

李思发 等著

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责任编辑 张雪娟

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上海科学技术出版社出版、发行

(上海瑞金二路 450 号 邮政编码 200020)

新华书店上海发行所经销 浙江农业大学印刷厂印刷

开本 787×1092 1/16 印张 15.75 插页 4 字数 354 000

1998 年 2 月第 1 版 1998 年 2 月第 1 次印刷

印数 1—1 300

ISBN 7-5323-4611-0/S·481

定价:50.00 元

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内 容 简 介

本书对鲢、鳙、草鱼、青鱼、团头鲂、兴国红鲤、散鳞镜鲤、方正银鲫、尼罗罗非鱼和奥利亚罗非鱼的形态特征、生长性能、繁殖性能、生化遗传、核型、DNA 含量、营养成分进行了详尽的比较研究和种质分析,提出了它们的种质标准,并介绍了研究方法和手段。书中列有非常翔实的科学性和可靠性的数据,对我国淡水养殖苗种生产体系的标准化和规范化具有重要指导意义。

本书可供国内外鱼类原、良种生产和研究者参考。

前言

我国是世界上淡水养殖业最发达的国家,淡水鱼产量占全世界产量的二分之一。这同我国种类繁多、种质优异的淡水鱼类种质资源是分不开的。辽阔的沿海海域与内陆水域,以其多种多样的地理、气象等自然条件,孕育了多样性的水生生物种质资源。自然分布于我国的淡水鱼类有 800 余种,海淡水洄游性鱼类近 70 种,其他如虾、蟹等甲壳类,蚌、螺等贝类,蛙、大鲵等两栖类,龟、鳖等爬行类的水生动物,以及莲、藕、菱等水生维管束植物,种质资源十分丰富。

60 年代,我国突破了“四大家鱼”人工繁殖技术,彻底扭转了我国淡水养殖受天然苗种限制的局面,也为其他水产养殖对象的人工繁殖奠定了基础,从而为我国水产养殖业的大发展创造了条件。1994 年全国人工繁殖鱼苗产量达 1 400 亿尾之多。但生产单位普遍存在只注重产量,不讲质量,忽视种质,近亲交配,逆向选择,品种混杂等问题。

70 年代末,改革开放的政策给水产养殖业带来了空前的发展机遇。水产养殖产量成倍增长。但与此同时,水产苗种在国内的东西南北大交流,国内外的无序交流也达到了空前的程度。杂交鱼已大量进入天然水体。经生物技术处理,改变了遗传性状的鱼开始进入社会。天然基因库的“基因污染”问题已迫在眉睫,成为持续发展水产养殖的巨大潜在威胁。

我国是世界上人口最多、人均耕地较少的国家。近年来,水产生产的高速发展在很大程度上是依靠消耗大量生产要素资源、自然资源来维持的,造成水资源不足,水质环境恶化,渔业资源衰退。种质资源正面临空前的压力乃至破坏。

基因一旦丢失,物种或品种一旦消灭,就永远不能恢复。面对上述已存在的问题和行将到来的威胁,而我们对传统的或引进的主要淡水养殖鱼类的种质又尚不明了,这是多么的危险。种质及其参数的研究、种质标准的制定已紧迫地摆在我们的面前,它对保护和利用优良养殖对象,对我国水产养殖业的持续发展,既具有时代意义,又具有历史意义。

二

青鱼、草鱼、鲢、鳙、团头鲂、鲤、鲫等鱼类具有生长快、食性广、抗病力强、肉质鲜美、生态互补性强及综合效应高等特点,成为我国淡水池塘养殖及大水面增养殖的优良对象,我国还先后从国外引进了镜鲤、尼罗罗非鱼、奥利亚罗非鱼等优良养殖鱼类,丰富和发展了我国水产养殖所需的种质资源。

鲢 (*Hypophthalmichthys molitrix*), 鳙 (*Aristichys nobilis*), 草鱼 (*Ctenopharyngodon idellus*), 青鱼 (*Mylopharyngodon piceus*), 是我国特产的经济鱼类,是我国水产养殖的“当家

鱼”，也是世界性重要养殖鱼类。鲢、鳙、草鱼的养殖产量分别居我国淡水养殖总产量的第一、三、二位。然而，这些重要养殖对象基本上还停留在野生群体阶段，即尚未形成人工选育的优良品系。在几乎所有的养殖场，都面临着有效群体数量较少，逆向选择，近亲交配以及由此而引起的经济性状衰退和基因库的萎缩等问题。

团头鲂(*Megalobrama amblycephala*)是60年代发现的优良养殖对象。30多年来，由于原产地的过度捕捞，以及大量的人工放流，还有各地的广泛移植和人工繁殖，团头鲂的种质资源正受到衰退和混杂的威胁。

鲤鱼(*Cyprinus carpio*)是我国分布最广的经济鱼类之一，也是世界上许多国家的主要淡水养殖对象。我国和世界上其他国家劳动人民通过长期生产实践，在自然变异的基础上，经过多年的人工选择和自然选取，培育了许多鲤鱼品种。在我国有兴国红鲤、荷包红鲤等。兴国红鲤(*Cyprinus carpio* var. *singunensis*)是江西省的地方品种，具有体色鲜红、肉嫩味美、生长较快、繁殖力强、抗逆性强、较耐低氧、食性杂、适应性广等优点。在国外，镜鲤是在欧洲从家养鲤鱼分离出来的一个品系，鳞被变异是其主要形态特征。镜鲤的鳞被由基因S和N控制，无鳞的称为裸鲤或革鲤，基因型为ssNN；在侧线鳞位置有一行鳞片的称为线鳞镜鲤，基因型为SSNn或SsNn；体表覆被离散鳞片的称为散鳞镜鲤，基因型为ssnn。我国于60年代由苏联引进了散鳞镜鲤，80年代又先后从西德引进了德国镜鲤，从苏联引进了乌克兰散鳞镜鲤。镜鲤具有生长速度快的优点。

上述红鲤和镜鲤除了直接用来养殖外，在我国普遍利用它们作为育种材料。70年代以来，我国利用这两种鲤鱼同其他鲤、鲫鱼配制了不少杂交组合，对池塘养殖的增产起了一定的作用。

银鲫(*Carassius auratus gibelio*)是鲫的亚种，广泛分布在我国东北地区、西北地区、朝鲜及欧洲各国。黑龙江流域所产的银鲫不但有其独特的遗传特性和繁殖特征，而且具有生长快、肉味鲜美等特点。在黑龙江银鲫中，尤以产于方正县双凤水库的银鲫(简称方正银鲫)最为突出，被全国各地普遍引种推广。方正县双凤水库近年曾因库区水位严重下降，越冬期间冰下缺氧，发生库内各种鱼类几乎死亡殆尽的事件，加之过去对资源管理不善，造成了银鲫原种资源的严重破坏，现正采取措施予以恢复中。不过，方正银鲫仍然是全国影响最大的鲫鱼品系。这是因为，我国自70年代后期以来，用雌方正银鲫和雄兴国红鲤生产的异精雌核发育子代——异育银鲫被广泛使用于养殖生产。所以，本研究选用方正银鲫作为研究材料。

尼罗罗非鱼(*Oreochromis niloticus*)和奥利亚罗非鱼(*Oreochromis aureus*)具有适应性强、繁殖力高、食性广杂、抗病力强及肉味鲜美等特点，为世界重要养殖鱼类。自70、80年代分别引进我国以来，已成为我国重要的淡水养殖对象。我国罗非鱼产量现居世界首位。罗非鱼类很容易在种间自行杂交。近年来，由于近亲繁殖、亲本混杂等原因，引起了罗非鱼种类的退化和混杂，造成生长速度降低、体色变杂、性成熟提早等。

三

水生生物种质资源是建设和发展“高产、优质、高效”渔业的重要物质基础。国内外都十分重视种质资源的开发、保存、利用及良种培育。种植业在这方面已取得了令人瞩目的成就。

在国外,发达国家都十分重视水生生物种质资源的研究。洄游性鱼类的过鱼设施、水生生物天然产卵场保护技术较为完善。近年来,更为重视种质资源基因的保护研究,先后发展了从细胞水平、分子水平对种群进行遗传鉴别的技术、超低温保存精子技术,种质资源经济性状基因定位及预测技术也有了良好的开端。前苏联成功地保护了占世界 90% 以上的鲟科鱼类资源,其鱼子酱产量已达历史最高水平;挽救了名贵的小白鲢,其禁渔令已由于资源的恢复而取消。美国对主要养殖对象虹鳟、斑点叉尾鲟等均建有品系登记制度。

我国自 80 年代以来开始重视水生生物种质资源的研究。在基础理论方面,“六五”期间农业部提出了“长江、珠江、黑龙江鲢、鳙、草鱼原种收集和考种”课题;“七五”期间提出了“淡水鱼类种质鉴定技术”课题;“八五”期间进行了“淡水鱼类种质标准参数的研究”课题研究;在开发应用方面,设立了“淡水鱼类种质资源库研究”课题,探讨在封闭型和开放型的长江故道里保护和开发长江“四大家鱼”、在湖泊里保护和开发利用团头鲂的途径;在水产原、良种生产体系和管理方面,成立了全国水产原、良种审定委员会,已批准在全国建设 20 多个水产原、良种场。

为了建立我国水产养殖苗种的生产体系,实现良种生产的科学化、标准化、系列化及产业化,迫切需要养殖种类的种质标准。过去,虽然对主要养殖对象进行过不少研究,但从种质标准角度的研究却是凤毛麟角;“七五”期间“淡水鱼类种质鉴定技术”对鲢、鳙、草鱼、青鱼等十种鱼的种质标准曾做过许多工作,但结果尚不能满足制定种质标准和科学管理的需要。种质标准是一项十分严肃、十分认真的基础工作,“失之毫厘,谬以千里”。所以,国家在“八五”期间再次列题研究,务期得出比较可靠的结果,以指导原、良种生产。

1 研究对象和材料来源

本项目研究“淡水鱼类种质标准参数研究”包含十种鱼,它们是传统的重要养殖对象——鲢、鳙、草鱼、青鱼、鲤、鲫鱼,60 年代开发的重要养殖对象——团头鲂,以及 70 年代引进的两种罗非鱼——尼罗罗非鱼和奥利亚罗非鱼。

鲢、鳙、草鱼、青鱼自然分布于北起黑龙江(无鳙鱼天然群体),南到红河的东亚的大、中型河流域水系里。现已查明,长江水系的养殖性能最优,加之长江种群数量最大,对我国养殖生产的影响最大,故本研究选取这四种鱼的长江种群为代表。

团头鲂的自然分布很窄,仅限于湖北省梁子湖、淤泥湖,江西省鄱阳湖等长江中游一些大、中型湖泊中。本研究选取淤泥湖的团头鲂为代表。

鲤鱼,如前所述,我国鲤鱼天然种群的种质已混杂,本研究选用我国选育而且保存良好的兴国红鲤、黑龙江水产研究所引进的散鳞镜鲤为研究材料。我国的普通鲤鱼已难觅原种,无材料进行种质研究,实为憾事。

方正银鲫是全国影响最大、研究资料较丰富的鲫鱼品种。本研究选其作为鲫鱼的代表。

目前,在我国养殖比较普遍的尼罗罗非鱼,是 1978 年中国水产科学研究院长江水产研究所从苏丹引进的后代。奥利亚罗非鱼是中国水产科学研究院无锡淡水渔业研究中心从美国奥本大学引进的后代。本研究所用的这两种材料来自江苏省南京水产良种场。该场是我国罗非鱼生产规模较大、影响较广的场家之一。

凡有天然群体的,研究材料尽可能采用天然材料;凡无天然群体的,研究材料均从相应的原种场或保种单位引入苗种,在上海水产大学种质资源试验站培育,以供试验的需要。

2 研究方法和手段

本研究选用历史比较长、技术较为成熟、结果比较可靠的方法。不求在方法上标新立异,但在结果上稳定可靠,可操作性和可比性强。为此,我们要求做到:

(1)研究材料代表性强。材料来源如上所述。众所周知,生长环境对鱼有较大影响,因而在研究中,凡有天然种群的,尽可能使用天然种群;凡无天然种群的,则在适宜的饲养环境里培育。

(2)研究样本材料数量大,足以满足统计学要求。

(3)测定方法统一并标准化。

(4)测定基本上做到专人负责,减少人为误差。

(5)研究从定性、定量两方面进行。应用生物统计方法统计分析。

四

本研究共对十种鱼的 10 600 余尾标本进行了各项测定,测定数据达 30 万个以上,是我国目前关于鱼类种质标准参数研究最完善而详尽的一次。这对我国淡水养殖苗种生产体系的标准化和规范化具有重要的指导意义,是实现水产养殖“种子工程”的根本性工作。为发挥研究成果的社会效益,我们把主要成果和有关资料汇编成此书,以供鱼类原、良种生产和研究参考。

全书文稿承上海市水产研究所俞豪祥研究员和湖南省水产研究所吴维新研究员审阅,特此致谢。

李思发

上海水产大学 1996 年 10 月

PREFACE

1. China is the most developed country in freshwater aquaculture; its production consists of 1/2 of the total freshwater aquaculture production of the world. The developed aquaculture largely depends on rich aquatic genetic resources characterized by abundant species and outstanding performance. In China, the broad inland waters and coastal waters and the diverse geography, climate and other natural conditions breed plentiful aquatic genetic resources. There are more than 800 freshwater fishes, 70 migratory fishes, and many other aquatic animals such as crustaceans (shrimps, crabs), shellfish (mussels, snails), amphibian (frogs), reptiles (turtles) and aquatic vascular plants (lotus, water caltrops).

In 1960s, the breakthrough of artificial propagation of "four Chinese farmed carps" radically changed the passive situation in which the freshwater fish culture had been limited by the natural fry, and laid a foundation for propagation of other fishes. This success created the new era of quick development of aquaculture in China. The total production of fish fry reached 1 400 000 000 in 1994. But some serious problems such as brooder quality, inbreeding, negative selection, mixture of brood stocks exist extensively in fish farms.

Since 1980s, the Reform & Open policy in China has provided an unprecedented opportunity for the development of aquaculture. The total production of aquaculture increased drastically year by year. Meanwhile, frequent exchange and poorly planned transplantation of aquatic seeds has become serious; various fish hybrid enter into natural waters, some genetic modified fishes produced by biotechnology appear in society. The "genetic pollution" problem has been posed and has become a great potential threat to the sustainable development of aquaculture.

China has the largest population and the lowest arable land per capita. In recent years, the quick development of aquatic production depended mostly on the use of productive natural resources, which have caused deterioration of the aquatic environment and decline of fisheries resources. The aquatic genetic resources are facing high pressures and serious destructive forces.

It would be unrecoverable if a gene is lost, or species/strain becoming extinct. Faced with above existing and impending menace, it is even more dangerous if we don't understand the genetic characters of major traditional and introduced freshwater culture fishes. It is of contemporary and historic significance for the sustainable development of Chinese aquaculture to study fish genetic resources and its characters, to formulate genetic criteria and to conserve and utilize these superior culture fishes.

2. Endemic black carp, grass carp, silver carp, bighead carp, blunt snout bream, common carp and crucian carp characterized by fast growth, wide feeding, high disease resistance, good taste, ecological complement and high culture efficiency, are the superior species for Chinese pond culture and inland water enhancement. By the way, exotic fishes such as mirror carp, Nile tilapia (*Oreochromis niloticus*) and blue tilapia (*Oreochromis aureus*), have enriched the genetic resource of Chinese aquaculture.

Silver carp (*Hypophthalmichthys molitrix*), bighead carp (*Aristichthys nobilis*), grass carp (*Ctenopharyng-*

godon idellus) and black carp (*Mylopharyngodon piceus*) are Chinese endemic economical fishes, most important species in aquaculture. The production of silver carp, bighead carp and grass carp ranks at the first, third and second in Chinese total freshwater culture production respectively. But these major culture species still stay at wild population stage and have not become the superior breed strains by artificial selection. Almost all fish farms are faced with the problems, such as small effective brood stocks, negative selection, inbreeding, which causes decay of economical characters and shrinkage of gene pools of these species.

Blunt snout bream (*Megalobrama amblycephala*) was found in 1960s, and became an excellent culture species. In the past 30 years, due to excessive harvest in original places, extensive artificial stocking, large scale transplantation and artificial propagation, the genetic resource of blunt snout bream has been threatened.

Common carp (*Cyprinus carpio*) is widely distributed in China, and also was the major culture species in other countries. Through long term practice in China and other countries, many varieties of common carp have been produced by artificial and natural selection. In China, the famous varieties are Xingguo red carp and purse red carp. Xingguo red carp (*C. c. var. singuonesis*) is a native breed of Jingxi Province with bright red color, good taste of flesh, faster growth, high fecundity, high disease resistance, low oxygen consumption, wide feeding habit and wide adaption. Mirror carp was a strain separated from farmed carps in Europe, characterized by scale cover variation in morphology. The scale coverage of mirror carp are dominated by gene S and N in genetics; fish without scale coverage is called naked carp or leather carp, its genotype is ssNN; fish with one line scale on the position of lateral line is called line-scaled mirror carp whose genotype is SSNn or SsNn; fish with scattered scales on the body is scattered mirror carp, which genotype is ssnn. Mirror carp are characterized by fast growth. It was introduced into China from the West Germany and USSR in 1980s.

The red carp and mirror carp, mentioned above, except used in culture, are used widely as breeding materials. Since 1970s, many hybridization combinations were produced between these carps and local strains of common carp and crucian carp, some of them have played a significant role in increasing of pond culture production.

Silver crucian carp (*Carassius auratus gibelio*), a subspecies of crucian carp, are mainly distributed in the northeast and northwest of China, Korea and European countries. The populations of crucian carp in Heilongjiang river basin is well known not only by its unique triploidy character and gynogenesis propagation type, but also its fast growth and good taste. Among these populations, crucian carp in Fangzheng reservoir of Heilongjiang Province is an outstanding one, which has been widely introduced and extended in most of provinces of China. Because the water level decreased drastically and oxygen depletion under water in wintering stage in recent years, almost all fishes in the Fangzheng reservoir died, the crucian carp resource suffered severely destruction. Now some measures have been taken to restore this population. Because Fangzheng crucian carp is the most influenced strain of crucian carp in China, particularly since the end of 1970s, female Fangzheng crucian carp is used with male Xingguo red carp (heterologous sperm) to produce allogynogenetic crucian carp, which have been widely extended and cultured in production.

Nile tilapia (*Oreochromis niloticus*) and blue tilapia (*Oreochromis aureus*) are characterized by strong adaption, high reproduction, wide feeding habit, disease resistance and good taste of flesh, are the major farmed fish species in the world. After introduction to China in 1970s and 1980s, they have become major farmed species in China. Now the tilapia production of China has reached the first in the world. Because easy interspecific hybridization, inbreeding and mixture of stocks, degeneration has appeared. For example, their growth rate has decreased, body color has mixed and earlier maturity happened.

3. Aquatic genetic resources are the most important basic substance to develop high production, super quality and high efficiency fisheries. Therefore, high attention has been paid on the exploitation, conservation, utilization of genetic resources in the world. Crops have had an outstanding achievement in these fields.

In developed countries, research on aquatic genetic resource have been paid much attention earlier. Facilities of fish passage for migratory fishes, protection techniques of natural spawning grounds have been developed perfectly. In recent years, genetic conservation have got an extreme attention, the techniques of identification of different populations from cell level and molecular level, cryopreservation of sperm have been developed. Study on the gene location of economic traits and forecasting also have a good beginning. The former Soviet Union had protected successfully 90 percent of sturgeon resource in the world, the production of sturgeon egg jam reached the highest historical level. For the famous *Coregonus* spp, fishing forbidding regulation has been withdrawn because the reestablishing of resource. In U. S. A., the strain registration policy has been established for major culture fishes such as rainbow trout and channel catfish successfully.

In China, the research on fish genetic resource was started in 1980s. In fundamental theory fields, projects of "Collection and genetic evaluation of silver carp, bighead carp and grass carp populations in the Changjiang River, Zhujiang River and Heilongjiang River" in 1981-1990, "Genetic identification of major freshwater fishes" in 1986-1990, "Genetic characterization of major freshwater culture fishes" in 1991-1995 had been conducted successfully. In exploitation and utilization aspects, the project "Genetic resources pool of major freshwater fishes", aiming the conservation of Chinese carps in open-type and close type oxbows of the Changjiang river, and the conservation of blunt snout bream in lakes were conducted. In seed production system and management aspects, National Certification Committee for Aquatic Origin and Improved Seed was founded, and over 20 aquatic origin fish station had been constructed.

In order to build the production system of aquatic seeds, and to realize the scientific, standardized, serialized and industrialized production of superior seeds, there is an urgent need to understand the genetic characters of major culture fishes. In past, many research was done on major freshwater culture fishes, but few work was on the genetic resource. In 1986-1990, many works had been done in the identification techniques of germplasm, a lot of work had been conducted in genetic characterization of major freshwater fishes. But the existing results are still imperfect to meet the establishment of genetic criteria and to put the management on a strong scientific basis. Genetic characterization is a serious and fundamental work.

In order to obtain reliable results to build production and management of origin fish and genetic improved seeds, the project "Genetical characterization of major freshwater culture fishes" (1991-1995) was listed in national program again to further and perfect this important research. Here are the major points of this study:

(1) Fishes species and materials

The species in this study include ten species, involving traditional culture fishes, such as silver carp, bighead carp, grass carp, black carp, common carp and crucian carp; new exploited species in 1960s, blunt snout bream; introduced species, Nile tilapia, blue tilapia, scattered mirror carp. Silver carp, bighead carp, grass carp and black carp are naturally distributed in large rivers of East Asia, north to Heilongjiang river (There is no natural population of bighead carp), South to Honghe River. Much investigation show that the population from the Changjiang river are the best in aquaculture performance and the largest in population size, they play a large influence in Chinese aquaculture. Therefore silver carp, bighead carp, grass carp and black carp from the Changjiang river are chosen as representative of these four species.

Blunt snout bream, its natural distribution is very narrow, limiting in Liangzi lake (Hubei province), Yuni

lake(Hubei Province),Poyang lake(Jiangxi Province)and other large-middle lakes in the middle stream of the Changjiang river. The blunt snout bream from the Yuni lake is chosen as a representative.

Common carp,as described above,the natural populations of common carp in mainland China have been mixed and the original common carp is difficult to find. Therefore,xingguo red carp and scattered mirror carp were chosen as the representative of common carp in this study.

Fangzheng Crucian Carp,is an excellent strain which was widely used in most parts of China. More genetic study has been done in this strain.

Nile tilapia and blue tilapia,the most widely used Nile tilapia in Chinese aquaculture was the progeny of the population introduced by Changjiang River Fisheries Research Institute from Africa in 1978. The most widely used of blue tilapia is the progeny of the population introduced by Wuxi Freshwater Fisheries Research Center from Auburn University,USA in 1983. The materials of these two fishes used in study come from the Nanjing National Tilapia Breeding Farm,Jiangsu Province,which is a large and influenced tilapia farm.

For these ten species,if they have natural population,the study materials were collected from the natural waters;if they have not had natural population,the study materials were collected from the best seed farm, and raised at the Genetic Resources Experimental Station of Shanghai Fisheries University to meet the research need.

(2)Study methodology

The study methodology were chosen from those methods with long history,high maturity and high confidence,proven results with high reliability,high practicability and high comparability.

(A)Representative. As we all know,environments have a great effect on fish. In this study,fish populations were collected from natural waters,those which haven't natural population were bred in appropriate waters.

(B)Sampling size. Sample size is big enough to satisfy the statistical requirement.

(C)Unique and standard methodology.

(D)Measuring operation conducted by special person to minimize the personal deviation.

(E)Combination with quantitative and qualitative analysis.

4. In this study,over 10 600 fish specimens were measured or determined,about 300 000 data were recorded,it was the most perfect and detailed study on the fish genetic characterization in China. This research was of an important significance to build the standardization and regulation of freshwater fish seed production system,was a fundamental work to realize"Seed Engineering"of aquaculture. In order to exploit the social efficiency of this study,the major research achievements and relevant data are summarized in this book as reference for production and research of the origin and genetic improved fish.

We greatly thank Professor Yu Haoqiang,Shanghai Fisheries Institute,and Professor. WuWeixin,Hunan Fisheries Institute,for their prereview of the manuscripts.

Professor Li Sifa

Shanghai Fisheries University Oct. 1996



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第 一 部 分

PART ONE

综 述——比较研究

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