第2卷第2—3期　　上海水产大学学报　　Vol. 2, Nos. 2-3
1993年9月　　JOURNAL OF SHANGHAI FISHERIES UNIVERSITY　　Sep., 1993

制冷装置节能除霜型电脑控制器的研制

葛茂泉　周　红
(上海水产大学食品科学技术系,200090)

提　要　本课题的研究目标是设计以中、小型制冷装置为服务对象的通用电脑控制器。本文介绍了该电脑控制器的软件设计框图,输入输出接口线路原理;中、小型制冷装置电脑控制系统;节能型自动除霜的软硬件设计。该电脑控制器具有体积小,价格低,控制功能强,稳定可靠等优点。适合中、小型制冷装置生产过程的自动检测和实时控制,是对制冷装置自动控制微机应用产品化的有益尝试。

关键词　制冷装置,电脑控制器,软、硬件设计,自动除霜

我国的食品冷库制冷装置,大都采用继电器控制方式。对于工艺复杂或自动化程度较高的制冷装置,这种控制方式线路复杂,触点多,可靠性不高。而且重复设计,重复调试,浪费人力物力,更改工艺也极为不便。随着单片机技术的发展,采用单片机控制方式取代继电器控制方式,已成为自动控制领域的发展趋势之一。本文就采用MCS-48单片机研究设计适合中、小型制冷装置的节能型通用电脑控制器的软硬件设计思想简介如下[1]。

1　电脑控制器的软件设计思想

设定以配置1冻结间和1冻结物冷藏间的小型生产性冷库为服务对象,由1台单机双级制冷压缩机集中供冷。采用液泵强制循环方式。

1.1　制冷装置自动控制工艺要求

(1) 制冷系统运行参数的实时检测;制冷压缩机、液泵的自动保护及事故处理。
(2) 制冷压缩机、液泵等自动开停。
(3) 低压循环桶的液位控制。
(4) 冷间温度及冻结过程控制。
(5) 冷间蒸发器供液及回汽控制。
(6) 冷风机自动除霜控制。

1.2　软件设计框图

程序总框图如图1所示。其中包括冻结供液子程序DG;冷藏供液子程序CG;液泵开泵子程序KB;制冷压缩机开机子程序KJ;冷藏温控子程序CWK;节能除霜子程序CHS;正常停机子程序ZHTJ等。各子程序的编制要求符合常规继电器控制工艺规律和工人的操作习惯。

1993-06-23收到。

节能型自动除霜始点为 $I/I_0=1.125$[2]。式中 I_0 为冷风机的鼓风机初始运转电流，在冷风机启动后4分钟检测；I 为冷风机的鼓风机随机运转电流，每隔4分钟采样1次。该比值一旦达到设定值，则调用节能除霜子程序，发出除霜指令。

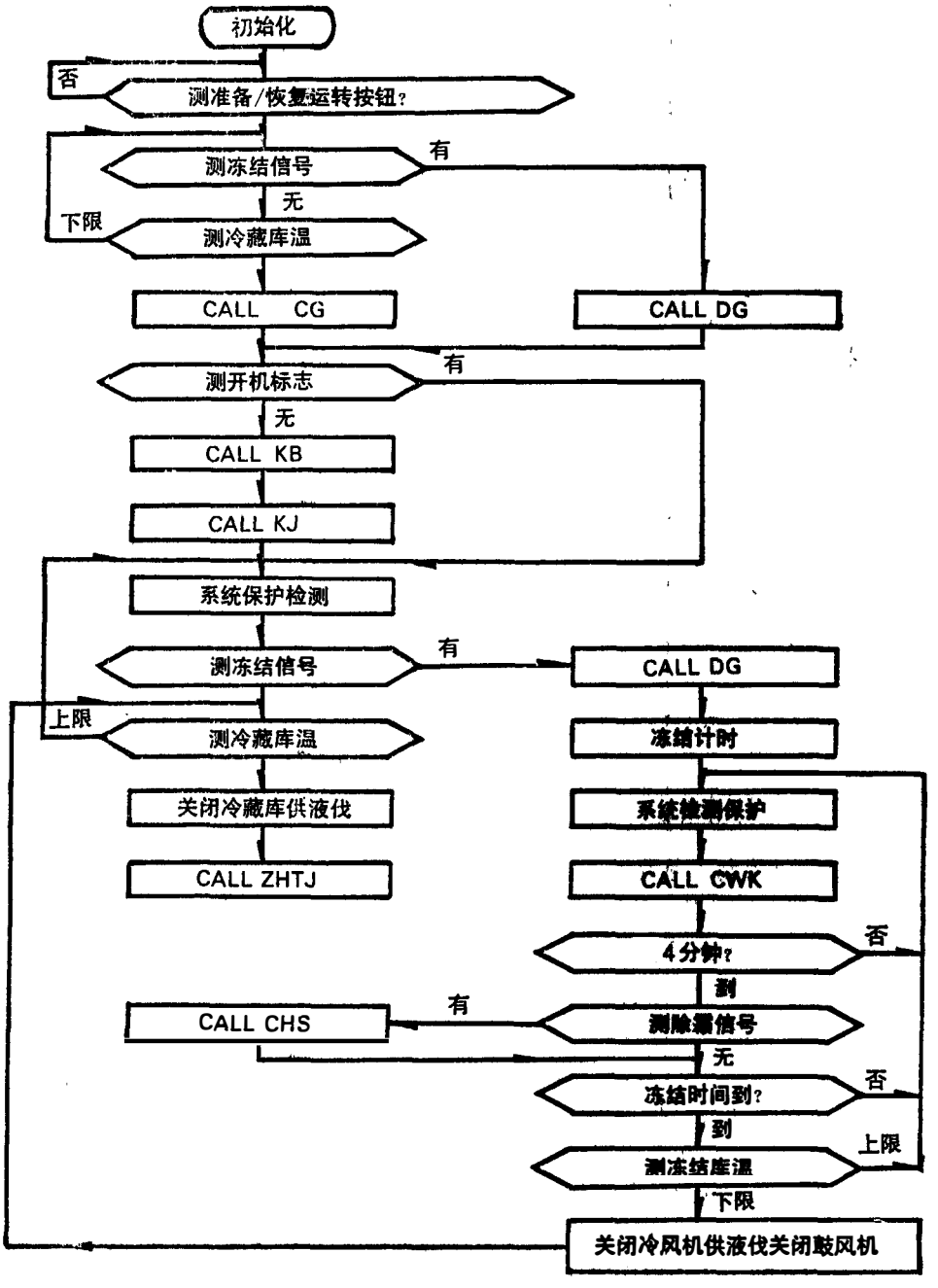

图1 程序总框图

Fig.1 Schematic diagram for program

2　电脑控制器硬件设计和制作

2.1　电脑控制器的设计要求

(1) 开关量输入。为保证制冷压缩机、液泵正常运转，在制冷系统中设置高低压控制器、油压差控制器等安全保护装置。在制冷装置运转过程中，当被控参数超出正常范围时，控制器触头动作，输出信号，通过开关量输入接口板输入单片机。本系统共有温度、液位等 11 个开关量信号。

(2) 开关量输出。单片机通过输出接口板向电磁伐等执行元件输出开关量信号，以控制制冷压缩机、液泵等被控对象的开停。本系统共设 16 个开关量输出信号。

(3) 自动/手动切换。

(4) 事故声光报警。

(5) 制冷装置运行状态信号灯显示。

2.2　电脑控制器的构成

电脑控制器由单片机、开关量输入接口、开关量输出接口三部分组成。单片机部分主要由 8039 芯片、2732 芯片、4 KEPROM 和 8243 I/D 接口扩展组成。

开关量输入接口是把各种继电器、温控器等触头动作转变为“0”、“1”信号输入单片机。在线路图 2 中，当触点 b 断开时，p 点为高电平，输入计算机信号为“1”；当触点 b 闭合时，发光两极管亮，光电耦合器导通，p 点为低电平，输入计算机信号为“0”。

开关量输出接口是将计算机的“0”和“1”信号转变为执行机构的开、关，交流接触器的闭合、断开等动作，其线路图如图 3 所示。

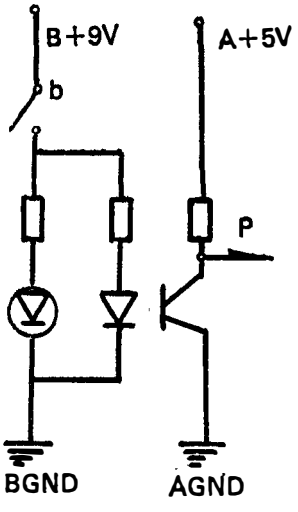

图 2　开关量输入接口

Fig.2　Switch input interface

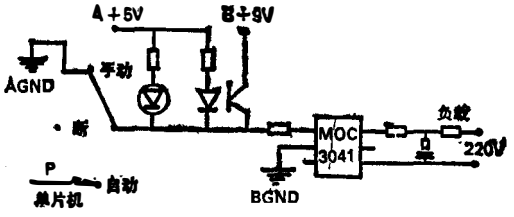

图 3　开关量输出接口

Fig.3　Switch output interface

2.3　冷风机除霜自动控制

本电脑控制器设计了两种除霜方式：淋水式及淋水与制冷剂热蒸汽联合式。除霜控制方

法设计了节能型自动除霜和指令程序除霜两种。冷风机除霜始点的选择对能耗有重要影响。我们根据对除霜始点与能耗关系的研究，确定了最佳除霜条件。冷风机的风机电流经变送器转变为频率信号，由单片机的计数引脚下输入，保证实现节能除霜自动控制。为适应不同用户的要求，本电脑控制器还设计了指令程序除霜。在电脑控制器面板上设有除霜按钮，在需要除霜时，按下该按钮，制冷装置将按预置程序进行除霜操作。除霜结束后自动恢复运行。

3 中、小型制冷装置电脑控制系统

本课题试验用制冷装置系统原理如图4所示。把压力、压差、温度、液位等控制器触点与电脑控制器相连；把电磁伐，压缩机和液泵的交流接触器线圈与电脑控制器对应接线端子相连，启动电脑控制器投入运行，即完成制冷装置电脑控制系统[3]。

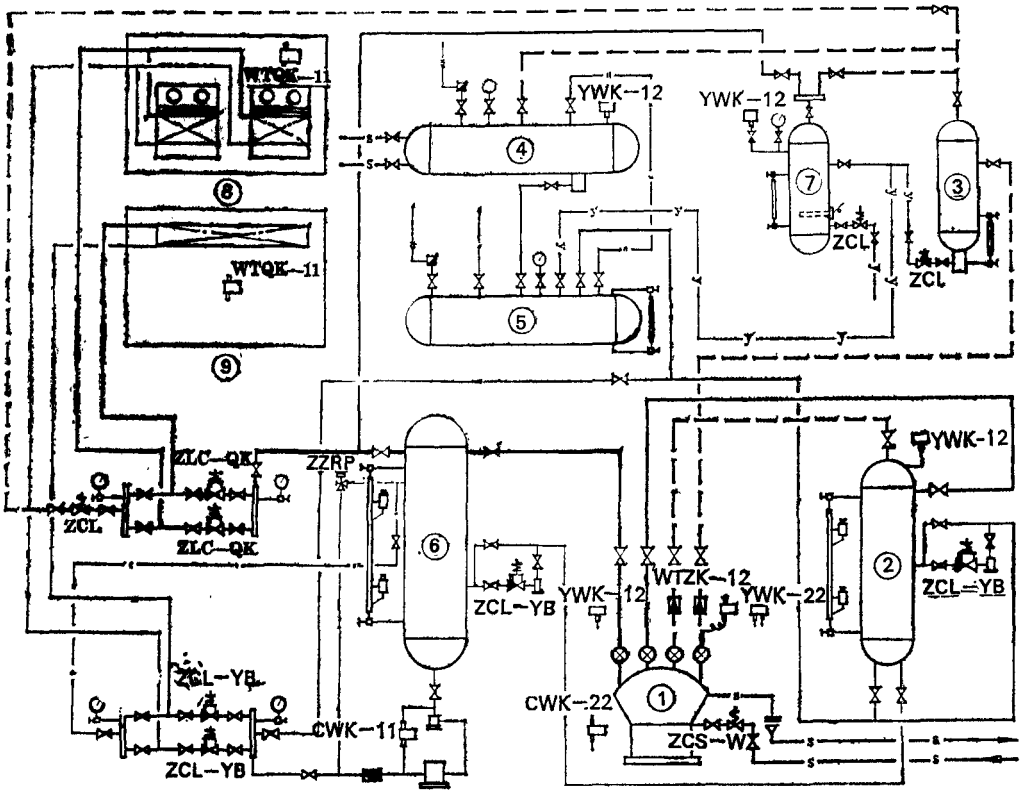

图4 试验装置系统原理图

Fig.4 Diagram for experimental installation system

1. 制冷压缩机； 2. 中间冷却器； 3. 油分离器； 4. 卧式冷凝器；
5. 贮液器； 6. 低压循环桶， 7. 贮油器； 8. 冻结间； 9. 冷藏间.

该电脑控制器的每一个执行机构都具备手动/自动切换功能。不用的设备只需把面板的对应开关置于"断"位；若用户的制冷系统与图5的试验装置不同，可使相应元件位置接线端子空着，不影响制冷装置的正常运行和控制功能。当系统运行发生故障时，电脑控制器可自动检测和保护处理。也可随时手动处理。

电脑控制器的硬件均采用接插件方式，由1块单片机板，2块输入板，3块输出板构成，便于维修。采用固态开关输出，可靠性提高。如果需要改变制冷工艺，只需修改软件，重新固化后插入控制箱内即可，不必更动线路，通用性较强[4](1)。电脑控制器箱体尺寸：240mm×150mm×135mm，体积小巧，成本远比同功能的继电式控制箱为低，而且避免了一般继电控制系统重复设计、重复调试的弊病。本机以冷风机风机电流为控制信号，实现除霜始点的最优控制，进行自动除霜或指令程序除霜操作，在我国是首次尝试，取得较好的节能效果。

本文得到王季襄教授的帮助，特此致谢。

参 考 文 献

[1] 徐爱卿等，1986.单片微型计算机，4—127.北京航空学院出版社(京).
[2] 葛茂泉，周红，1993.冷风机除霜始点的最优控制. 上海水产大学学报，2(1)：24—33.
[3] 石家泰等，1980.制冷空调的自动调节，210—288.国防工业出版社(京).
[4] 潘新民，1988.微型计算机控制技术，4—178.人民邮电出版社(京).

ON MICROCOMPUTER CONTROL FOR ENERGY SAVE DEFROSTING SYSTEM IN REFRIGERATING INSTALLATION

Ge Mao-quan and Zhou Hong
(Department of Food Science and Technology, SFU. 200090)

ABSTRACT This paper aims at studying the microcomputer control for the refrigerating installation of middle or small size. The schematic diagram of software design, the principle of connection line for input and output interface, the microcomputer control system for the installation and the designs of software and hardware for auto-defrost system of energy-save type were studied in the paper. The microcomputer control has the features of small dimension, high controllability, good stability and reliability, low cost, etc, and is appropriate to the self-test and real-time control of the refrigerating installation in the process of running. Hence, it will help commercialize the energy save defrosting system for the refrigerating installation by microcomputer control.

KEYWORDS refrigerating installation, microcomputer control, designs of software and hardware, auto-defrost

(1) 复旦大学科教仪器厂，1987.MCS-48单片微计算机实用子程序手册，(Ⅰ-5-1)—(Ⅰ-7-6).复旦大学科教仪器厂.

第2卷第2—3期 上海水产大学学报 Vol.2, Nos. 2—3
1993年9月 JOURNAL OF SHANGHAI FISHERIES UNIVERSITY Sep., 1993

综 述

FISH BIOTECHNOLOGY IN CHINA

Zhang Ying-pei and Lou Yun-dong
(*Department of Aquaculture, SFU*, 200090)

ABSTRACT This review summarises the recent advancement of fish biotechnology in China. By means of temperature shock and hydrostatic pressure, Chinese scientists obtained six autopolyploid and two allopolyploid fishes. Combining the induced gynogenesis with the technique of sex reversal, Chinese scientists developed a method of establishing fish inbred lines. Several nucleo-cytoplasmic hybrids were obtained by combination of nuclei and cytoplasms from different species, genera and subfamilies. A nuclear transplanted fish was also obtained from the nucleus of short-term cultured kidney cell of crucian carp, which suggested the nucleus of fish somatic cell still retained totiptency. Electric field and laser microbeam were employed to induce the fusion between fish unfertilized eggs and blastula cells and between fertilized eggs respectively, fry or larvae were obtained in these experiments. To produce fast-growing transgenic fish, Chinese scientists made a serial investigations on integration, transcription, expression and biological effects of human growth hormone gene in fish. The method of gene transfer employed by Chinese scientists included microinjection, electroporation and exposure of spermatozoa to DNA followed by insemination. So far, Chinese scientists have cloned seven fish genes, i.e., growth hormone genes of *Cyprinus carpio*, *Ctenopyharyngodon idellus* and *Oncorhynchus keta*, beta-actin genes of *C. carpio* and *C. idellus*, prolactin cDNA of *Oncorhynchus tschawytscha* and antifreeze peptide cDNA of *Pseudopleuronectes yokohamae*.

KEYWORDS fish biotechnology, ploidy manipulation, nuclear transplantation, cell fusion, gene transfer, gene cloning

In the past decade, Chinese scientists paid much attention to fish genetic research. As a result, great progress has been made in fish biotechnology in China. The efforts to breed new cultural varieties with better traits promoted the rapid application of new technology in fis hbreeding. In the paper, some important achievements will be reviewed.

1993-05-28 收到.

1 PLOIDY MANIPULATION

So far, Chinese scientists have obtained eight artificially induced polyploid fishes, including triploids of *Cyprinus carpio*[17], *Ctenopharyngodon idellus*[13], *Salmo gairdneri*[36] and *Hypophthalmichthys molitrix*[14], autotetraploids of *S. gairdneri*[2] and *Aristichthys mobilis*[28] and allotetraploids of *Carassius auratus cuvieri* × *Cyprinus carpio*[24] and *C. carpio* × *C. idellus*[22]. The triploids of *C. carpio* and *C. idellus* displayed higher growth rates than the corresponding diploids. According to Wu *et al.* (1979), the average weight of 5-month-old triploids of carp is more than twice that of diploids reared in the same pond[17]. The methods usually employed in ploidy induction were temperature shock, chemical stimulation and hydrostatic pressure. Lu *et al.* (1982)[26] tried to produce polyploid fish by nuclear transplantation. Using the autotetraploid cells of *C. idellus* as nucleus donors, they obtained the embryos of heart-beating stage[26].

Chinese scientists have obtained the gynogenetic progeny of *C. idellus*[15], *H. molitrix*[15], *C. carpio*[18], *C. auratus*[34] and *S. gairdneri*[38]. Liu *et al.* (1987) successfully induced the androgenesis of loach (*Misgurnus anguillicaudatus*) by nuclear transplantation[3]. Combining artificial gynogenesis with the technique of artificial sex reversal, Wu *et al.* (1981) developed a way of establishing fish inbred lines[18]. After two successive gynogenesis, in the second generation of gynogenesis all individuals came of a same egg. After being treated with androgen, part of individuals of second gynogenetic generation was artificially reversed into "physiological male." By mating the "physiologically male" individuals with their sisters, three inbred lines were established[18, 31]. One of them, Red Carp 8305, was further analyzed by isozyme and transferrin electrophoresis and cross haemagglutination test. The results demonstrated that the loci controlling the transferrin, lactate dehydrogenase, malate dehydrogenase, superoxide dismutase, esterase, isocitrate dehydrogenase and red cell allotypic antigens were highly homogenous[20]. The result of scale transplantion suggested that the MHC (major histocompatibility complex) of Red Carp 8305 was homogenic.

2 NUCLEAR TRANSPLANTATION

Nuclear transplantation is a powerful technique in illustration of the functions of nucleus and cytoplasm as well as their relationship in development. Tong *et al.* (1963) initiated fish nuclear transplantation research in China[32]. They demonstrated that the nuclei of fish blastula cells still retained developmental totipotency. So far, several nucleocytoplasmic hybrids have been obtained by combination of nuclei and cytoplasms from different varieties, species, genera and subfamilies (Table 1). Morphological analysis

showed that the hybrids from the nuclei of *C. auratus* and the cytoplasms of *C. carpio* were almost identical to the nucleus donors[12], while in the hybrids from the nuclei of *C. carpio* and the cytoplasms of *C. auratus*, some features seemed to come from the cytoplasm host fish, such as the number of vertebrae. Yan *et al.* (1985) reported that the nucleo-cytoplasmic hybrid fish from the nuclei of *C. idellus* and the cytoplasms of *M. amblycephala* growed much faster than the nucleus donors and a little faster than the cytoplasm host fish and none of the hybrids was found to be dead of infective disease which is often observed in the nucleus donor fish[41]. In most cases, the nucleo-cytoplasmic hybrids are fertile and their gonads can mature normally. Some progeny of nucleo-cytoplasmic hybrid fish have been produced by crossing with either nucleus donor fish or cytoplasm host fish.

Table 1 Nucleo-cytoplasmic hybrid fishes obtained by Chinese scientists

Nucleus	Cytoplasm	Reference
C. auratus	*C. auratus*	[21]
C. auratus	*C. carpio*	[38]
C. carpio	*C. auratus*	[12]
C. idellus	*M. amblycephala*	[41]

Liu *et al.* (1987) reported that androgenetic diploid loach (*M. anguillicaudatus*) could be produced by nuclear transplantation[8]. The loach (♂) was first crossed with *Paramisgurnus dabryanus* (♀), then the female nuclei in the fertilized eggs were removed with grass needle and the haploid embryos were allowed to develop. At blastula stage, the haploid nuclei were transferred into enucleated eggs of *P. dabryanus*. Chromosome examination of 243 gastrula embryos indicated that 29.6% of them had duplicated chromosome number. In another experimental group, 5 adults were obtained from 769 nuclear transplanted eggs. Caudal fin chromosome examination, muscle LDH electrophoresis and morphological analysis all showed that they were androgenetic homozygous diploids.

In most fish nuclear transplantation experiments, nucleus donors were embryonic cells. Chen *et al.* (1986) reported that a nuclear transplanted fish had been produced from the subcultured blastula cell of *C. auratus*[23]. When the fish died three years later, it was found that its sexual glands were undifferentiated. In another experiment, a sexual matured adult fish was produced from the short-term cultured kidney cell nucleus of an adult crucian carp. Based on these results, Chen *et al.* (1986) suggested that the nuclei of subcultured fish blastula and somatic cells still retained their developmental totipotency[23]. These experiments implied that it would be possible to improve fish genetic traits by combination of manipulation of somatic cells and the technique of nuclear trasnplantation.

3 CELL FUSION

In China, the research on the fusion of fish cells was initiated in the 1970s. Yan, *et al.* (1984) reported that the fusion index could reach 29.5% by treating crucian carp cells ($4\times10^4/cm^3$) with 50% polyethylene glycol (PEG) 1000 for 1 to 2 minutes[29]. As observed in the fusion of mammalian cells, increase in the PEG concentration will result in decrease in cell viability in the fusion of fish cells. Glycerol and DMSO (dimethylsulfoxide) have been known as the promoting reagents in PEG-mediated fusion of mammalian cells, but Yan *et al.* (1986) reported that the fusion index would reduce about 80% in the presence of only 2.5% glycerol in the fusion of fish cells[30]. The death rate was quite high when the concentration of glycerol reached 20%. DMSO could promote the PEG-mediated fusion of fish cells, especially when the concentration of PEG was relatively low. For example, in 45% PEG 1000, 5% DMSO would increase the fusion rate by 10%, but in 50% PEG 1000, only 2%.

The fusion of fish cells can be facilitated by electric field (electrofusion). Compared with other cell-fusion techniques, electrofusion is rapid, simple and highly efficient. Liu *et al.* (1988) successfully induced the electrofusion of blastula cells of *P. dabryanus*[5]. According to their report, the fusion rate was 46.72% while the viability rate cells was as high as 88.6%. In the same year, Yi *et al.* (1988) reported the results of the fusion between blastula cells and unfertilized eggs of several fishes[25] (Table 2). Morphological features of the resulting fry clearly indicated that the diploid nuclei of the blastula cells had participated in the development of the fused embryos. The fate of the haploid nuclei from the unfertilized eggs was unclear. In these experiments, only 0.8% of the eggs could develop to fry stage, most embryos were abnormal, which was attributed to the damage of the donor nuclei caused by the electric field.

Table 2 Electric fusion between fish blastula cells and unfertilized eggs (% in parentheses as the ratio of the number of fry to that of blastula)*

Blastula cells	Eggs	Blastula embryos	Fry
P. dabryanus	*P. dabryanus*	33	6(18.2%)
P. dabryanus × *M. anguillicaudatus*	*P. dabryanus*	32	6(16.7%)
C. carpio	*C. auratus*	113	4(3.6%)

* Data source: Reference[25].

It has been known that irradiation of the contact points of cells with laser microbeam will result in the fusion of these cells. Zhang *et al.* (1988) used laser microbeam to induce the fusion of fertilized eggs of *M. anguillicaudatus*[27]. The results showed that

most fused eggs could continue to cleave. A few of them could develop to larval stage. Because the laser microbeam can be precisely oriented and the irradiation time and points can be easily controlled, the damage to the cells is very little. This is an obvious advantage of the method.

4 GENE TRANSFER

Chinese scientists have made a serial investigations on the possibility of producing fast-growing transgenic fish. According to Zhu *et al.* (1985, 1989), the human growth hormone (hGH) gene, which had been microinjected into the fertilized eggs of fish, could replicate in several physical forms during early embryonic stages[8,42]. Amplification of the exogenous DNA sequences reached peak at blastopore-sealing stage. After tail-budding stage, the copy number of these sequences reduced. More of them were detected as macromolecules. After blood-circulating stage, almost all of the detected exogenous sequences co-migrated with the cellular total DNA. Some of these squences could be detected in macromolecular form in 50-day-old fish. Southern blot results suggesetd that they had been integrated into the host DNA, probably at late embryonic stages.

Zhu *et al.* (1986) reported that some individuals of transgenic loach containing mouse MT-1 promoter controlled hGH gene growed significantly faster than the control group[7]. At the age of 14 days, over 10% of the transgenic group were 1.5 times larger than the control group, which was rather uniform in size. At the age of 43 days, the average weight of 12 individuals in the control group was 35.1 mg (from 25 to 46 mg), while in the putative transgenic group, there were two larvae weighing 160 mg and 120 mg, i. e., 4.6 and 3.4 times that of the average weight of the control group respectively. This is the first report on the growth-promoting effect of hGH gene in transgenic fish. Zhu *et al.* (1989) reported that the transcripts of the MT-1-hGH transgene could not be detected untill gastrula stage in transgenic crucian carp[8]. The hGH could be detected in both fry (35 days) and adults (913 days), but its concentration was higher in fry than in adult. It was observed that the growth promoting effect of the hGH gene was more prominent in early developmental stages in transgenic crucian carp (Xu *et al.*, 1991).

Yu *et al.* (1989) studied the fate of cytoplasmically injected DNA in fish fertilized eggs during embryogenesis[11]. It was observed that neither circular nor linear DNA would degrade rapidly. They could be detected at least at tail-budding stage (60 to 70 hours after injection). The injected circular DNA was rescued from the blastula cells. Southern blot results suggested that only linear DNA sequencs might have been integrated into the host DNA. In another approach to transfer genes into fish, Wang *et al.* (1991) injected exogenous DNA sequences into the germinal vesicle (GV) of goldfish

oocytes[39]. Then the injected oocytes were incubated to mature and inseminated with fresh sperm. Dot blot analysis of the resulting fish (from 2-month-old to adult) showed that 18.6% (30 of 161) were positive. Southern blot analysis of one dot-blot positive fish showed that the foreign DNA sequences had been integrated into the fish genome.

Besides microinjection, two other methods of gene transfer were used by Chinese scientists. Xie *et al.* (1989) reported that 10% dot-blot positive fish (1-month-old) could be obtained with electroporation[33]. Shen *et al.* obtained transgenic fish by exposing spermatozoa to DNA followed by fertilization[36].

Although it is now possible to change the traits of fish by the gene transfer technique. Unfortunately only a very limited number of the genes which can be used for this purpose have been cloned. Liu *et al.* (1991) recently reported that the transfer of a certain gene without previous cloning of it was feasible in fish[4]. The total DNA of common carp was introduced into the eggs of red crucian carp by microinjection and exposure of spermatozoa to the DNA followed by fertilization. They observed that a small portion of the resulting fish expressed the black pigments of common carp in both experimental groups. This method should be useful in the improvement of multiple-gene-controlled traits of fish.

5 GENE CLONING

So far, Chinese scientists have cloned seven fish genes (Table 3). Although the hGH gene works well in fish, fish originated growth hormone genes were better candidates for commercial production of fast-growing fish. For this purpose, three fish growth hormone genes have been cloned.

Mouse MT-1 promoter has been used by many researchers to express novel genes in fish. Shen *et al.* (1990) reported that the promoter of SV40 early gene could direct the expression of bacterial CAT reporter gene in grass carp CK cells[10]. To isolate fish endogenous strong promoter, Zhu *et al.* (1990) cloned the beta-actin genes of grass carp and common carp[9].

Table 3　The fish genes cloned by Chinese scientists

Gene	Species	Reference
Growth hormone	*C. carpio*	[9]
Growth hormone	*C. idellus*	[9]
Growth hormone	*Oncorhynchus keta*	[16]
Beta-actin gene	*C. carpio*	[9]
Beta-actin gene	*C. idellus*	[9]
Prolactin cDNA	*O. tschawytscha*	[11]
Antifreeze peptide cDNA	*Pseudopleuronectes yokohamae*	[35]

参考文献

[1] 于建康等,1989.*E.Coli* galk 和 gpt 基因重组质粒(pIDB103)导入金鱼受精卵的研究.生物化学杂志,**5**(5):417—422.

[2] 马涛等,1987.热休克诱导虹鳟四倍体.水生生物学报,**11**(4):329—336.

[3] 刘汉勤等,1987.泥鳅雄核发育纯合二倍体的产生.水生生物学报,**11**(3):241—246.

[4] _____,1991.总 DNA 介导鱼类基因转移的初步研究.水生生物学报,**15**(3):286—288.

[5] 刘沛霖等,1988.鱼类细胞电融合的初步研究.水生生物学报,**12**(1):94—96.

[6] 许克圣等,1991.转移人生长激素基因和注射人生长激素对促进银鲫生长的研究.水生生物学报,**15**(2):103—109.

[7] 朱作言等,1986.人生长激素基因在泥鳅受精卵显微注射转移后的生物学效应.科学通报,**5**:387—389.

[8] _____,1989.转基因鱼模型的建立.中国科学(B),**2**:147—155.

[9] _____,1990.鲤鱼和草鱼基因文库的构建及其生长激素基因和肌动蛋白基因的筛选.水生生物学报,**14**(2):176—178.

[10] 沈孝宙等,1990.哺乳动物病毒 SV40 早期启动子在鱼类细胞中具有转录调节功能.科学通报,**5**:381—382.

[11] 宋诗铎等,1989.鲑鱼泌乳素 cDNA 的分子克隆和序列分析.遗传学报,**16**(6):374—380.

[12] 严绍颐等,1984.硬骨鱼类的细胞核移植一鲫鱼细胞核和鲤鱼细胞质配合的杂种鱼.中国科学(B),**13**(8):729—732.

[13] 苏泽古等,1983.草鱼三倍体及其核型的研究.鱼类学论文集,**3**:53—60.科学出版社(京).

[14] _____,1984.白鲑三倍体及其核型的研究.动物学研究,**5**(3)增刊:15—20.

[15] 杨永铨等,1981.人工诱导鱼类雌核发育的实验研究.淡水渔业,(4):1—4.

[16] 杨学成等,1991.虹鳟鱼(Salmo gairdneri Richardson)基因文库的构建及其生长激素基因的克隆和亚克隆.生物技术,**1**(1):13—16.

[17] 吴清江等,1979.鲤鱼杂种优势多代利用的探讨.水生生物学集刊,**6**(4):445—452.

[18] _____,1981.鲤鱼人工雌核发育及其作为建立近交系新途径的研究.遗传学报,**8**(1):50—55.

[19] _____,1986.鲤鱼染色体组人工调控的核型证明.水生生物学报,**10**(3):265—270.

[20] _____,1991.雌核发育系红鲤 8305 的产生及其生物学特性.海洋与湖沼,**22**(4):295—299.

[21] 吴尚勤等,1980.不同品系金鱼间细胞核的多代移植.实验生物学报,**13**(1):65—77.

[22] 吴维新等,1988.鲤鱼和草鱼杂交四倍体及其回交三倍体的研究.水生生物学报,**13**(4):387—389.

[23] 陈宏溪等,1986.鱼类培养细胞核发育潜能的研究.水生生物学报,**10**(1):1—7.

[24] 陈敏容等,1987.人工诱导白鲫(♀)×红鲤(♂)异源四倍体鱼的初步研究.水生生物学报,**11**(1):96—98.

[25] 易泳兰等,1988.鱼类囊胚细胞和卵的电融合.水生生物学报,**12**(2):189—192.

[26] 陆仁后等,1982.四倍化草鱼细胞株的获得、特性和移核实验的初步试探.遗传学报,**9**(5):381—388.

[27] 张闻迪等,1988.激光诱导泥鳅卵细胞融合——一种新的细胞融合方法.生物工程学报,**4**(4):289—303.

[28] 洪云汉,1990.热休克诱导鳙鱼四倍体的研究.动物学报,**36**(1):70—75.

[29] 阎康等,1984.鱼类细胞融合的初步研究.遗传,**6**(6):19—21.

[30] _____,1986.鱼类细胞融合中助融剂效应和特异性.水生生物学报,**10**(4):373—379.

[31] 童金苟等,1987.鲤鱼不同品种(系)红血球和抗原特异性的初步研究.水生生物学报,**11**(2):112—116.

[32] 童第周等,1963.鱼类细胞核的移植.科学通报,(7):60—61.

[33] 谢岳峰等,1989.泥鳅受精卵的电脉冲基因转移.水生生物学报,**13**(4):387—389.

[34] 蒋一珪等,1982.鲫鱼的人工和天然雌核发育.水生生物学集刊,**27**(4):471—480.

[35] 蒋耀青等,1990.鱼类抗冻蛋白的研究,Ⅰ:黄盖鲽抗冻蛋白基因 cDNA 的克隆及其在大肠杆菌中的表达.遗传学报,**17**(3):202—210.

[36] 魏彦章等,1992.鱼类基因工程研究的现状和展望.水生生物学报,**16**(1):71—78.

[37] Lou, Y. D. and C. E. Purdom, 1984. Polyploidy induced by hydrostatic pressure in rainbow trout, *Salmo gairdneri* Richardson. *J. Fish Biol.*, **25**(3):345—351.

[38] _____, 1984. Diploid gynogenesis induced by hydrostatic pressure in rainbow trout, *Salmo gairdneri* Richardson. *J. Fish Biol.*, **24**(6):665—670.

[39] Research Group of Cytogenetics, Institute of Zoology, Academia Sinica *et al.*, 1980. Nuclear transplantation in teleosts. I. hybrid fish from the nucleus of carp and the cytoplasm of crucian. *Scientia Sinica* (B), **23**(4):517—523.

[40] Wang, R. X. *et al.*, 1991. The study of transgenic goldfish (*Carassius auratus*) from the oocyte matured in vitro. *Chinese Science Bulletin*, **36**(8):692—695.

[41] Yan, S. Y. *et al.*, 1985. Nuclear trasplantation in teleosts IVA, nuclear transplantation between different subfamilies-hybrid fish from the nucleus of grass carp (*Ctenopharyngodon idellus*) and the cytoplasm of blunt-snout bream (*Megalobrama amblycephala*). *Chinese J. Biotech.*, **1**(4):15—26.

[42] Zhu, Z. Z. *et al.*, 1985. Novel gene transfer into the fertilized eggs of goldfish (*Carassius auratus* L. 1758), *J. of Applied Ichthyology*, **1**:31—34.