中缅树鼩 广西猕猴 脑立体定位图谱

A STEREOTAXIC ATLAS OF THE BRAIN OF TUPAIA BELANGERI AND MACAQUE MONKEY LIVING IN GUANGXI

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序　一

猕猴在生物医学实验上的重要性已为大家所熟知。对树鼩则还可能有认识不足者。

多年的研究和最近的进展均说明：树鼩基本上可确定是一种低等灵长目的小型动物。这就对生物医学实验提供了一种良好的实验动物模型。树鼩与人类同属一目；体型小，便于实验操作处理。我国的广西、云南是树鼩的重要产地之一。

对重要灵长目实验动物的脑结构作出准确的立体定位图谱，不只可提供广大生物医学科学工作者以此动物作神经科学等实验的方便条件，而且脑立体定位图谱的本身已是对该动物脑研究的重要科学工作。广西医学院灵长类研究室杨文光教授等同志对我国西南树鼩脑作了精美的连续切片染色以及准确的立体定位图谱，这是对我国灵长类学及生物医学实验的重要贡献。

据所知，对我国树鼩品种作出系统的立体定位脑图谱，在国内、外的神经科学中尚属首次。

图谱的出版，定可促进我国神经科学及生物医学事业的繁荣与发展，并向国际生物医学界介绍中国树鼩种。

中国医学科学院
中国协和医科大学　**神经科学委员会主席**
神经生物学教授

万选才

1989 年 10 月

Preface 1

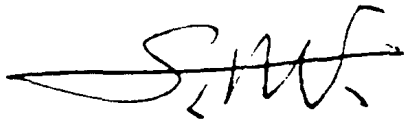
It is well known that the *Macaque* monkey serves importantly as an indispensable animal in Bio-medical experiments. The importance of tree shrews (*Tupaia belangeri*, Wagner) has however not been appropriately recognized.

Previous and recent researches indicate that tree shrews (*Tupaia*) can be identified to be primitive primates with small body size. It is naturally more convenient to adopt *Tupaia* as experimental animals modelling primate in Bio-medical researches. *Tupaia*, *Macaca* and human beings belong to the same order of vertebrates; the body size of *Tupaia* is much smaller and is therefore easier and more convenient to manage than large-sized primates in experiments. Guangxi and Yunnan provinces of China are native haunts of *Tupaia belangeri*.

Accomplishing a precise stereotaxic atlas of the brain of this primitive primate provides not only a useful reference for Bio-medical workers to carry out their experiments involving central structures of the *Tupaia* brain, but it is also an important work in itself, a piece of study on primate brain. Prof. Yang Wenguang, together with his co-workers of the Department of Primatology of Guangxi Medical College, has made an elegant and precise stereotaxic atlas based on well stained serial sections of the brains of *Tupaia belangeri* from southwest China. This is a great contribution to primatology and experimental Bio-medicine.

So far as I know, it is for the first time, both at home and abroad, that an atlas has been made to describe systematically the steric location of brain structures of this Chinese species *Tupaia belangeri Chinensis*, and *Tonquinia*, Thomas. Its publication will undoubtedly promote the prosperity and progress of Neuroscience and Bio-medicine in China and introduce the Chinese *Tupaia* to international academic circles of Bio-medicine as well.

Oct. 1989



Xuancai S. T. Wan, M. D.
Chairman of the Academic Committee for Neuroscience
Chinese Academy of
Medical Sciences (CAMS) and Peking
Union Medical College (PUMC).
Professor of Anatomy and Neurobiology.

序　二

世界上已出版了好几本猕猴脑立体定位图谱。过去的工作已说明，猕猴脑立体定位在个体间有极大差别。如何纠正误差，如何筛选与培殖出专供神经科学实验的猕猴新品种，仍然是神经科学家十分关注的问题。

广西医学院灵长类研究室杨文光教授、航天医学工程研究所刘觐龙教授及其同僚对以上问题已作出了重要贡献。

根据他们十年的实验总结，已编写了一本实用的具有特点的广西猕猴脑立体定位图谱。从70多例广西猕猴颅、脑测量结果，找到了颅、脑结构表里关系的一系列数学公式，创造了按颅型特点进行脑立体定位的方法，即根据颅测量数值，用数学方法，准确推算脑结构的空间位置，同时解决了实验前预测问题，提出了实验猕猴的筛选标准。这是本图谱最大特点。他们已筛选培殖出具有建立条件反射快、易于巩固、脑立体定位数值稳定的广西猕猴新品种。这是对神经科学和灵长类学的极大贡献。据所知，在国内、外是首次的。

广西猕猴目前已遍布于我国和发达国家如美国、苏联、日本等国家养殖场，在国际上有一定代表性。图谱的出版，定会促进神经科学和这个猕猴品种养殖业的繁荣与发展。

中国中医研究院
针灸研究所
神经解剖室教授
陶之理
1989年10月

Preface 2

As we know that various copies of stereotaxic atlas of Macaque monkey have published over the world during the past years. The previous research have indicated that a considerable variation of the steric location being existed in different individual' s brain. Great attentions have been paid to the neuroscientists correcting the deviation, selecting and raising a new species lab rhesus monkey for neuroscientific experiment.

Dr. Yang Wenguang, Prof. of the Department of Primatology of Guangxi Medical College, Dr. Liu Jinlong, Prof. of the Institute of Space Medico-Engineering, together with their colleagues made a conclusive contribution to it.

Based on the findings of the past ten years, they concluded a distinctive and effective stereotaxic atlas of the brain of Guangxi rhesus monkeys and drew several mathematical formulas representing the exterior and interior of the skull and the brain of this species through measurement of skull and brain of 70 odd. They initiated the procedures of steric location of the monkey' s brain according to the features of the shape of skull. That is to say that they can work out with precision the spatial position of the brain structures on the basis of the data obtained through the skull measurement, and calculated exactly before experiment. They sugested the screening standard of experimental rhesus monkey. All the above findings are the distinquish characters of this atlas presented to our readers. I' m sure of it. The new species of Guangxi rhesus monkey which can form conditioned reflex and strenthen it rapidly and stable steric location value were cultivated out from Dr. Yang' s laboratory. The atlas will be a great contribution to Neurology and Primatology. It' ll be an initiation of it in the world as well.

As the Guangxi rhesus monkey domesticated all through the big farms in China and the U. S. A. , The USSR, Japan, etc. , it has some international representation of this species. I' m sure the atlas will promote the development and prosperity of Neuroscience and domestication of this species.

Oct. 1989

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前　言

灵长目实验动物在神经科学的研究，特别是脑的高级功能的研究中占有重要地位。神经解剖学、神经生理学、神经病理学和神经心理学实验中，猕猴最常用于脑的研究(Frederrick，A. 1988)。用立体定位技术研究脑结构的神经解剖学与生理学，要求不打开颅盖，以颅表面骨性标志，用三维座标预测脑结构的位置。故预测得准确，对实验的成功有决定性意义。迄今，已出版了多种猕猴脑图谱为解剖学研究提供参考。然而，猕猴颅、脑的大小比例在不同亚种与种群间存在极大差别，导致图谱与实验动物很不匹配，随之使实验失败。

中国广西、云南、贵州及其相邻地区，灵长目动物树鼩与猕猴资源丰富，为实验动物的主要来源。编写这些产区的动物图谱是符合需要的。这本图谱是广西猕猴和云南、广西树鼩脑图谱。考虑两者都属灵长目，脑皮质区结构、基底神经节和间脑以下各脑部的脑结构相似，合编成一册，便于比对研究。此外，鉴于筛选与培殖实验动物对提高脑立体定位的准确性十分重要，对这些问题也作了阐述。

图谱的第一部分为广西、云南树鼩脑图谱，第二部分为广西猕猴脑图谱。

图谱的拉丁文名词，采用 1963 年 R. Emmers 和 K. Akert 写的松鼠猴脑立体定位图谱中的名词。颅、脑的重要资料与参数列于附表。

图谱的编制工作应追溯到 1979 年，当时作者从事脑的高级功能研究。为了提高脑结构立体定位的准确性，同时为操作式条件反射筛选良种，我们把猕猴的解剖学、生理学、行为学的研究与驯养、筛选、培殖结合起来，后来又扩展到树鼩的研究。故本图谱是我们十多年经历和实验的结果。现在 GM－Ns 广西猕猴良种已发展到第三代。

作者对为图谱作出贡献的同僚和朋友深表谢意。十分感谢张唯嘉小姐、唐有新先生辛勤而技术熟练地制作了许多组织切片和照片，覃立进先生在实验动物的筛选培殖方面做了辛勤的工作，何少健先生协助了对树鼩脑的大体测量。特别感谢方中祜教授对这项工作给予精神上的鼓励与支持。最后十分感谢中国医学科学院神经科学委员会主席万选才教授、中国中医研究院针灸研究所陶之理教授在审稿方面的特殊帮助。

感谢广西壮族自治区卫生厅、教委、科委给予支持。

编　者

1989 年 10 月于南宁

Introduction

Primates as laboratory animals occupy an important position in the study of neuroscience, particularly in the study of higher-order functions of the brain. Compared with the other primates, monkeys are more often used for brain researches in the laboratories of neuroanatomy, neurophysiology, neuropathology and neuropsychology. The adoption of stereotaxic technique to study the anatomy and physiology of interior structures of the brain requires prediction of the locations of the structures by using bony landmarks on the skull as reference points under a three-dimensional coordinate system without removal of the skull. Therefore, the precision and accuracy of the prediction plays a decisive role to ensure the success of the experiments. Up to the present time, various atlases of the brian of rhesus monkeys have been published to serve as an anatomical guide. However, owing to the difference in subspecies and populations, there exists a considerable variation in the proportions of the skull and brain of the monkeys which brings about serious mismatch between the atlas and the individuals and results in failure.

In Some provinces of China such as, Guangxi, Yunnan, Guizhou and their neighbouring areas are rich in primate animals, including the rhesus monkeys and the shrews, and being become the main sources to provide laboratory animals. Therefore, it would be desirable to make atlases from animals produced in these areas. The datas of the rhesus monkeys collected in the present atlas are *Macaca mulatta* from Guangxi, and the shrews are *Tupaia belangeri* from Yunnan and Guangxi. Considering that both rhesus monkeys and shrews are primate animals with the similar structures in cortical areas, basal ganglia and below the diencephalon in the brain, and are rich in natural resources in China as well, it would be much convenient for comparative studies to compile these animals in one atlas. Furthermore, in view of the great importance of selection and breeding of the animals in raising the accuracy of the localization of the interior structures in the brain, these issues have also been included in the present atlas.

The first part of this atlas is the brain of *Tupaia belangeri* originated from Yunnan and Guangxi, the second part of this atlas is the brain of Macaque monkey originated from Guangxi.

The Latin nomenclature in this atlas is adopted from a stereotaxic atlas of the brain of the Squirrel monkey, edited by Raimond Emmers and Konrad Akert, 1963. Important data and parameters of the skull and brain are listed in attached tables.

The preparation of the atlas can be traced back to 1979 when the present authors were engaged in a research project on the mechanism of higher-order functions of the brain of the rhesus monkeys. In order to improve the accuracy of the localization of interior structures of the brain

with stereotaxic instrument and to screen out a fine breed for operant conditioning as well, we carried out anatomical, physiological and behavioral studies on the monkeys in combination with training, selection and breeding, and soon after that we extended our work to shrews. So, the present atlas is based on the ten year's experience and experimental results. Now, a fine breed of rhesus monkeys, GM—Ns, in our laboratory has entered the third generation.

The authors are deeply indebted to all colleagues and friends who have contributed greatly to this atlas. Our greatest acknowledgement goes to Ms. Weijia Zhang and Mr. Youxin Tang for their assistance in making histological sections and photographs diligently and skillfully, to Mr. Lijin Qin for his hard work on selection and breeding of the animals, and to Mr. Shaojian He for his help in making gross measurement on Tupaia's brain. Our special thanks go to Prof. Zhongfu Fang for his greatest encouragement and moral support. Finally, we are very grateful to Prof. Xiancai Wan, the chairman of Neuroscience of Chinese Medical Academy of Science and Prof. Zhili Tao of the Research Institute of the Academic Committee Acupuncture and Moxibustion of Chinese Academy of Traditional Chinese Medicien for their reviews on our manuscription.

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Oct. 1989 **Editors**

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目　录

Contents

中缅树鼩脑立体定位图谱

树　(*Tupaia belangeri*)脑新皮质占全脑皮质面的59%。根据细胞构筑特征,新皮质可分为五个区域,即前额区皮质、中央额区皮质、顶区皮质、颞区皮质和枕区皮质。众所周知,额区型皮质是种系发生上最晚的结构,它首先出现在哺乳动物,随种系发生而迅速增大,到人类则发育到最高峰。树鼩的前额区型皮质占整个皮质面的15%,比黑猩猩(16%)略小。与前额区皮质密切联系的皮质下主要的神经核——背内侧核占树鼩丘脑体积的8%,比猕猴(12%)为小。此外,树鼩的腹后外侧核占丘脑体积的21%,比猕猴者(18%)更大(张培林等,1987)。这些资料表明,树鼩划为灵长目动物最恰当,需要时可作为理想的神经科学研究用的实验动物(杨文光,1990)。目前尚缺树鼩脑立体定位图谱。这本图谱的目的是给研究树鼩脑内结构立体定位者提供有效的解剖学指南,内容包括大脑皮质区、基底神经节、间脑、中脑、脑桥的主要神经核团。

材料与方法

本研究用成年树鼩42例,体重为90～120克。其中32例(23例为雄性,9例为雌性)为产于云南省的中缅树鼩滇西亚种,其余10例(9例为雄性,1例为雌性)为捕自广西壮族自治区龙虎山的中缅树鼩越北亚种。根据外生殖器官的形态和齿数为判别动物年龄的标准(邹如金等,1987)。脑固定于10%福尔马林液52h.以上。29例脑用大体测量方法检查,其余13例用神经组织学方法检查。

1. 立体定位技术

立体定位技术是以三个互相垂直的标准平面的三维座标系统为基础。这些平面是:正中矢状面或正中面,位于正中线,把脑分成"左"和"右"("左"或"右")两半球;APO平面或耳间线平面,为通过耳间线的垂直面把脑分成咀侧和尾侧部;HO平面或水平面,是一个经修正后的零平面,与脑轴平行且位于耳间线上4mm。APO平面前方诸额状切片冠以"A"并且用正毫米数表示,而APO平面后方的诸额状切片冠以"P"并且用负毫米数表示。HO平面以上的诸水平切片用正毫米数表示,而HO平面以下的诸水平切片用负毫米数表示。

为了使HO平面与脑轴平行又需通过齿桥上缘和耳间线,为此,齿桥上缘应低于耳间线3mm,即把头牢固地固定于上颌齿槽突下缘第二门齿后隙。这样做时,通过齿桥上缘与

耳间线的假想平面 0′即成为修正后的零平面(图 1)。而三个平面,即正中平面,APO 平面和 HO 平面之交点即为立体定位三维座标系统的零点。必须强调,要使测量准确,调准零点是很重要的。

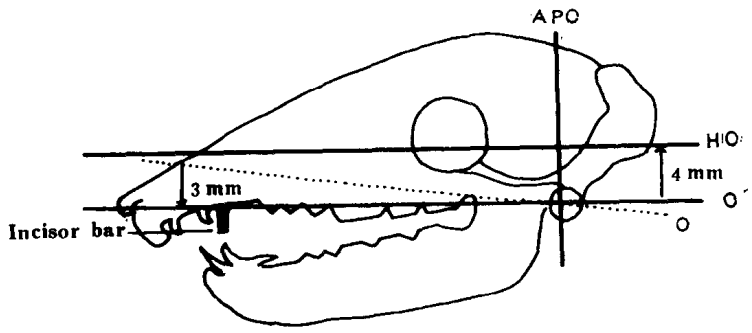

图 1　APO 与 HO 平面的设计　(外侧面观)

为了提高座标系统的准确性,采取了下列措施(杨光文,1990):

(1) 脑上 APO、HO 平面的标志系用装在脑立体定位仪(日产成茂 SN—2)上的专用刀作出(图 2)。

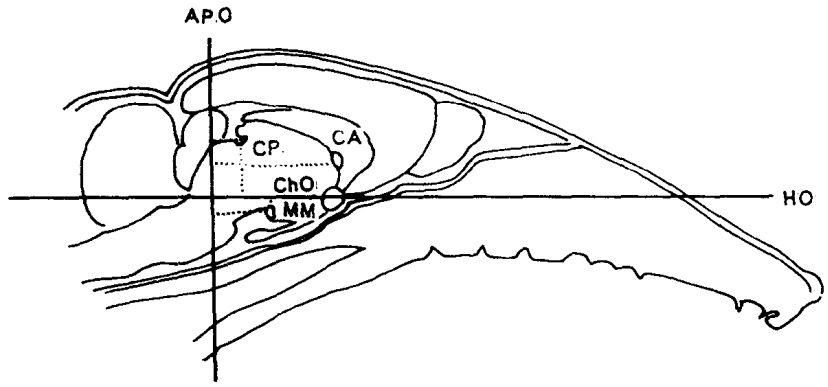

图 2　头正中矢状切内侧面示 APO 和 HO 平面经脑内结构位置

(2) 用体视显微镜核对纠正了用肉眼观察的大体测量数据的偏差。

(3) 用装在脑立体定位仪上的刀切成 5mm 厚之脑块。然后,作冰冻连续切片 40μm 厚。膨胀系数为 0.06/mm。用相应脑块切片之平均数来纠正误差。11 例脑作了连续额状切片,1 例作了连续矢状切片,1 例作了连续水平切片。相邻的切片,分别用改良 Pischinger 美蓝染色,Bielschowsky-groβ 方法进行细胞与纤维染色,以便对照观察。(杨文光,1987、1990;陈佛痴,1954)

(4) 用大体和组织学测量脑数的比例为 7∶3,两个树鼩亚种的比例是相同的。

2. 图谱简介

图谱包括三部分：

(1) 树鼩脑的外侧面、背面和腹侧面大体结构图解。

(2) 矢状切片之照片及其对照的线条图由 34 号(雄性)脑的切片直接投影制成。

(3) 额状切片之照片及其对照的线条图由 30 号脑切片直接投影制成。

线条图从相应照片并且在显微镜下与切片细心地核对下绘成。用三维座标确定其结构及其毗邻结构的空间位置。神经核名称是用缩写字标明，用虚线画界。照片和线条图相结合对使用者验明脑结构及其准确定位都会提供方便。座标上刻度以 mm 为单位，实际长度反映放大倍数。

脑研究用树鼩的选择

正如大家所知，脑研究方面的大量工作是用立体定位仪完成的。好像许多特殊技术一样，立体定位方法有长处亦有限度。为了使电极安插得准确，它要求颅骨和脑的数值个体间差别小。附表 1 的资料分析表明产于广西龙虎山地域的中缅树鼩越北亚种脑的差别比产于云南省的中缅树鼩滇西亚种脑的差别为小。以图谱所示为例，树鼩丘脑下部室旁核的大小在额状位是 0.5mm 而在额状切片的垂直径是 1.0mm，因为大多数结构比这个核大，额状位和垂直位上分别以 0.4mm 和 0.8mm 的误差作为评价标准似乎是可行的。用这个标准分析附表 1(第 18 页)与附表 2(第 19 页)的资料可见产于云南的滇西亚种树鼩额状位的误差较多地超过此标准。因此，筛选和培殖恰当的树鼩亚种是满足脑立体定位研究需要的根本措施。

脑的大体解剖

菲律宾种树鼩皮质第一、二体感区的定位已有过描述(Sur, M., R. E. Weller, 1978, 1981)。缅甸种树鼩大脑半球外侧面除有嗅沟外就没有脑沟了。在大脑上静脉的深面，脑切片显微观察可见浅的脑沟。在活体，翻开头皮，透过薄的颅骨，在上矢状窦的两旁，该静脉易为肉眼辨认。它们可作为划分各皮质区的解剖学标志(图 3、4、5)，同时，当在上矢状窦旁进行手术，可防止因伤害这些血管而引起的大出血。