *C. (Coronocephalus) zhaishanensis* Zhang, 张全忠, 1983, 246 页, 图版 86, 图 10, 11。两个尾部。

曾归于 *Semicucullus* 的种:

池州刺头虫 *S. chizhouensis* Zhang, 张全忠, 1983, 247 页, 图版 83, 图 3, 4。头盖和尾部。

锯齿刺头虫 *S. denticulatus* Lee, 李善姬, 1978, 270 页, 图版 113, 图 1。完整的头部。

美丽刺头虫 *S. elegans* Xia, 张文堂, 1974, 182 页, 图版 84, 图 1, 2; 图版 85, 图 9。带有部分胸节的头部, 尾部。

四川刺头虫 *S. sichuanensis* Chang, 张文堂, 1974, 182 页, 图版 84, 图 3, 4。不完整的带有胸节的头部, 不完整活动颊。

刺尾刺头虫 *S. spinicaudatus* Chang, 张文堂, 1974, 182 页, 图版 84, 图 5。尾部。

铜陵刺头虫 *S. tonglingensis* Zhang, 张全忠, 1983, 247 页, 图版 86, 图 1, 2。不完整的头盖、尾部。

曾归于 *Coronocephalus (Coronocephalina)* 的种:

高罗小王冠虫 *C. (Coronocephalina) gaoluoensis* Wu, 伍鸿基, 1979, 139 页, 图版 1, 图 1, 2; 图版 2, 图 9。不完整个体, 活动颊, 尾部。

湖口小王冠虫 *C. (Coronocephalina) hukouensis* Zhang, 张全忠, 1983, 246 页, 图版 85, 图 8, 9。不完整的活动颊, 尾部。

江苏小王冠虫 *C. (Coronocephalina) jiangsuensis* Lin, 林天瑞, 1982, 451 页, 图版 2, 图 6 a, b。尾部的内模和外模。

东方小王冠虫 *C. (Coronocephalina) orientalis* Wu, 伍鸿基, 1979, 140—141 页, 图版 1, 图 6—8。一个活动颊和两个完整尾部。( *C. granulatus* 和它是同物异体。)

桐城小王冠虫 *C. (Coronocephalina) tongchengensis* Wu, 伍鸿基, 1979, 141 页, 图版 2, 图 4。完整头盖。

上述 34 种中, 多数是根据头、胸、尾分开保存的标本建立的, 有的甚至仅根据一个头盖或一个尾部确定的。而完整的个体为少数。现将 34 种按它们原始和后来补充描述中所论及的对建种有决定意义的特征, 包括它们数量的变化, 列表比较它们之间的相似性。归纳出以下 10 项变异或变量上的特征:

1. 前头鞍叶轮廓的形状 圆形(代号为(1), 以下同), 扁圆形或椭圆形(2), 其它形状(3)。
2. 前头鞍叶向上突起 较高(4), 相对扁平(5)。

3. 前头鞍叶瘤点分布 密集(6), 局部, 分布于前叶之后(7), 光滑(8)。
4. 头鞍叶上瘤点分布 成对出现(9), 单个或无(10)。
5. 头鞍沟横穿头鞍的状况 3对都横穿头鞍叶(11), 第三对不横穿(12)。
6. 头鞍前沟 横穿头鞍前叶(13); 长, 但不横穿前头鞍叶(14); 极短或无(15)。

表1 表示王冠虫类 34 种的 10 项形态特征  
Graph showing the ten morphological characteristics

种名	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	
<i>badongensis</i>	○			○		○			○			○			○		○										
<i>changningensis</i>	○			○		○				○	○				○	○				○		○					○
<i>constrictus</i>	○			○		○				○		○			○												
<i>dejiangensis</i>	○			○		○				○	○				○					○		○					○
<i>dentatus</i>		○			○		○		○			○			○	○			○		○			○	○		
<i>fentouensis</i>	○			○		○			○		○			○		○											
<i>guangdongensis</i>		○			○	○			○		○		○														
<i>longispinosus</i>	○			○		○				○	○				○	○				○		○					○
<i>nanjingensis</i>		○			○	○			○		○				○	○				○				○	○		○
<i>ovatus</i>	○				○		○		○		○				○	○				○				○			
<i>qianjiangensis</i>	○			○		○				○		○			○	○				○		○					○
<i>rex</i>		○			○	○			○			○			○	○				○				○	○		
<i>rongxiensis</i>		○			○	○			○			○			○		○										
<i>simplex</i>	○				○		○			○		○				○											
<i>spiculum</i>			○		○		○		○		○					○											
<i>tenuisulcatus</i>		○			○	○			○			○			○												
<i>transversus</i>		○			○		○		○			○				○											
<i>ulangabensis</i>																											
<i>wuningensis</i>		○			○	○			○						○					○				○			
<i>xuanenensis</i>	○				○		○			○	○				○												
<i>yinhuiensis</i>	○				○		○		○			○			○					○				○			○
<i>zhaishanensis</i>																				○				○			○
<i>chizhouensis</i>		○			○		○		○			○			○					○				○			○
<i>denticulatus</i>		○			○		○		○			○			○					○							
<i>elegans</i>		○			○		○		○			○			○					○					○		○
<i>sichuanensis</i>		○			○				○	○			○		○					○							
<i>spinicaudatus</i>																				○					○	○	
<i>tonglingensis</i>		○			○				○	○			○		○					○					○	○	
<i>gaoluensis</i>		○			○		○		○			○			○					○				○	○		○
<i>granulatus</i>	○				○	○			○		○				○					○				○	○		○
<i>hukouensis</i>																				○					○	○	
<i>jiangsuensis</i>																				○					○	○	
<i>orientalis</i>																				○					○	○	
<i>tongchengensis</i>		○			○		○		○			○			○												

10 项形态特征以纵向粗线分隔表示。数字 1—26 分别表示每项形态中的变异特征。某种在某项形态中的特征以“○”符号表示, 某项形态特征不明者不记任何符号。

indicated in column separated by vertical thickened lines. Nos. 1—26 indicating variations in each of the ten morphological characteristics; “○” indicating the characteristic in a certain form of a certain species. No signs given to any unclear morphological characteristic.

7. 活动颊上的瘤点形状 瘤状(16);齿状(17);长刺状(18)。
8. 尾部轮廓的形状 亚三角形(19);亚半圆形(20);其它形(21)。
9. 尾中轴节数 35 节以下,不包括35节(22); 35 节至 39 节(23); 40 节以上(24)。
10. 尾肋末端 尖、带刺(25);钝,无刺(26)。

在上述十项特征中共计 26 点,但没有包括口板、固定颊和胸节的特征。这是因为所建新种中极少提出口板的特征,不能比较。有限的各种口板材料中,显示了它们之间的差异较小。且所建的新种没有以固定颊的特征为主要依据的。胸节除个别种中有特殊的形态外,极大多数种都没有可以区别于其它种的独特特征,至多也只是提到在某一节上长出长刺等,当然在绝大多数种中目前尚未发现胸节。

在表 I 中,只有 10 种可以测量到 10 项特征,其中 *ovatus* 一种因尾缘破裂,第十项特征已不清楚。这 10 个种中,正好包括前述 3 属或亚属的模式种 *C. rex*, *S. elegans* 及 *C. (C.) gaoluensis*。将表 I 中判断的结果作一比较,很容易计算出其相似点的百分比(表 II),而表 II 中的百分比,就是两种之间 10 项特征内相似率的百分比。可以看出, *rex* 和 *elegans* 在这 10 项内相似率达 80%, 和 *gaoluensis* 相似率为 70%, 和 *qianjiangensis* 的相似率只有 40%, 最低的是和 *changningensis*, 仅达 20%, 最高的是和 *nanjingensis*, 相似率达 90%。其中 *longispinosus* 和 *changningensis* 的相似率达 100%。相似率达 90%—100% 的种, 其它特征如无显著的差异, 是否是同义名或同一种, 可以研究。这 10 个保存较完整的种中, 按其和 *rex* 的相似率的高低重新组合, 可以分出两组(1)相似率达 60% 以上为一组, 有以下各种: *nanjingensis*, *elegans*, *dentatus*, *gaoluensis*, *granulatus*, *ovatus*; (2) 相似率达 40%, 有以下各种: *qianjiangensis*, *changningensis*, *longispinosus*。从表 II 中还可以看到: 第一组和第

表 II 10 项特征齐全的 10 种王冠虫的的对比  
Correlation between the ten species of coronacephalid trilobites provided with all of the ten morphological characteristics

10 项特征相似点百分比 种名	种名	<i>changningensis</i>	<i>dentatus</i>	<i>longispinosus</i>	<i>nanjingensis</i>	<i>ovatus</i>	<i>qianjiangensis</i>	<i>rex</i>	<i>elegans</i>	<i>gaoluensis</i>	<i>granulatus</i>
<i>changningensis</i>											
<i>dentatus</i>		20									
<i>longispinosus</i>		100	20								
<i>nanjingensis</i>		20	70	20							
<i>ovatus</i>		33	66	33	66						
<i>qianjiangensis</i>		80	20	80	30	33					
<i>rex</i>		20	80	20	90	66	40				
<i>elegans</i>		0	80	0	80	66	20	80			
<i>gaoluensis</i>		10	90	10	50	55	10	70	80		
<i>granulatus</i>		30	50	30	70	77	30	70	60	60	

表 III *changningensis*, *qianjiangensis*, *rex*, *elegans* 及 *gaoluensis* 5 种三叶虫按 6 项特征分别和其它种的对比  
Correlation of five species *changningensis*, *qianjiangensis*, *rex*, *elegans* and *gaoluensis* with other species respectively according to six characteristics

6 项特征相似点百分比 种名	种名																												
	<i>badongensis</i>	<i>changningensis</i>	<i>constrictus</i>	<i>dejiangensis</i>	<i>dentatus</i>	<i>fentouensis</i>	<i>guangdongensis</i>	<i>longispinosus</i>	<i>nanjingensis</i>	<i>ovatus</i>	<i>qianjiangensis</i>	<i>rex</i>	<i>rongxiensis</i>	<i>simplex</i>	<i>spiculum</i>	<i>tenuisulcatus</i>	<i>transversus</i>	<i>wuningensis</i>	<i>xuanenensis</i>	<i>yinhuiensis</i>	<i>chizhouensis</i>	<i>denticulatus</i>	<i>elegans</i>	<i>sichuanensis</i>	<i>tonglingensis</i>	<i>gaoluensis</i>	<i>granulatus</i>	<i>tongchengensis</i>	
<i>badongensis</i>																													
<i>changningensis</i>	66																												
<i>constrictus</i>		66																											
<i>dejiangensis</i>			83																										
<i>dentatus</i>				16																									
<i>fentouensis</i>					66																								
<i>guangdongensis</i>						33																							
<i>longispinosus</i>							100																						
<i>nanjingensis</i>								33																					
<i>ovatus</i>									33																				
<i>qianjiangensis</i>	66	83	100	83	16	100	16	83	16	16																			
<i>rex</i>	50	16	50	33	66	50	66	16	83	50	50																		
<i>rongxiensis</i>											33	83																	
<i>simplex</i>												50	33																
<i>spiculum</i>													0	33															
<i>tenuisulcatus</i>													33	83															
<i>transversus</i>														16	66														
<i>wuningensis</i>															50	100													
<i>xuanenensis</i>																66	16												
<i>yinhuiensis</i>																	50	66											
<i>chizhouensis</i>																		50	83										
<i>denticulatus</i>																			16	66									
<i>elegans</i>	33	0	33	16	83	33	50	0	83	66	33	83	66	50	50	66	83	83	0	83	100	83							
<i>sichuanensis</i>																									83				
<i>tonglingensis</i>																									83				
<i>gaoluensis</i>	50	16	16	0	100	16	50	16	66	50	16	83	83	66	50	83	83	66	16	66	83	100	83	83	66				
<i>granulatus</i>																										50		33	
<i>tongchengensis</i>																											83		100

二组之间相似率比较偏低,最高只达 40%,最低为 0—20%。组内之间相似率较高,第一组内之间最高达 80—90%,最低到 50%;第二组内之间最高达 100%,最低也到 80%。值得注意的是, *elegans*, *gaoluensis* 和 *rex* 被置于同一组内,相似率较高。

如再扩大比较,由于多数种依据的标本不完全,能以头盖来比较的种只有 28 个。头盖共有 6 项变异和变量的特征;而比较特征项目越少,准确率越低。即使如此,仍然可以看出和上述近似的结论。还是按表 I 中表示的结果,将选出较完整,具头盖特征的种分别比较。看一看模式种 *rex* 与 *elegans* 分别同这 28 个种的相似率情况:用上述相同的方法很容易得出表

III。表 III 中可以看出,对比表中只有 5 个“*Senticucullus*”的种可与 *rex* 比较,4 个和 *rex* 的相似率达 83%,1 个是 66%。而王冠虫本身的(包括其亚属小王冠虫)的种和模式种 *rex* 比较,相似率达 83—100% 的种只有 6 个,达 66% 的有 5 个,50% 有 5 个,33% 有 3 个,16% 有 3 个。而 *elegans* 和上述 28 种及本属的 5 种对比,相似率达 83% 以上;和 *Coronocephalus* 的种对比,有 6 个种(包括 *rex*) 相似率达 83%。和 *rex* 相似率高的种和 *elegans* 的相同率也高。因此不论按 10 项特征或头鞍的 6 项特征比较,都有类似的结果,说明此两种的确比较接近。如细分,这两种应在一个组合内。

属于“*Senticucullus*”的种只有 6 个,除 *elegans* 外,其余 5 种的标本个体均不完整,其中 *chizhouensis* 和 *tonglingensis* 虽为不完整的头盖和尾部,但其特征和 *elegans* 相差无几,其头盖和 *elegans* 的相似率分别达 83—100%,其它特征又没有显著的差异,可能是 *elegans* 的同义名。*denticulatus* 只有头部,活动颊上的瘤是短齿状,和 *gaoluensis* 的头鞍相似率达 100%,其它特征也没有显著的差异,可能也是同义名。*sichuanensis* 和 *elegans* 仅在头鞍前叶和头鞍沟的宽、窄有差异,这可能和保存时压力引起变形有关。*spinicaudatus* 以两个尾部为依据,分别带瘤点和不带瘤点。后者和 *elegans* 之间的差异相对宽了一点(Zhang, 1983, p. 211)。“*Senticucullus*”中,只发现头部的种和 *rex* 的相似率比 *Coronocephalus rex* 和 *Coronocephalus* 的其它一些种(如 *changningensis*) 的相似率要高得多。如按上述和 *rex* 的相似率的高低划分组合,无论如何,大多数原归“*Senticucullus*”的种都应和 *rex* 在一个组内,其中包括 *Senticucullus* 的模式种 *elegans*。

同样“*Coronocephalina*”亚属的模式种 *gaoluensis* 和 *rex* 的 10 项特征相似率也高达 70%。该亚属共有 6 种,除模式种外,其余和 *rex* 的 6 项相似率也达 66% 至 83%。*hukouensis* 和 *jiangsuensis* 只有尾部,不能对比;*orientalis* 和 *granulatus* 是同义名,和 *gaoluensis* 的 10 项特征相似率是 60%,而和 *rex* 的 10 项相似率是 70%;*tongchengensis* 和 *gaoluensis* 的 6 项相似率达 100%,建新种时强调其头鞍相对短,其宽度不同于 *gaoluensis*,很可能是保存时受挤压有关。因此,*tongchengensis* 可能是 *gaoluensis* 的同义名。

由此可见,以南京龙潭坟头组的新模为代表的 *rex* 与“*Senticucullus*”和“*Coronocephalina*”的所有种的相似率都较高,如按上述 28 个种和 *rex* 的相似率高低分组合,大多数所谓的“*Senticucullus*”和“*Coronocephalina*”的种,其中包括它们的模式种 *elegans* 和 *gaoluensis* 均应和 *rex* 放在同一个组合内。因此,笔者提出,“*Senticucullus*”和“*Coronocephalina*”应归属 *Coronocephalus*, 它们与后者为主观同物异名。

### 五、新亚属 *Coronocephalus* (*Coronaspis*) 的建立

对以上 34 种比较的结果表明,现有的王冠虫的种至少可以分为两个组合。按 10 项特征和 *rex* 的相似率达 60% 以上及 6 项特征相似率达 83% 以上的种,可归第一组合,为王冠虫亚属 *Coronocephalus* (*Coronocephalus*), 这些种有: *chizhouensis*, *dentatus*, *denticulatus*, *elegans*, *gaoluensis*, *granulatus* (*orientalis* 为同义名,应废弃), *nanjingensis*, *ovatus*, *rongxiensis*, *sichuanensis*, *tenuisculcatus*, *tongchengensis*, *tonglingensis*, *wuningensis*, *yinhuiensis*。此外,以下 4 种 *hukouensis*, *jiangsuensis*, *spinicaudatus*, *zhaishanensis* 等仅以尾部为依据建立的种,但其尾肋节末端尖,具有小刺或长刺,也应划归该组合。

其余不宜归入 *Coronocephalus* (*Coronocephalus*) 的种,为第二个组合。笔者建议,以其

中和 *rex* 相似率最低的长宁王冠虫 *Coronocephalus changningensis* 为模式种，将这一种群建立一个新亚属，称王冠盾壳虫 *Coronocephalus (Coronaspis)*，并以此作为第二组合的名称；包括以下这些种：*badongensis*, *constrictus*, *dejiangensis*, *fentouensis*, *guangdongensis*, *longispinosus*, *qianjiangensis*, *simplex*, *spiculum*, *transversus* 和 *xuanenensis*。当然，这些种之间，有的差别很大。而且多数只依据头鞍特征建立的种，其尾部形状不明，在没有新属发现之前，暂划归该亚属是适宜的。（插图 1）。*ulangabensis* 不是王冠虫，可能是 *Encrinurus* 的一个种。

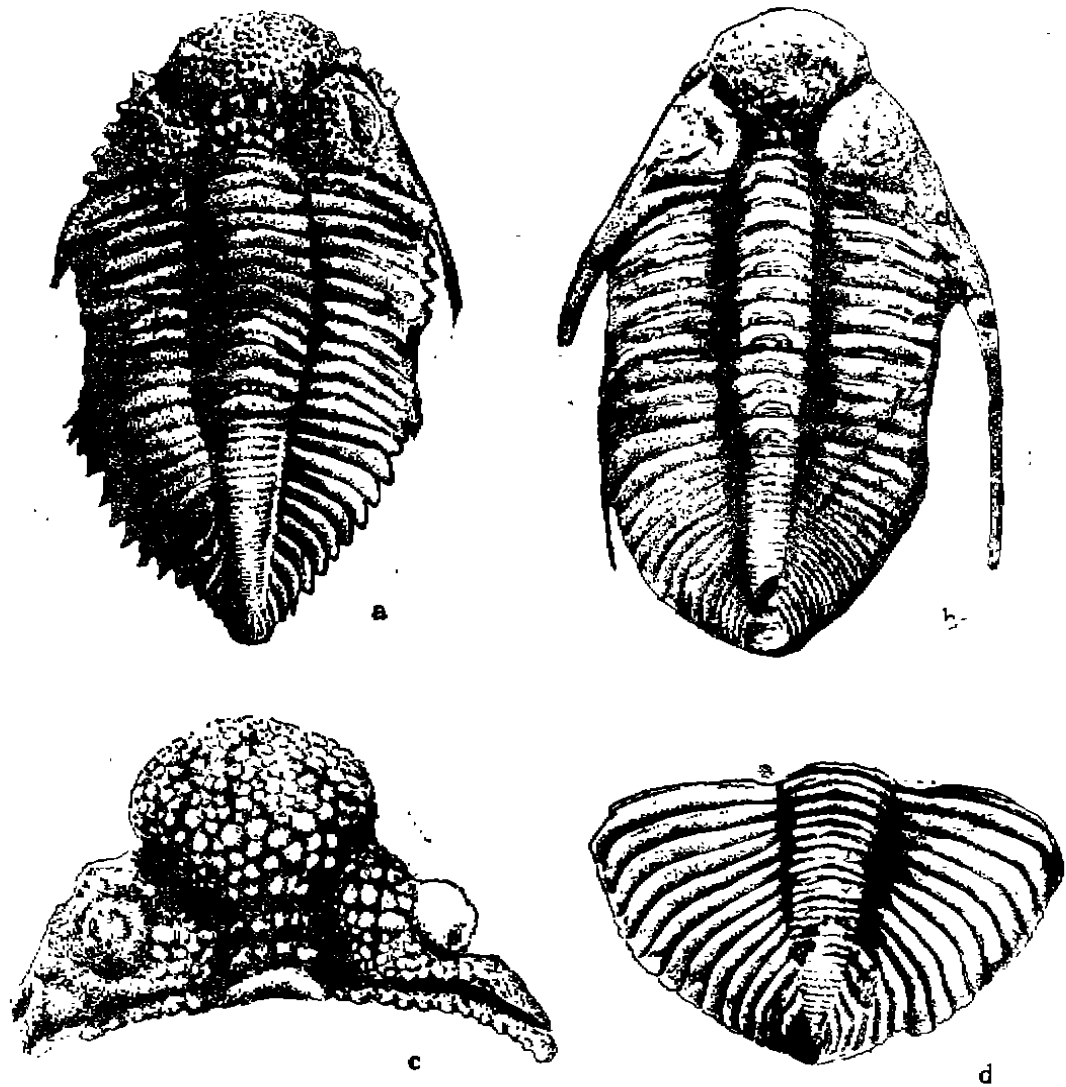


插图 1

a. *Coronocephalus (Coronocephalus) rex* Grabau emend. Wang, 1938  $\times 2$ .  
b-d. *Coronocephalus (Coronaspis) changningensis* Chang, 1974, b,  $\times 1.5$ ; c, holotype  $\times 2$ ; d,  $\times 2$ .

此外，张文堂定的 *rex yangsinensis* 和 *rex lushanensis*，其中 *lushanensis* 的头鞍圆而

突起,瘤点密集,尾部肋节末钝而方,无刺(Zhang, 1983, p. 299, pl. 6, figs. 4,5); *yangsinensis* 以3个尾部的一个活动颊标本为据,尾肋节末也是方钝状,无刺(Zhang, 1983, p. 230, pl. 8, figs. 4, 6; pl. 9, figs. 3,4)。这些特征和 *Coronocephalus* (*Coronaspis*) 的亚属相符,应归第二个组合内,亦即可划归新亚属内。

该亚属地质历程相对较长,先于 *Coronocephalus* (*Coronocephalus*) 出现,并可延续至秀山“期”之后。

## 六、*Coronocephalus*, *Rongxiella* 及 *Kailia* 的地层分布

*Coronocephalus* 广布于我国华南,北至陕南宁强,东至江苏南京,南至广东云浮,西南至云南大关均产于下志留统秀山组或与其相当的地层内。*Coronocephalus* 可能由似彗星虫 *Encrinuroides* 某个种演化而来,它们之间有中间类型的标本,见于相当“下秀山组”上部或“上秀山组”下部的层位中。*Coronocephalus* 在此层位之上才开始出现,至晚秀山“期”,繁盛一时。秀山“期”之后,沉积了一套红色或紫红色的粉砂岩,当时的沉积环境看来已不再适应这一动物群生存。但是,此时扬子海盆地的边缘如陕南、川北一带,或其它一些地区,却仍然保留着晚秀山“期”那种环境,王冠虫类某些属种,依然能继续生存下去。

王冠虫类三叶虫动物群在华南从晚秀山“期”普遍出现到消失的过程中,它们的一种特殊的构造——刺显示从无到有的规律。亦就是说,那些头尾具刺的种比无刺的种出现较晚。具刺的种中,以 *Coronocephalus* (*Coronocephalus*) *elegans* 为最,无论头、尾,皆伸出长刺。此外,还有 *Coronocephalus* (*Coronocephalus*) *rex* 及 *Coronocephalus* (*Coronocephalus*) *gaoluensis*, 它们的尾部均有短刺。这些具刺的种,都在秀山“期”末或相当的时间出现。另外有些种,其尾缘肋节末端纯圆,无刺,尾部轮廓近似亚半圆形,头鞍前叶相对圆,如 *Coronocephalus* (*Coronaspis*) *changningensis*, *C.* (*Coronaspis*) *qianjiangensis* 等,则早于上述这些种,于晚秀山早“期”出现。这种“刺”的产生,很可能是该类三叶虫为适应当时环境的变化而产生的。因为除上述的王冠虫 *Coronocephalus* (*Coronocephalus*) 外,还有另一个属即小溶溪虫 *Rongxiella*, 在秀山“期”末,也出现一些具刺的种。例如,在湖北阳新富池口富池页岩上部,亦即当年葛利普(Grabam, 1924)命名 *rex* 的地点,发现和 *rex* 共生有带刺的小溶溪虫,在其两个粗大的颊刺上又产生许多壮实的支刺,其中有一种,以此特征命名,笔者定其为新种: *Rongxiella macrospinata* (图版 II, 图 1—4)。在同一层位上,还有一个亦具相同的支刺的种,壳面光滑无瘤,和 *Rongxiella* 相近,系未定种(图版 II, 图 6)。四川广元的志留系剖面中,也见到此种带刺的 *Rongxiella* 和带刺的王冠虫共生。

张全忠(1982, 102 页)认为相当秀山组上段的地层中,自下而上可以划分3个三叶虫组合;最先出现的是 *Kailia*, *Rongxiella* 组合;第二是 *Coronocephalus* 和 *Coronocephalus* (*Coronocephalina*) 组合,但也包括“*Senticucullus*”某些种,如“*S.*” *tonglingensis*; 最上部是“*Senticucullus*”组合。局部地区似有这样的规律,但还不很确切,如最先出现组合中的 *Rongxiella* 和 *Kailia* 有些种,有时也可延续到最高的组合中。如除上述的 *Rongxiella macrospinata* 外,在湖北恩施太阳河秀山组上段,具刺的 *Coronocephalus* (*Coronocephalus*) (即过去认为的“*Senticucullus*”)出现之后,仍有 *Kailia* 出现,并和 *C.* (*Coronocephalus*) *sichuanensis* 共生。第二组合和第三组合,有些地区不能区分,例如贵州石阡雷家屯的秀山组上段, *Coronocephalus* (*Coronocephalus*) *gaoluensis* 和 *C.* (*C.*) *sichuanensis* 共生,甚至于 *C.*

(*C.*) *sichuanensis* 出现之后, 还有 *C. (C.) gaoluensis* 发现。

现将王冠虫的两个亚属与其有关的属小溶溪虫 *Rongxiella* 和凯里虫 *Kailia* 的地质延限列表如下。

地层 属及亚属	Llandovery (Telychian)		
	秀山组		廻星哨组及 相当地层
	下 段	上 段	
<i>Coronocephalus</i> ( <i>Coronocephalus</i> )			
<i>Coronocephalus</i> ( <i>Coronaspis</i> )			
<i>Rongxiella</i>			
<i>Kailia</i>			

## 七、新种描述

### 小溶溪虫属 Genus *Rongxiella* Chang, 1974

#### 支刺小溶溪虫(新种)

#### *Rongxiella macrospinata* sp. nov.

(图版 II, 图 1—4)

**定义** 前头鞍叶横椭圆形, 平凸。具 3 对浅的头鞍沟。头鞍后叶中线对应于后两对头鞍叶的位置上分别具有 1 个小瘤点。固定颊相对宽, 平凸。颊刺粗大, 两倍于头鞍中线位置的长度, 两侧有 10 对以上的强状短支刺。

**描述** 头鞍轮廓为倒梨形, 向前向后都扩大, 中间窄; 最窄处于第 2 对头鞍沟(向后数起)的位置上。头鞍最宽处是在对应固定颊最前端和背沟相汇合点之间。最窄和最宽处之比为 1:2。向后扩张比前面的小。后部最宽距离和中间最窄处之比为 6:5。前叶轮廓为横椭圆形, 平凸。但后部突起较高, 最高点略偏向后部, 向前平缓地倾斜, 但向后则陡峭地近于垂直倾入第二对头鞍沟内。具 3 对头鞍沟; 后两对可见, 并横穿头鞍, 第三对不甚明显。3 对头鞍沟于头鞍上极浅, 于背沟两侧呈凹口状。最后 1 对头鞍沟宽度(纵向)和后 1 对头鞍叶宽度(纵向)相当, 第二对宽度(纵向)比后 1 对宽, 且略深。第三对仅于头鞍两侧呈小凹口状, 于头鞍中线位置上不显。后两对头鞍叶窄(纵向), 第二对比后面一对更窄(纵向), 此两对头鞍叶分别于头鞍中部联成一体, 其中线位置上分别有一单个小瘤。前头鞍叶后部具有 16 至 18 颗中等大小的瘤点, 聚集于前头鞍叶后半部, 前半部光滑无瘤。颈沟相对后 1 对头鞍沟深, 略比后 1 对头鞍沟窄(纵向); 中间浅, 于背沟两侧深, 凹入背沟。颈环宽度(纵向)大致为后一对头鞍叶的两倍, 其上平坦; 偶尔在后缘有零散极细小的瘤点分布。颈环横向宽度略窄于头鞍前叶, 大致为 5:7。固定颊宽, 两眼沟通过第二对头鞍叶之间距离和前头鞍叶最大宽度之比大致为 5:3。平凸, 最高点在眼沟附近, 向背沟方向呈弧度状倾斜, 倾至背沟内。眼叶大, 平凸于固定颊之上。固定颊壳面光滑、无瘤。背沟宽, 且深, 其宽度约为头鞍最窄的宽度(横向)的 1/3 强。后侧翼宽(横向), 后侧沟比头鞍沟窄, 向外延伸逐渐变浅而窄(纵向); 至颊角处略向后弯曲。后侧边缘偶有

一排稀疏的极细小瘤点,颊角向后伸出极强状、粗大的颊刺。其长度约为头鞍长度的两倍强。虽然近末端变细,但仍显示出其粗状,至末端呈钝刀尖状。颊刺两侧生长出大约 10 对以上的支刺,支刺短而粗,末端尖锐;分别排列在颊刺的内外两侧。

其它部位器官未知。

**比较** 迄今为止,曾被定为 *Rongxiella* 的种一共有 3 个, *R. globosa* Chang, 1974, *R. convexa* Wu, 1979, *R. lixiensis* Zhang, 1982。此 3 种的形态上极为接近,其差别仅为前头鞍叶宽度的不同, *R. convexa* 和模式种 *R. globosa* 极为相近,其头鞍形状宽窄的差异很可能和保存因素有关;和 *R. globosa* 应是同义名。

本新种和 *R. globosa* 的头鞍形状有明显的差异;本种的头鞍相对短,后部相对宽;而 *R. globosa* 的前头鞍叶相对窄长。此外, *R. globosa* 头鞍后部相对前叶下凹很深,头鞍沟不显,其上光滑。本种的头鞍后部头鞍沟虽不深,但还显著,头鞍叶中线位置上有单个瘤点出现。

本种的固定颊相对 *R. globosa* 的平缓,而且宽。

其重要的特征是颊刺上横向伸出两行成对的粗壮的短刺;这种特征不仅本属的其它的种未曾见到,就是王冠虫类也从未发现。故以此特征定为新种。

**产地层位** 湖北阳新富池口,富池页岩上部(相当于秀山组上部)。

### 小溶溪虫(未定种) *Rongxiella* sp.

(图版 11, 图 6)

**描述** 头鞍轮廓为短棒形,向前扩大,中间窄;于后起第二对头鞍沟处最窄。前头鞍叶最宽处和头鞍后部最窄处之比为 2:1 强。向后扩张不强;头鞍基部和最窄处之比为 6:5 弱。前叶轮廓近似横圆形,微凸,向前及向后都平缓倾斜,最高点在前叶中心位置上。3 对头鞍沟明显,后两对横穿头鞍,第三对较浅。后面一对中间浅,近背沟两侧凹入背沟,其宽度(纵向)和第二对头鞍叶宽度(纵向)大致相当。第二对深,两侧宽(纵向)而深,其宽度(纵向)为第二对头鞍叶宽度(纵向)两倍强,但中线位置处变窄,且相对两侧浅得多;因而使头鞍沟两侧形成如楔形。第三对极浅,近背沟两侧有一点小凹口;向内侧有一点浅沟,略向前伸,不横穿头鞍。后 1 对头鞍叶最窄(纵向),为第二对的宽度(纵向)的 1/2;中间略向前弯曲。第二对两侧相对窄(纵向),中间宽(纵向)。颈沟的宽度(纵向)和第二对头鞍叶的相当;两侧近背沟处深,中间浅;但中间比两侧宽(纵向)。颈环宽度(纵向)略比第二对头鞍叶大,横向宽度和第三对头鞍叶两侧(横向)距离相当;其中间一段略向后弯曲。固定颊相对较窄,两眼沟通过第二对头鞍叶之间距离略比前头鞍叶最大宽度强。固定颊平凸,向背沟方向呈弧状倾斜。眼叶大,平凸于固定颊之上。背沟宽,且深,其宽度约为第二对头鞍两侧一段的宽度(纵向)相当。后侧翼下凹,后侧沟宽度(纵向)略比背沟窄,且浅,向外变得更浅。颊角具粗大的颊刺,颊刺两侧生长出若干对支刺。支刺短而粗,末端尖锐。分别排列在颊刺两侧。整个壳面光滑无任何装饰。

其它部位器官未知。

**比较** 此未定种前头鞍叶和 *Rongxiella globosa* 的十分近似,故置于同属。其颊刺生长支刺,和上述新种近似。但其壳面光滑,无任何装饰,头鞍后部 3 对头鞍沟十分明显,比所有 *Rongxiella* 的种都明显。照片上图象和 *Kailia* 属近似,但实体标本的前头鞍叶凸起,于第二对头鞍沟处紧缩,这一特征应属于 *Rongxiella*。此外,鉴于此未定种的颊刺上产生许多支刺,

将它和上述新种对比,置于 *Rongxiella* 较合适。

**产地层位** 湖北阳新富池口,富池页岩上部(相当秀山组上部)。

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## ON GENUS *CORONOCEPHALUS* GRABAU, 1924 (SILURIAN TRILOBITE)\*

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### Summary

#### I. Introduction

Although the genus *Coronocephalus* Grabau 1924 is frequently found in the Silurian rocks in Southwest China and the description of this genus was completed in 1938, discussion on the genus actually began in later years (Chang, 1974, 1983, Wu, 1979). A subfamily Coronocephalinae was raised by Chang in 1983, including four genera, namely *Coronocephalus*, *Senticucullus*, *Kailia*, *Rongxiella*. In the present paper 34 coronocephalid species are compared with *rex*, indicating that they can be divided into two groups. The type species of three genera (or subgenera), *Coronocephalus rex*, *Coronocephalus* (*Coronocephalina*) *gaoluensis* and *Senticucullus elegans*, are included in the same group. For this reason, the present paper holds that *Senticucullus*, *Coronocephalus* (*Coronocephalina*) and *Coronocephalus* are synonymous, and therefore *Senticucullus* and *Coronocephalina* should be abandoned. Here established is a new subgenus *Coronocephalus* (*Coronaspis*), which appeared in the late Xiushan age, and extended into Huixingshao or corresponding stratigraphic units.

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## II. Previous work

The name of *Coronocephalus* was originally published by Grabau (1924, p. 438). The locality of the species sits on a small hill south of Fuchikou Town, Yangxin County, Hubei Province. The specimens containing several cranidia and pygidia occurred in the upper part of the Fuchih Shale which was established by C. C. Liu and C. Y. Hisch, and was considered as early Silurian (Grabau, 1924, p. 439), with its upper part corresponding to the Xiushan Formation or Telychian Llandovery. Although the name of the genus and species *Encrinurus* (*Coronocephalus*) *rex* had been established by Grabau, it is a great pity that nothing about the specimens nor any description was given. Only a figure combining the features of *Encrinurus* with those of *Coronocephalus* was published (Grabau, 1924, p. 438, fig. 297). Later, the name of *Coronocephalus rex* was quoted in his work (Grabau, 1925, p. 82), still with no figures nor description indicated in the chapters. Up to 1938, an entire animal of *Coronocephalus rex* was discovered by Y. S. Chi, T. Y. Hsu, and S. F. Sheng in Longtan, Nanjing. The rock bearing *rex* was composed of silt shale called the Kaochiapien Shale, with the specimens found from the upper part of the silt shale, which was later named the Fentou Formation. Although the specimen had been selected as the neotype of *Coronocephalus rex* with a minute description by Wang Yu (1938, p. 9—30), no figures of *rex* from Fuchikou in Yangxin, Hubei were published in his works. This means that the specimens of Grabau's *rex* had been lost. Another complete specimen from Wengxiang east of Lushan City, Guizhou was selected as the paratype of *rex* in his paper. It is shown that between the neotype and paratype the features are more different in glabella or pygidium. In the neotype the frontal lobe of glabella is plane-convex, elliptic in outline and the terminal of the pygidium's pleural segment is sharp (Wang, 1938, p. 28), whereas in the paratype the outline of frontal lobe is relatively circular, and more convex than that of the neotype, and the end of the pygidium's pleural segment is blunt and spineless. Lately, based on the *rex* from Wengxiang a new subspecies *Coronocephalus rex lushanensis* was established by Chang (Chang, 1983, p. 229); many specimens of *rex* have been collected by Wu in the Fuchih shale, Fuchikou, Yangxin, Hubei, with some figures of the *rex* specimens published in the present paper (Pl. I, figs. 1—10; Pl. II, figs. 7—9). It cannot be sure whether these specimens are the same as those of Grabau's *rex* but they are similar in features to the neotype from Longtan, Nanjing.

## III. Doubts about *Senticucullus* and *Coronocephalina*

For a long time the description of *Coronocephalus*' type species was based on a complication with the shape of *rex* from Longtan composed of that from Wengxiang. As mentioned above, the paratype *rex* from Wengxiang was separated from *rex* to set up a new subspecies by Chang, and therefore the diagnosis of the genus *Coronocephalus*' type species should be limited to the features of the neotype *rex* from Longtan.

In this case, while examining all the species of *Coronocephalus*, only by comparing them with *rex* from Longtan, e. g. the neotype *rex*, can it be shown that some of them are closely related to the neotype *rex*, such as *Coronocephalus ovatus*, *C. dentatus*, while some others are rather far from it, such as *Coronocephalus changningensis*, *C. qianjiangensis*. It is a question that the type species of *Senticucullus elegans* and that of *Coronocephalus* (*Coronocephalina*) *gaoluensis* are in the first group closely related to *rex*; moreover, it is difficult to determine which genera should some of these species belong to. For example, *Coronocephalus granulatus* was established based on two incomplete cranidia: it appears closely similar to the species *C. rex* in glabella. While restudying some of the coronocephalid trilobites, Chang Wen-tang suggested that the species of *granulatus* might be considered as a subspecies of *rex* (Chang, 1983, p. 224). Another species *Coronocephalus* (*Coronocephalina*)

*orientalis* represented by two pygidia and one free cheek was also separated from the genus of *Coronocephalus* by Chang in his study of the subfamily Coronoccephalidae. He was doubtful that the free cheek should be referred to *Coronocephalus*, and therefore he suggested the subgenus *Coronocephalina* to be included in the genus *Senticucullus* (Chang, 1983, p. 212). During recent years plentiful specimens of *granulatus* were found in the topotype locality. The materials are abundant isolated cranidia about 3 mm. to 25 mm. in length together with bypostoma, thoracic segments, free cheeks and pygidia in different sizes. They are quite enough for studying the ontogeny of the species *granulatus*. Among these specimens some of them show the entire animal composed of *granulatus* and *orientalis*, in which the cranidium is named *granulatus* and the free cheek and pygidium named *orientalis*. These two species are doubtlessly synonymous, but it is troublesome to determine which genera they should belong to.

#### IV. Synonymous with *Coronocephalus*

In the present paper the writer tries to study all of the species included in *Coronocephalus* and *Senticucullus*. When they were separately compared with the type species *rex*, some of them appeared to be more closely related to the latter than to the others.

Up to now 34 species of coronoccephalids regarded as *Coronocephalus* and *Senticucullus* have been described, which are listed according to original publications as follows:

*Coronocephalus* (*Coronocephalus*) *badongensis* Chang, Zhang, 1974, p. 184, pl. 84, fig. 9, pl. 85, fig. 10, incomplete cranidium, free cheek.

*C.* (*Coronocephalus*) *changningensis* Chang, Zhang, 1974, p. 184, pl. 84, fig. 10, pl. 85, figs. 2—4, cranidium bypostoma, free cheek, pygidium.

*C.* (*Coronocephalus*) *constrictus* Wu, Wu, 1979, p. 136, pl. 2, fig. 8, cranidium.

*C.* (*Coronocephalus*) *dejiangensis* Yin, Yin, 1978, p. 581, pl. 189, figs. 9—11, incomplete cranidium.

*C.* (*Coronocephalus*) *dentatus* Chang, Zhang, 1974, p. 185, pl. 83, fig. 1, incomplete dorsal shield.

*C.* (*Coronocephalus*) *femouensis* Lin, 1982, p. 451, pl. 1, figs. 7—8, incomplete external mould of cranidium, free cheek.

*C.* (*Coronocephalus*) *granulatus*\* Wu, Wu, 1979, p. 138—140, pl. 2, figs. 2, 3, pl. 1, figs. 6—8, two cranidia two pygidia and a free cheek.

*C.* (*Coronocephalus*) *guangdongensis* Zhou, Zhou, 1977, p. 256, pl. 77, fig. 8, cranidium.

*C.* (*Coronocephalus*) *longispinosus* Lee, Lee, 1978, p. 268, pl. 112, figs. 5—7, incomplete dorsal shield, incomplete cranidium, pygidium with part of thorax.

*C.* (*Coronocephalus*) *xuanensis* Zhou, Zhou, 1982, p. 450, pl. 2, figs. 1—3, complete dorsal shield, cranidium, pygidium.

*C.* (*Coronocephalus*) *ovatus* Chang, Zhang, 1974, p. 185, pl. 83, fig. 2, incomplete dorsal shield.

*C.* (*Coronocephalus*) *qianjiangensis* Wu, Wu, 1979, p. 137, pl. 2, figs. 10—13, cranidia and pygidia.

*C.* (*Coronocephalus*) *rex* Grabau emend. Wang, 1938, p. 21—28, pl. 1, figs. 1a—c, complete dorsal shield.

*C.* (*Coronocephalus*) *rongxiensis* Chang, Zhang, 1974, p. 185, pl. 85, figs. 6—8, incomplete cranidium, two free cheeks.

*C.* (*Coronocephalus*) *simplex* Zhou, Zhou, 1977, p. 257, pl. 77, figs. 6, 7, incomplete cranidium and free cheek.

\* included in an entire animal with *orientalis*

- C. (Coronocephalus) spiculum* Wu, Wu, 1979, p. 137, pl. 2, fig. 19, incomplete cranidium.
- C. (Coronocephalus) tenuisulcatus* Chang, Zhang, 1974, p. 185, pl. 85, fig. 5, incomplete cranidium.
- C. (Coronocephalus) transversus* Wu, Wu, 1979, p. 137, pl. 2, fig. 16, incomplete cranidium.
- C. (Coronocephalus) ulanqabensis* Nan, Nan, 1976, p. 347, pl. 198, figs. 13—16, incomplete cranidia and two pygidia.
- C. (Coronocephalus) wuningensis* Zhang, Zhang, 1983, p. 245, pl. 84, figs. 8, 9, incomplete cranidium, free cheek, pygidium.
- C. (Coronocephalus) xuanensis* Zhou, Zhou, 1977, p. 257, pl. 77, fig. 9, incomplete cranidium.
- C. (Coronocephalus) yinhuiensis* Zhang, Zhang, 1983, p. 245, pl. 84, figs. 2, 3, incomplete cranidium and pygidium.
- C. (Coronocephalus) zhaishanensis* Zhang, Zhang, 1983, p. 246, pl. 86, figs. 10, 11, two pygidia.
- Senticucullus chizhouensis* Zhang, Zhang, 1983, p. 247, pl. 83, figs. 3, 4, cranidium and pygidium.
- S. denticulatus* Lee, Lee, 1978, p. 270, pl. 113, fig. 1, complete cephalon.
- S. elegans* Xia, Zhang, 1974, p. 182, pl. 84, figs. 1, 2, pl. 85, fig. 9, cephalon with part of thorax and pygidium.
- S. sichuanensis* Chang, Zhang, 1974, p. 182, pl. 84, figs. 3, 4, incomplete cranidium with thorax, incomplete free cheek.
- S. spinicaudatus* Chang, Zhang, 1974, p. 182, pl. 84, fig. 5, pygidium.
- S. tonglingensis* Zhang, Zhang, 1983, p. 247, pl. 86, figs. 1, 2, incomplete cranidium and pygidium.
- Coronocephalus (Coronocephalina) gaoluensis* Wu, Wu, 1979, p. 139, pl. 1, figs. 1, 2, pl. 2, fig. 9, incomplete dorsal shield, free cheek, cranidium incomplete.
- C. (Coronocephalina) hukouensis* Zhang, Zhang, 1983, p. 246, pl. 85, figs. 8, 9, incomplete free cheek, pygidium.
- C. (Coronocephalina) jiangsuensis* Lin, Lin, 1982, p. 451, pl. 2, figs. 6a—b, internal and external moulds of pygidium.
- C. (Coronocephalina) tongchengensis* Wu, Wu, 1979, p. 141, pl. 2, fig. 4, cranidium.
- The characters of these emphasized by different authors in their descriptions are listed as follows:
- (I) Outline of glabella: circular (1)\*, transversely broad or elliptical (2), otherwise (3);
- (II) Frontal lobe of glabella: strongly convex (4), relatively flat (5);
- (III) Presence of tubercles: on frontal lobe of glabella, contracted (6), on posterior part of glabella (7), smooth (8);
- (IV) Presence of tubercles on glabella lobes: a pair of tubercles on second pair of glabella lobes (9), single or absent (10);
- (V) Glabellar furrows: three pairs of glabellar furrows transverse and across glabella (11), third pair short, not across glabella (12);
- (VI) Preglabellar furrow: present, slightly across front of glabella (13), a pair of short depressions in front of glabella (14), absent (15);
- (VII) Tubercles on border of free cheek: large granular (16), dentate in shape (17), long spine (18);
- (VIII) Outline of pygidium: subtriangular (19), subsemicircular (20), otherwise (21);
- (IX) Number of axial rings on pygidium: less than 35, excluding 35th (22), 35 to 39 (23), over 40, including 40th (24);

\* referring to the code number, the same below.

(X) Pleural terminal on pygidium: sharp or with spine (25), blunt, without spine (26).

Most of the species mentioned above are based on isolated cranidia and pygidia; a few of them are preserved with only one cranidium or pygidium. Since no specimens with thorax have been described, the characters of thorax are absent in the list. Although some authors emphasize the different outlines of hypostoma, there appear to be few variants in these specimens; the various shapes might be caused by pressure.

According to the code numbers on the list mentioned above, the related characters from the original descriptions and diagnosis of the type species are filled in the blanks in Table I. Among the 34 species, only 9 species can be shown on the table with ten characters, while one species can be shown on the table with nine characters. Each of the remaining species can be shown on the table with only 3—6 characters. It is easy to compare the 10 relatively complete specimens with each other according to the data on Table I. There are no complex mathematical questions in listing the percentages of identical characters between two compared species on table II. It can be seen that the compared species *rex* and *elegans* show an 80% identity while *rex* and *gaoluensis* show a 70% identity. If *rex* is compared with *changningensis*, they show a 20% identity; with *qianjiangensis*, 40%; and with *nanjingensis*, 90%. If *changningensis* is compared with *longispinosus*, they show a 100% identity. Those two compared species show a 90—100% identity. If there are no distinct differences between them, the two species may be synonymous. To separate these species into two species-groups

based on a standard of 60% similarity in comparison with *C. rex*, the species with more than 60% similarity include *nanjingensis*, *elegans*, *dentatus*, *gaoluensis* and *granulatus*, *ovatus* while those with less than 40% identity include *qianjiangensis*, *changningensis* and *longispinosus*. It is noticeable that *rex* and *elegans* and *gaoluensis* are in the same group. According to the six characters of the glabella in Table I, twenty-eight species can be shown with their glabellar characters. In comparison of these species separately with *rex* in glabellar features, it is shown that five species which have been regarded as belonging to *Senticucullus* are much closer to *rex*. The identities between the compared species and *rex* reach to 66—83%. The remaining species of *Coronocephalus* which have been regarded as *Coronocephalus* (*Coronocephalina*) are separately compared with *rex*; six of them reach to 83% or more than 83% in identity, ten to 50—66% and six to 16—33%. In comparison of the 28 species separately with *elegans* by using some methods, an approximate result as mentioned above can be obtained. All species of "*Senticucullus*" are closer to *rex* than some species of *Coronocephalus*.

Up to now six species have been regarded as belonging to *Senticucullus*. Only one species, *elegans*, is preserved relatively intact. *C. zhichouensis* and *C. tonglingensis* are based on incomplete cranidia and pygidia respectively. On table III the two species are compared with *elegans*, showing an 83% and a 100% identity respectively. These two species are closely similar to *elegans* in features; they should be synonymous with the latter. *C. denticulatus* based on only one cephalon differs not much from *gaoluensis*; they show a 100% identity to each other on table III, and therefore may be synonymous, too. *C. sichuanensis* differs from *elegans* in its frontal lobe of glabella and glabellar furrows. *C. spinicaudatus* based on two pygidia is much wider than *elegans*.

Six species have been regarded as belonging to the subgenus *Coronocephalus* (*Coronocephalina*). Among them, the specimens of *C. gaoluensis* are relatively complete; *C. hukouensis* and *C. jiangsuensis* only based on pygidia are closely related to those with *rex* in the same group; *C. orientalis* and *C. granulatus* are different parts of the same animal, as mentioned above. While *C. tongchengensis* is very similar to *C. gaoluensis*, showing a 100% identity to each other (Table III); with no differences between them, and therefore they should be undoubtedly synonymous.

However, except those isolated pygidia or incomplete cranidia, most of the species belonging to either *Senticucullus* or *Coronocephalina*, are closer to *rex* than some species of *Coronocephalus*.

Even though the 28 species are separated into two groups based on characters of glabella, *C. elegans* and *C. gaoluensis* with *rex* might be in the same group. Therefore, all of these species should belong to the genus *Coronocephalus*, while *Senticucullus* and *Coronocephaline* are synonyms of the latter.

### V. New subgenus *Coronocephalus* (*Coronaspis*)

As a result, all of the species can be separated into two groups when they are compared with *rex*. Those species in comparison with *rex* showing a 60% (Table II) and 83% (Table III) identity can be included in the same group. They persist in the subgenus *Coronocephalus* (*Coronocephalus*) including the species *chizhouensis*, *dentatus*, *denticulatus*, *elegans*, *gaoluensis*, *granulatus* (*orientalis* being synonymous), *nanjingensis*, *ovatus*, *rongxiensis*, *sichuanensis*, *tenuisculcatus*, *tongchengensis*, *tonglingensis*, *wuningensis* and *yinhuiensis*. Besides these, four species, *hukouensis*, *jiangsuensis*, *spinicaudatus* and *zhaihanensis*, are only based on pygidia with spines at the end pleural segment, they should also be included in this genus. It is inadvisable to include another group which is rather far from *rex* in feature into *Coronocephalus* (*Coronocephalus*). The present paper suggests to establish a new subgenus, *Coronocephalus* (*Coronaspis*), for those species with *Coronocephalus changningensis* as the type species. In this case, the following species should be included in this subgenus: *badongensis*, *constrictus*, *dejiungensis*, *fentouensis*, *guangdongensis*, *longispinosus*, *qianjiangensis*, *simplex spiculum*, *transversus* and *xuanenensis*. It must be pointed out that some of these species distinctly differ from *rex* in features, especially those based on only one cranidium. Before the discovery of available new material, it is appropriate to temporarily include all of these species in the subgenus *Coronocephalus* (*Coronaspis*).

Two subspecies *C. rex yangsinensis* and *C. rex lushanensis* were established by Zhang (Zhang, 1983, p. 299, pl. 6, figs. 4, 5; p. 230, pl. 8, figs. 4, 6; pl. 9, figs. 3, 4). As mentioned above in Chapter II, *C. rex lushanensis* distinctly differs from *C. rex* either in glabella or in pygidium. *C. rex yangsinensis* is based on three pygidia and a free cheek; in the pygidium the terminal of pleural segment is shown blunt and without spines. These two subspecies should also be included in this subgenus *Coronocephalus* (*Coronaspis*).

### VI. Stratigraphical ranges

*Coronocephalus* is widely distributed over south and southwest China, from Ningqiang of southern Shaanxi in the north to Yufu of central Guangdong in the south, and from Nanjing of Jiangsu in the east, to Dagan of eastern Yunnan in the west, occurring in the upper part of the Xiushan Formation which is corresponding to the late Llandovery. After the Xiushan age, a set of red or purple siltstone deposited in this area, which might be unfavourable for the fauna. A few of these species could extend into the Huixingshao Formation or the corresponding strata in this region. On the margin of the area, such as southern Shaanxi and northern Sichuan, there still existed the original environment, in which the fauna continued to persist until it was relatively later than the Xiushan age.

There are some species with spines on the border of free cheek and the margin of pygidium, such as those of *Coronocephalus* (*Coronocephalus*). They appeared in the upper Xiushan Formation, and generally disappeared in the end of this formation.

Those without spines on the border of free cheek and the margin of pygidium such as the species of *Coronocephalus* (*Coronaspis*) also occurred in the upper part of the Xiushan Formation, but relatively earlier than those with spines; sometimes they could extend into a later age.

This is also the case with another coronocephalid *Rongxiella* which generally occurred in association with *Coronocephalus*; its stratigraphical range is very close to that of the latter. For example, some species of *Rongxiella* without strong branch spines on genal spines appeared relatively earlier than those with strong branch spines in the late Xiushan age. Some of them occurring near the end of the Xiushan age were associated with *Coronocephalus* (*Coronocephalus*) and produced strong branch spines on genal spines. A new species *Rongxiella macrospinata* which is distinguished by the strong branch spines (Pl. II, figs. 1—4) occurred in the upper part of the Fuchih Shale corresponding to the upper part of the Xjushan Formation in association With *rex*; its locality is by the road of Fuchikou Town, Yangxin, Hubei, with the occurrence of the species *Encrinurus* (*Coronocephalus*) *rex* Grabau, 1924. Another species of *Rongxiella* was also found in the same locality (Pl. II, fig. 6). Although the surface of its cranidium is smooth, the genal spines also produce many strong branch spines.

As a result, it seems that some of the coronocephalids produced more or less spines on any possibly related organs when they extended into the top of the Xiushan Formation or corresponding strata. Q. Z. Zhang (1982, p. 102) held that there were three trilobite assemblage-zones in this area: the lower zone with the genera *Kailia* and *Rongxiella*; the middle zone with *Coronocephalus* and *Coronocephalus* (*Coronocephalina*) including some species of "*Senticucullus*" such as *tonglingensis*; the upper zone with the genus "*Senticucullus*".

In fact, it is not often the case, because some species of *Kailia* or *Rongxiella* could extend into the third assemblage-zone (upper zone), in association with those which had been regarded as species of "*Senticucullus*". For example, besides *Rongxiella macrospinata* mentioned above which occurred in association with *rex* in Fuchikou, Yangxin, Hubei, some species of *Kailia* appeared in the upper Xiushan Formation associated with *Coronocephalus* (*Coronocephalus*) *sichuanensis* in Taiyanghe of Enshi, Hubei. In addition, it is difficult to separate the middle part and the lower part of the assemblage into two zones. For example, at Leijiatuan, Shiqian, *Coronocephalus* (*Coronocephalus*) *gaoluensis* is associated with *C. (C.) sichuanensis*; even after re appearance of the latter, the former still extends into the upper part of the strata, indicating that it is inappropriate to set up the three assemblage zones.

In this case it may be useful for stratigraphical correlation to divide these species into two assemblages. These species in comparison with *rex* display relatively lower identities, and without spines on free cheek and pygidium, such as the new subgenus *Coronocephalus* (*Coronaspis*) suggested in the present paper, which appeared earlier in geological age than those showing relatively higher identity and with spines on free cheek and pygidium, such as the species of *Coronocephalus* (*Coronocephalus*). In comparison with other coronocephalid genera *Kailia* and *Rongxiella*, their geological extension can be listed as follows:

Genera and Subgenera	Llandovery Telychian		
	Xiushan or Ningqiang Fm.		Huixingshao or Shenxuanyi Fm.
	Lower member	Upper member	
<i>Coronocephalus</i> ( <i>Coronocephalus</i> )		—	
<i>Coronocephalus</i> ( <i>Coronaspis</i> )	-----		-----
<i>Rongxiella</i>		-----	-----
<i>Kailia</i>	-----		

## VII. Systematic description

Genus *Rongxiella* Chang, 1974*Rongxiella macrospinata* sp. nov.

(Pl. II, figs. 1-4)

**Diagnosis** Frontal lobe of glabella transversely elliptic in outline. Plane convex, with three pairs of glabellar furrows. Two single small tubercles appearing on middle of glabella corresponding to the posterior two pairs of glabellar lobes respectively. Fixed cheek gently convex, relatively wide. Fixigenal spine strong, large and long, about more than two times as long as glabella. Both sides of each fixigenal spine with more than ten pairs of branch spines, which are also strong, and rather long.

**Description** Glabella inversely pyriform in outline, transversely expanded forwards and backwards, with the narrowest part on second pair of glabellar furrows. Widest part of frontal lobe about two times as wide as the narrowest part; frontal lobe to posterior margin of glabella with a ratio of 6:5. Frontal lobe of glabella transversely elliptic in outline, gently convex. Highest point of glabella on frontal lobe, sloping forwards to front of glabella, and inclining backwards nearly at right angle with second pair of glabellar furrows. Three pairs of glabellar furrows with posterior two pairs relatively distinct, extending across glabella, and third pair obscure, not extending across glabella. Glabellar furrows very shallow in middle (tr.) of glabella, but very deep on both sides, joining the axial furrow on both sides of glabella. Each pair of glabellar furrows different in width (exsag.): first pair nearly as wide as the second pair of glabellar lobes (exsag.); second pair much wider than the first pair (exsag.). Posterior glabellar lobes relatively narrow (exsag.), but the second pair of glabellar lobes narrower than the first one (exsag.). Two small tubercles appearing on the median line (exsag.) of posterior glabellar lobes respectively; frontal lobe with 16-18 tubercles close to posterior part. Anterior part of frontal lobe smooth. Occipital furrow much deeper but narrower (exsag.) than the first pair of glabellar furrows. Both sides of occipital furrow deeper than its middle part. Occipital ring about two times wider (exsag.) than the first pair of glabellar lobes (exsag.) and slightly wider (tr.) than the base of glabella, plane, with several small granules rowed on posterior margin. Width (tr.) of occipital ring to maximum width of frontal lobe in ratio of about 5:7. Distance between two palpebral-furrows to maximum width of frontal lobe in ratio of about 5:3. Fixed cheek wider, gently convex, with the highest point near palpebral furrow, inclining from the highest point to axial furrow in a rather great curve. Palpebral lobe large. Lateral fixed cheek gently convex. Surface of fixed cheek smooth, without tubercles. Axial furrow wider and deeper, about 1/3 time as wide as second pair of glabellar lobes (tr.). Posterior-lateral border very wide (tr.). Posterior-lateral furrow much narrower (exsag.) than glabellar furrow, gradually becoming narrower (exsag.) while extending to lateral side and slightly curved backwards on the fixed cheek angle. Several small granules rowed on the posterior margin of fixed cheek. A strong and big genal spine extending backwards, about two times as long as glabella, still showing very strong although gradually becoming thinner backwards; terminal in the shape of a sharp knife. Genal spine on both sides producing more than ten pairs of branch spines, which are short but strong; terminal also sharp.

Other organs unknown.

**Comparision** Up to now three species are included in this genus, namely, *Rongxiella globosa*, *R. convex* and *R. lixiensis*, which can be distinguished by the different widths of the frontal glabellar lobe. *R. convex* is very close to the holotype *R. globosa*, and should be synonymous with the latter. The differences between their frontal lobes may be caused by pressure.

The new species differs from *R. globosa* in the relatively shorter (exsag.) glabella with a wider

base. In *R. globosa*, the posterior part of glabella is more concave and seems very smooth, without glabellar furrows. But in the new species, the posterior glabella possesses three pairs of glabellar furrows, with two small tubercles on it, and the fixed cheek is wider and plane as compared with *R. globosa*.

An important character lies in the genal spine which produces more than ten pairs of strong branch spines on both sides. This character is neither seen in all species of *Rongxiella*, nor in conocephalid species.

**Horizon and locality** Upper part of Fuchih Shale corresponding to upper part of xiushan Formation. Fuchikou, Hubei.

## 图 版 说 明

所有标本保存在中国科学院南京地质古生物研究所。

### 图 版 I

本图版标本均产于湖北阳新富池口下志留统富池页岩上部。

#### 1—10. *Coronocephalus rex* Grabau

1. 头盖, ×3。野外编号: R-A; 登记号: 110535。
- 2, 8. 尾部 ×2。野外编号: R-B; 登记号: 110536, 110537。
3. 尾部 ×2。野外编号: R-A; 登记号: 110538。
- 4, 9. 活动颊 ×2。4. 边缘被挤压略向上翘, 见瘤刺钝圆, 呈似瘤状。野外编号: R-A; 登记号: 110539。边缘平坦, 边缘瘤刺略显尖圆。野外编号: R-A; 登记号: 110540。
- 5a, b. ×3。为不完整头盖与活动颊同于一标本上, 头盖受横向轻微挤压。野外编号: R-A; 登记号: 110541, 110542。
6. 不完整头盖 ×2, 受纵向强烈挤压, 前头鞍叶向下弯, 瘤点相对减少。野外编号: R-A; 登记号: 110543。
7. 完整口板 ×3, 中心体突起较高, 前边缘窄, 实体标本比照片上要窄, 边缘沟宽。野外编号: R-A; 登记号: 110544。
10. 头盖 ×3, 横向挤压强烈, 变长。野外编号: R-A; 登记号: 110545。

### 图 版 II

#### 1—4. *Rongxiella macrospinosa* sp. nov.

1. 完整头盖 ×5, 强壮的颊刺两侧产生许多支刺。野外编号: R-B; 登记号: 110546。(Holotype)。产于湖北阳新富池口下志留统富池页岩上部。
2. 头盖 ×5; 4. 同一标本的颊刺外膜 ×6, 野外编号: R-B; 登记号: 110547。(Paratype)。产地层位同上。
3. 部分颊刺 ×5, 见粗壮的支刺。野外编号: R-B; 登记号: 110548。产地层位同上。
5. *Rongxiella globosa* Chang  
头盖 ×2, 颊刺无支刺。野外编号: XUS; 登记号: 110549。产于四川秀山溶溪下志留统秀山组上部。
6. *Rongxiella* sp.  
头盖 ×4, 头鞍向上突起较高, 颊刺带强壮的支刺。野外编号: R-A; 登记号: 110550。产于湖北阳新富池口下志留统富池页岩上部。

#### 7—9. *Coronocephalus rex* Grabau

7. 活动颊 ×2。野外编号: R-A; 登记号: 110551。产地层位同上。
8. 不完整头盖 ×3。野外编号: R-A; 登记号: 110552。产地层位同上。
9. 尾部 ×2。肋末端尖刺长短不一。野外编号: R-A; 登记号: 110553。产地层位同上。