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# 贵州金沙寒武系牛蹄塘组的古盘虫类三叶虫*

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**提要** 贵州金沙寒武系牛蹄塘组产出大量古盘虫类三叶虫化石,包括分离头盖、尾部和完整背甲。依据标本中具分类鉴定意义的构造特征的测量数据比值并线性拟合,结合形态学特征、个体发育趋势等特点分析,认为 *Tsunyidiscus armatus* 和 *Tsunyidiscus niutitangensis* 两个三叶虫种是有效的,支持以尾部肋区分节差异作为两个种种征判别标志。本项研究可为厘定贵州金沙地区三叶虫 *Tsunyidiscus* 序列提供可靠证据。

**关键词** *Tsunyidiscus* 古盘虫类三叶虫 牛蹄塘组 寒武系 贵州金沙

## 1 前 言

古盘虫类是三叶虫最早出现的类群之一,属于小型等尾型三叶虫,广泛分布于全球寒武纪第二世及第三世地层中(Dai *et al.*, 2015)。由于该类群的属种多、分布广、时限短,对地层的划分和对比具有重要意义(张文堂等,1980;杨爱华等,2005;郑昊林等,2014)。其系统分类位置目前主要有两种观点:一认为与球接子类三叶虫有关,即球接子类可能起源于古盘虫类三叶虫(Cotton and Fortey,2005),二是通过异时发育从多节类三叶虫演化而来(Shergold, 1991; Babcock, 1994; Jell, 1997; Cederström *et al.*, 2009)。Dai 和 Zhang (2013)对湖北水井沱组 *Sinodiscus changyangensis* Zhang in Zhou *et al.*,1977 的个体发育研究认为古盘虫类既与多节类三叶虫的亲缘关系很近,又拥有球接子类的特征。

20 世纪中期开始,不少学者对我国西南地区古盘虫类三叶虫进行过研究(卢衍豪,1942;张文堂,1953,1966;张文堂、袁克兴,1964;卢衍豪等,1965,1974;尹恭正、李善姬,1978),张文堂等(1980)在此基础上做了系统而详细的厘定,将中国古盘虫类三叶虫分为 2 科、4 亚科、10 属、2 亚属,之后李善姬(1980)增加 1 属,合计 11 属。但由于缺少保存完整的模式标本,分类学上长期存在争议(Zhang,1987; Jell,1997;袁金良、赵元龙,1999; Steiner *et al.*, 2001;林天瑞等,2004;杨爱华等,2005),主要集中在 *Tsunyidiscus* Zhang, 1966, *Hupeidiscus* Zhang in Lu *et al.*, 1974, *Emeidiscus* Li, 1980, *Mianxiandiscus* S. Zhang and Zhu in Zhang *et al.*, 1980, *Mianxiandiscus* (*Liangshandiscus*) S. Zhang in Zhang *et al.*, 1980, *Guizhoudiscus* S. Zhang in Zhang *et al.*, 1980 和 *Shizhudiscus* S. Zhang and Zhu in Zhang *et al.*, 1980 等属(亚属)及其种的合并(Zhang,1987; Jell,1997;袁金良、赵元龙,1999; Steiner *et al.*, 2001;林天瑞等,2004;杨爱华等,2005; Li *et al.*, 2012;郑昊林等,2014; Dai *et al.*, 2015)。争议如下:1)合并为 *Tsunyidiscus* 一个属(Zhang and Jell,1987; Jell,1997;林天瑞等,2004);2)合并为 *Tsunyidiscus*, *Hupeidiscus* 2 个属(Zhang,1987; Steiner *et al.*, 2001;杨爱华等,2005;郑昊林等,2014);3)合并为 *Tsunyidiscus*, *Mianxiandiscus*, *Hupeidiscus* 3 个属(袁金良、赵元龙,1999);4)合并为 *Tsunyidiscus*, *Shizhudiscus*, *Hupeidiscus* 3 个属(Zhang and Clarkson,1993,2012)。

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Dai 等(2015)认为 Tsunyidiscidae 不应该只有 *Tsunyidiscus* 一属,但是要想正确地识别这些古盘虫类化石和其系统分类还是相当困难的,需要更多的化石材料去证实和完善。

贵州寒武系牛蹄塘组是一个富产古盘虫类三叶虫的地层单元,发现和报道过的古盘虫类化石有:*Tsunyidiscus*, *Mianxiandiscus*, *Shizhudiscus* 和 *Guizhoudiscus* 4 属(张文堂、袁克兴,1964;卢衍豪等,1974;尹恭正、李善姬,1978;周志毅等,1979;周志毅、袁金良,1980;张文堂等,1980)。*Shizhudiscus* 和 *Guizhoudiscus* 曾被认为应是 *Hupeidiscus* 的次同义名(Zhang,1987)。Li 等(2012)通过三维立体的 *Hupeidiscus orientalis* 个体发育研究后赞成将 *Shizhudiscus* 归入 *Hupeidiscus* 中。*Tsunyidiscus* 是具有古盘虫类最原始形态的属(Fortey,1990),*Mianxiandiscus* 曾被认为是其晚出同义名(Zhang,1987;林天瑞等,2004;杨爱华等,2005;郑昊林等,2014),但有学者根据两者尾部差异将其作为独立的两个属(袁金良、赵元龙,1999)。

近年我们在贵州金沙寒武系牛蹄塘组中采集到的 *Tsunyidiscus niutitangensis* 和 *Tsunyidiscus armatus*(原 *Mianxiandiscus armatus*)的大量化石标本,包括一些完整的个体、系列发育的标本,提供了数理统计定量分析其分类学证据的基础。本文旨在前人形态学讨论的基础上,通过数理统计定量分析方法进一步准确地厘定 *Tsunyidiscus* 和 *Mianxiandiscus* 的分类依据,为牛蹄塘组的精细地层划分和对比工作提供可靠证据。

## 2　地质背景

贵州金沙位于扬子台地西南部,属扬子区的遵义—织金地层小区(周志毅等,1979;尹恭正,1987)。研究剖面地处岩孔镇西北 13 km,岩石出露较好,早在 1970 年被张正华、周志毅等作为牛蹄塘组和明心寺组的标准剖面(周志毅等,1979;尹恭正,1987)。由下而上出露灯影组的白云岩;牛蹄塘组的黑色泥岩、页岩、粉砂质泥岩、粉砂质页岩,黄绿色、青灰色页岩、粉砂质页岩,酱黄色粉砂岩;明心寺组的灰绿色页岩,酱黄色粉砂岩、细砂岩,灰岩。牛蹄塘组与下伏灯影组为平行不整合接触,与上覆明心寺组呈整合接触关系。有学者(Yang *et al.*,2005, 2014;杨兴莲等,2009;王平丽等,2013;郑昊林等,2014)对该剖面牛蹄塘组的海绵、高肌虫和三叶虫等类群及组合特征进行过研究,其中牛蹄塘组的三叶虫生物地层被从下而上修订为 *Tsunyidiscus armatus* 延限带和 *Tsunyidiscus niutitangensis* 顶峰带(郑昊林等,2014),其时代属于寒武纪第二世第三期(插图 1)。本文研究的化石标本采自贵州金沙岩孔剖面的牛蹄塘组黑色泥、页岩中。

## 3　测量数据的选定及数理统计值分析

张文堂将 *Mianxiandiscus* 和 *Emeidiscus* 认为是 *Tsunyidiscus* 的次同义名(Zhang,1987)。林天瑞等(2004)认为 *Tsunyidiscus* 头盖前边缘上瘤状凸起是属内的种间差异, *Mianxiandiscus* 是 *Tsunyidiscus* 的晚出异名。袁金良、赵元龙(1999)根据尾部肋沟的有无区别 *Mianxiandiscus* 和 *Tsunyidiscus*。郑昊林等(2014)根据金沙盘虫类三叶虫标本的定性形态学研究赞成 *Mianxiandiscus* 应是 *Tsunyidiscus* 的晚出异名。李耀西等(1975)根据陕西勉县大河坝等地的 *Hupeidiscus* 研究发现尾甲肋部不分节的 *Hupeidiscus* 与众多 *Tsunyidiscus* 头部共同保存的现象,认为 *Hupeidiscus* 是 *Tsunyidiscus* 雄性个体,是 *Tsunyidiscus* 的性双形现象,因此也有学者提出了 *Tsunyidiscus armatus* 和 *T. niutitangensis* 之间的这些差异可能是同一种的性双形现象。但在金沙岩孔剖面 *T. armatus* 距前寒武系-寒武系界线 5.5 m 处首次出现(Yang *et al.*,2005),54.0 m 后再未被发现(郑昊林等,2014),而 *T. niutitangensis* 却一直上延至明心寺组。在正常情况下,动物一般都是有性生殖,不会是雌性个体大量存在而雄性个体极少,因此必须慎重对待(张文堂等,1980)。

目前在定性形态学研究、厘定这些古盘虫化石时,对最初定义的 *Mianxiandiscus* 和 *Tsunyidiscus* 在头盖或尾部肋区分节上的差异认识是一致的,但有学者提出这些差异只是属内种间的差异,甚至是种内的形态变化(林天瑞等,2004),为此我们选择金沙岩孔剖面中大量的 *Tsunyidiscus armatus* 和 *T. niutitangensis* 化石标本进行系统数据测量和线性统计分析,希望通过线性拟合度来判断其特征差异是个体发育过程中的差异还是种间变异。

### 3.1　测量数据选择

*Tsunyidiscus armatus* 是杨爱华(2002)根据章

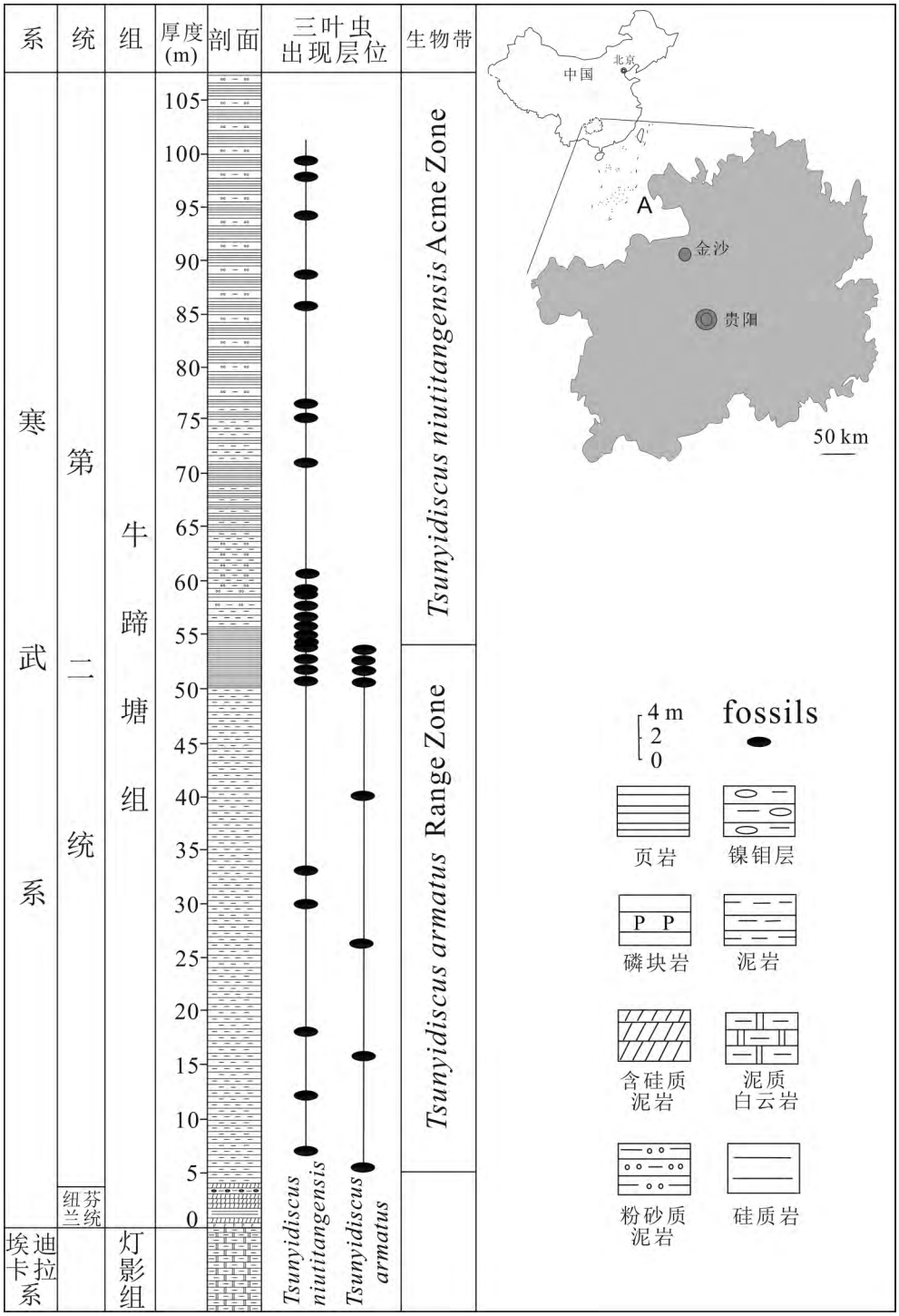


**插图 1 贵州金沙寒武系牛蹄塘组剖面柱状图(引自郑昊林等,2014)**

Stratigraphic column of the Cambrian Niutitang Formation in Jinsha County, Guizhou Province (from Zheng *et al.*, 2014).

森桂和朱兆玲建立的 *Mianxiandiscus armatus*(张文堂等,1980)重新修订的种,其主要特征是肋区光滑,尾轴分节不明显(见插图 2-B, 2-E—G)。*T. niutitangensis* 是张文堂、袁克兴(1964)建立的种,最初定义为 *Hebediscus niutitangensis*,后来被张文堂(1966)重新修订,并作为 *Tsunyidiscus* 的模式种,根据杨爱华(2002)种间判定标准,其主要特征是尾部发育 4 对清晰的肋沟(见插图 2-D, 2-H—J)。两个种的正模形态学特征也表明 *T. armatus*(张文堂等,1980,图版 7,图 2)较 *T. niutitangensis*(张文堂等,1980,图版 5,图 3)头盖向前的拱曲度大,固定颊刺和颈刺宽长,尾轴也很长。鉴于这些有鉴

定意义的特征,我们对金沙岩孔剖面牛蹄塘组中 360 块 *T. armatus* 和 *T. niutitangensis* 标本的头盖长、宽度、外边缘宽度、头鞍长、头鞍基叶宽度、头鞍侧叶宽度、固定颊宽度和尾部长、宽度、尾轴长度及尾轴第 2 轴节宽度进行了系统测量(插图 3—10)。

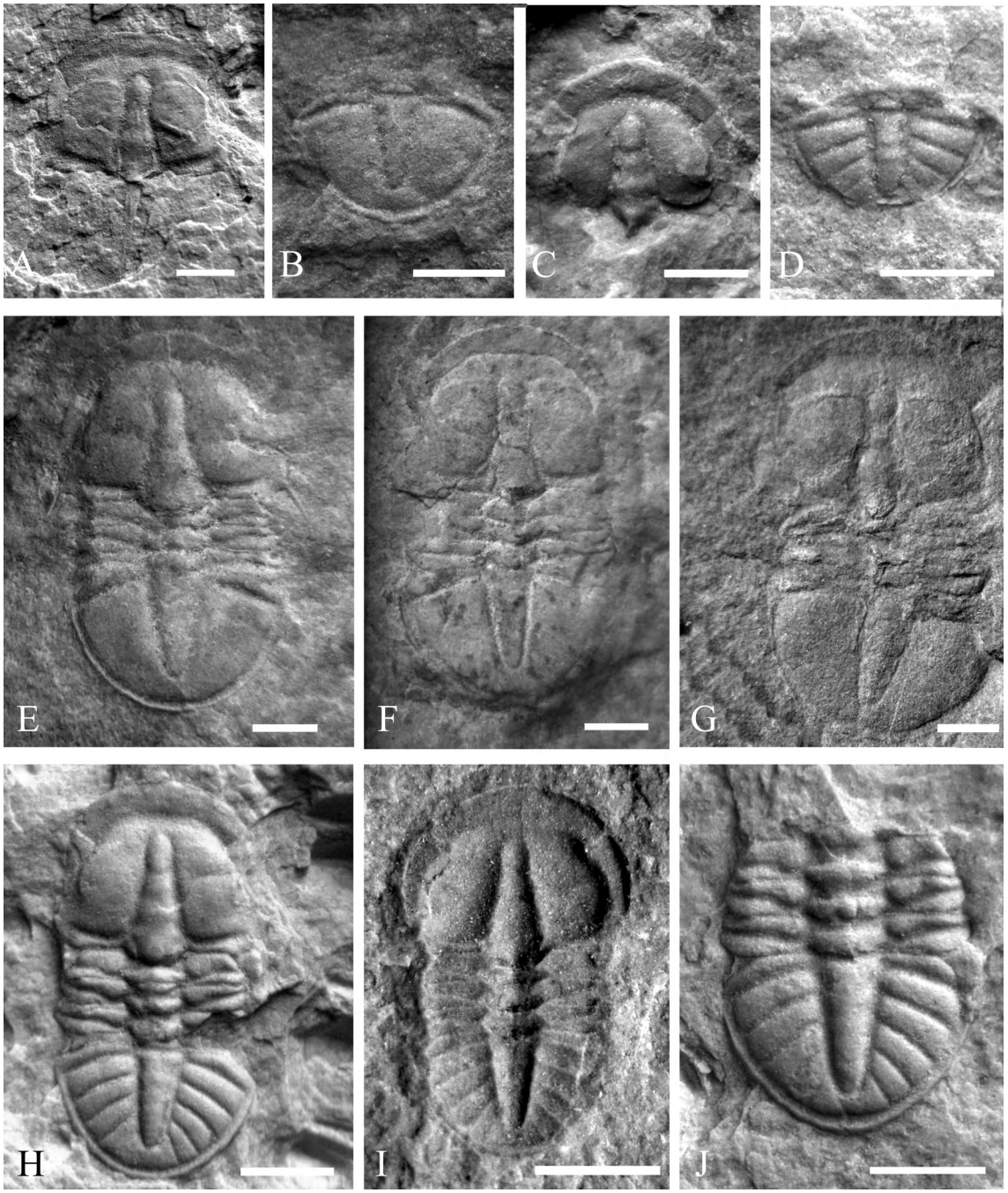


**插图 2　贵州金沙寒武系牛蹄塘组三叶虫** *Tsunyidiscus*

*Tsunyidiscus* specimens from the Cambrian Niutitang Formation at Jinsha, Guizhou.

A. *Tsunyidiscus armatus*,**头盖**(cranidium),JS-53-01-01。B. *T. armatus*,**尾部**(pygidium),JS-51-02。C. *T. niutitangensis*,**头盖**(cranidium),JS-54. 9-5。D. *T. niutitangensis*,**尾部**(pygidium),JS-54. 5-54。E—G. *T. armatus*,**完整背甲**(articulated exoskeletons),E. JS-53-10;F. JS-53-11-01;G. JS-53-09。H, I. *T. niutitangensis*,**保存头胸尾的完整背甲**(articulated exoskeletons),H. JS-55. 3-01a-01;I. JS-55. 3-21。J. *T. niutitangensis*,**保存胸尾的较完整背甲**(thorax and pygidium),JS-55. 3-91-03。**图中的所有比例尺均为** 1 mm,**保存于贵州省古生物研究中心**(All scale bars on pictures equal 1 mm and all specimens are deposited in the Guizhou Research Center for Paleontology, Guizhou University, Guiyang, China)。

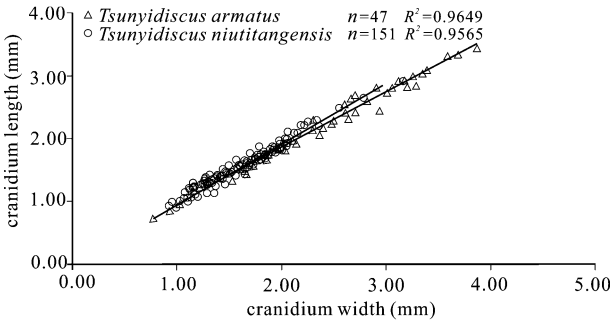


**插图 3 头盖宽长比值散点图**

Ratio scatter diagram of cranidium width against cranidium length.

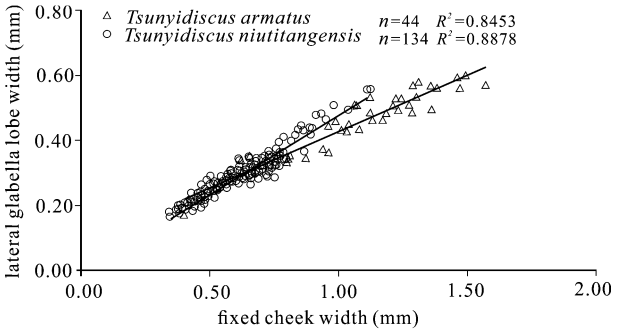


**插图 7 固定颊宽与头鞍侧叶宽比值散点图**

Ratio scatter diagram of fixed cheek width against lateral glabella lobe width.

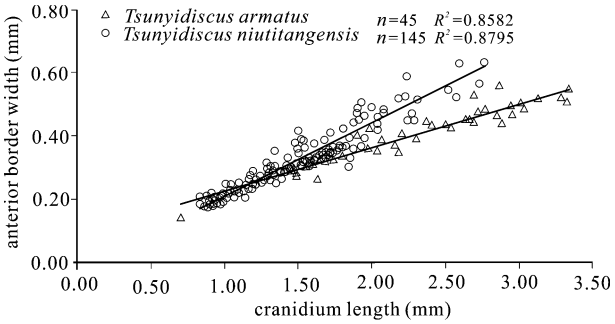


**插图 4 头盖长与外边缘宽比值散点图**

Ratio scatter diagram of cranidium length against anterior border width.

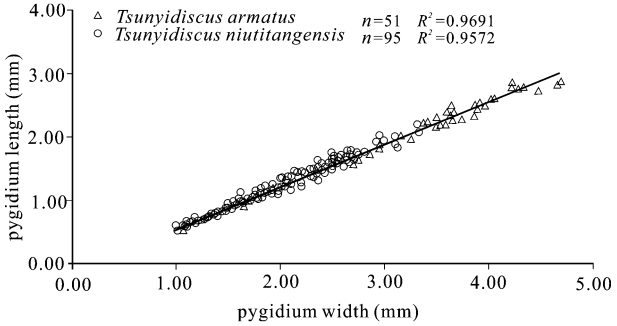


**插图 8 尾部宽与尾部长比值散点图**

Ratio scatter diagram of pygidium width against pygidium length.

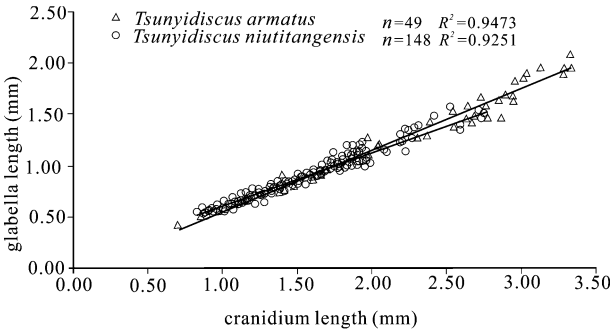


**插图 5 头盖长与头鞍长比值散点图**

Ratio scatter diagram of cranidium length against glabella length.

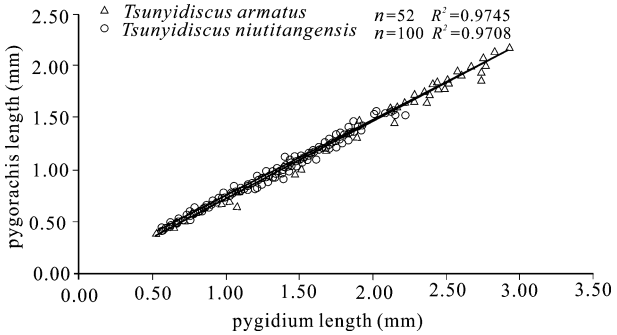


**插图 9 尾部长与尾轴长比值散点图**

Ratio scatter diagram of pygidium length against pygorachis length.

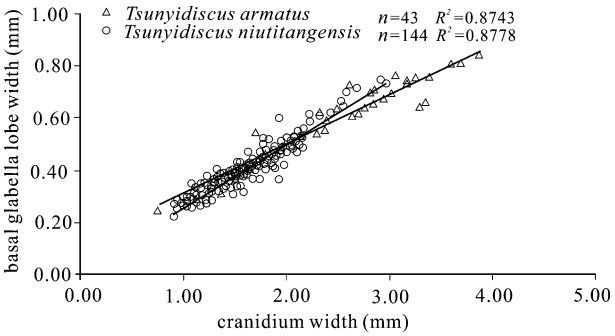


**插图 6 头盖宽与头鞍基叶宽比值散点图**

Ratio scatter diagram of cranidium width against basal glabella lobe width.

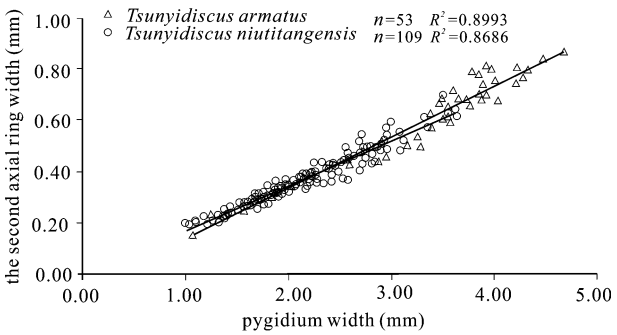


**插图 10 尾部宽与尾轴第 2 轴节宽比值散点图**

Ratio scatter diagram of pygidium width against the second axial ring width.

### 3.2　数理统计值分析

根据 44 块头部标本,50 块尾部标本及 5 块完整背甲标本的测量,*Tsunyidiscus armatus* 头盖宽度在 0.76—3.88 mm 之间,长度在 0.70—3.33 mm 之间,尾部宽度在 1.07—4.69 mm 之间,长度在 0.53—2.93 mm 之间;头盖长度约为宽度的 90.8%,外边缘宽约占头盖长的 17.4%,头鞍长约占头盖长的 58.6%,头鞍基叶宽约占头盖宽的 23.4%,头鞍侧叶宽度约占固定颊宽度的 41.7%,尾部长度约为宽度的 63.1%,尾轴长度约占尾部长度的 73.6%,尾轴第 2 轴节宽度约占尾部宽度的 18.1%。

根据 149 块头部标本,108 块尾部和 4 块完整背甲标本的测量,*T. niutitangensis* 头盖宽度在 0.91—2.96 mm 之间,长度在 0.83—2.76 mm 之间,尾部宽度在 1.00—3.63 mm 之间,长度在 0.56—2.34 mm 之间;头盖长度约为宽度的 96.1%,外边缘宽约占头盖长的 21.9%,头鞍长约占头盖长的 56.6%,头鞍基叶宽约占头盖宽的 24.9%,头鞍侧叶宽度约占固定颊宽度的 47.4%,尾部长度约为宽度的 62.6%,尾轴长度约占尾部长度的 72.9%,尾轴第 2 轴节宽度约占尾部宽度的 17.2%。

对 360 块大小不同的 *T. armatus* 和 *T. niutitangensis* 标本进行线性个体发育情况统计后(插图 3—10)显示,古盘虫类在发育过程中,其身体各部分保持一定的比例生长,两者在发育过程中拟合程度很高,亲缘关系很近,但个体大小,外边缘及固定颊宽的发育情况存在一定的差异性。

## 4　讨　论

根据以上对金沙 *Tsunyidiscus armatus* 和 *T. niutitangensis* 标本的统计结果和形态特征分析表明:前者个体形态较大(插图 3—10),固定颊较宽(插图 3,7),外边缘较窄(插图 2-A,2-E—G;4),尾部光滑(插图 2-B,2-E—G);而后者个体形态较小(插图 3—10),固定颊较窄(插图 3,7),外边缘较宽(插图 2-C,2-H,2-I;4),尾部发育 4 对清晰肋沟(插图 2-D,2-H—J),尾轴第 2 轴节和第 3 轴节存在瘤状突起(插图 2-D,2-H,2-I)。林天瑞等(2004)认为尾部是否有肋沟并无重要的建属意义,只是属内种间的差异,甚至是种内的形态变化,因为 *Hupeidiscus* 的幼年期尾部具有明显的肋沟,而到成年期仅保留一对前侧沟,是发育过程中的一个变化特征。但从目前研究的所有盘虫类化石的个体发育和躯干分节特征来看,成年期标本都具有 3 节胸节(Zhang and Clarkson,1993,2009;Li *et al.*,2012;Dai and Zhang,2013;Dai *et al.*,2015),而金沙尾部光滑的 *T. armatus* 和 4 对肋沟发育的 *T. niutitangensis* 的完整背甲标本均具 3 节胸节(插图 2-E—J),个体都较大,说明这些完整标本都是成年期标本,且 *T. niutitangensis* 个体较小的幼年期标本(插图 2-D)的尾部 4 对肋沟也较发育,意味着它们尾部是否有肋沟应该是种间差异而非个体发育过程中的变化。

综上所述,*Tsunyidiscus armatus* 和 *T. niutitangensis* 相比在边缘前沟、外边缘瘤状凸起、尾部宽长比等特征差异甚微,而在个体形态、外边缘宽度、固定颊宽度、眼脊形态、尾部肋沟发育情况等存在一定的差异,可以作为种间差异确定两者为不同的种。*Tsunyidiscus armatus* 和 *T. niutitangensis* 在剖面上常共生,但大多头尾分离,此次根据两个种完整的化石标本确定其形态特征,同时认为尾部特征分异最为显著,支持以尾部肋区分节差异作为两个种的最主要判别标志,这也是最容易识别两个种的标志。

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# A STUDY OF THE EODISCOID TRILOBITE FROM THE CAMBRIAN NIUTITANG FORMATION OF JINSHA, GUIZHOU

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**Key words**　*Tsunyidiscus*, eodiscoid trilobite, Niutitang Formation, Cambrian, Jinsha of Guizhou

## Abstract

The Cambrian Niutitang Formation of Jinsha, Guizhou yields many specimens of cranidium and pygidium and articulated exoskeletons of the eodiscoid trilobite. The focus of this study is mainly on the systematic measure and linear fitting of the characteristics of evaluation of *Tsunyidiscus* from the Cambrian Niutitang Formation of Jinsha, Guizhou. Combined with the study of morphology, ontogenic trends and characteristics, *Tsunyidiscus armatus* and *T. niutitangensis* are supposed to be two valid trilobites species, and further support to the morphology of the pygidium (with pleural furrows or not) is the main feature to distinguish these two species. This study not only sheds light on the taxonomy of *Tsunyidicus*, but also provides significant evidences for properly identifying the trilobite biozones of Jinsha area which can be better correlated with other regional stratigraphy.