CHINESE-AMERICAN

JOINT COMMISSION ON RURAL RECONSTRUCTION

Fisheries Series: No. 8

REPORTS OF FISH CULTURE RESEARCH SUPPORTED BY ROCKEFELLER FOUNDATION

Taipei, Taiwan, China
December, 1969

CHINESE-AMERICAN

JOINT COMMISSION ON RURAL RECONSTRUCTION

Fisheries Series: No. 8

REPORTS OF FISH CULTURE RESEARCH SUPPORTED BY ROCKEFELLER FOUNDATION

Eleven Technical Reports Of Studies
Carried Out In Taiwan
1967-1969

Table of Contents

A Summarized Report on Taiwan Fish Culture Research Supported by Rockefeller Foundation Grant Funds for the Period 1966-1969

In 1966 the Rockefeller Foundation approved a grant of US$150,000 as allocation No. 1 to support a fish culture research program in Taiwan for the first two years 1966-1968 and again in 1968 another grant of a similar amount as allocation No. 2 for a second two-year period 1968-1970. Apart from the above, the Joint Commission on Rural Reconstruction contributed annually funds to the same program. These funds were placed under the administration and technical supervision of JCRR, and the Taiwan Fisheries Research Institute was contracted as the Sponsoring Agency to carry out the researches.

Program of Research

The program was drawn up with three objectives in view. The first and most important of all is to establish scientific bases for the improvement of existing fish culture practices in Taiwan as well as in the other countries of the world where similar conditions exist to make the introduction of improved techniques possible. Fish farming in Taiwan is quite diversified; in fresh and brackish-water ponds mono- and polyculture under various ecosystems are found of Chinese carps, milkfish, grey mullet, eel, perch, catfish, *Tilapia*, shrimp and soft-shell turtle. But as many techniques are developed from experience handed down by tradition, scientific explanations are lacking.

The second objective is to introduce and to develop, wherever possible, new ecosystems of aquiculture. Along this line of programming three species of marine shrimps have been successfully propagated and their production culture is under experimentation. Due to the shortage of land for pond construction, research on freshwater shrimp propagation and culture has not yet been started.

The third aspect of research is an endeavor to coordinate investigations on inland water primary productivity to the International Biological Program. Work has been initiated to study the primary productivity of fresh and brackish water ponds and some reservoirs. Later, when funds are available, rivers, lakes and estuaries will likewise be investigated, and it is hoped that when the potential yields from photosynthesis in all these inland waters are roughly known, the production of aquatic plants and animals of economic importance would be cor-

related. In close connection with this research, the problem of pollution effect by industrial, domestic and agricultural wastes on inland water resources should be thoroughly studied.

The program of research for the past three years (1966-1969) and some years to come are outlined as follows:

1. Milkfish culture
   - 1.1 Study of mineral nutrient dynamics and fertilization in pond water and soil
   - 1.2 Determination of primary production, bottom algal standing crop in different seasons in relation to milkfish yield
   - 1.3 Study of algal pasture in relation to bacterial and fungal growth
   - 1.4 Identification of bottom algae and study of their ecological succession
   - 1.5 Ecological study of wintering ponds
   - 1.6 Ecology of milkfish feeding
   - 1.7 Pure culture of bottom algae and comparative study on the value of different algae as feeds to milkfish
   - 1.8 Study of algicides and Chironomid control
   - 1.9 Study of yellow water causes and remedies
2. Shrimp and grey mullet propagation and culture
   - 2.1 Experiments on artificial propagation of *Penaeus japonicus*, *P. monodon* and *Metapenaeus monoceros* and grey mullet
   - 2.2 Shrimp feeding experiments and physiological and biochemical research
3. Freshwater pond culture
   - 3.1 Pure culture of freshwater algae and feeding experiments
   - 3.2 Taxonomic study of freshwater algae
   - 3.3 Mineral nutrient dynamics and fertilization in ponds
   - 3.4 Feeding habits of Chinese carps and grey mullet
   - 3.5 Fish genetics and breeding study
   - 3.6 Primary productivity in ponds and lakes in relation to fish yield
   - 3.7 Ecological study of fish fry rearing
   - 3.8 Determination of optimum conditions for culture of Chinese carp spawners
   - 3.9 Fish parasites and diseases
4. Oyster culture
   - 4.1 Experiments on hanging and long line methods of culture
   - 4.2 Enemies, pests and diseases of oyster
   - 4.3 Oyster seed production experiments
5. Eel culture
   - 5.1 Eel nutrition and mixed feed study
   - 5.2 Water conditioning of eel pond studies
   - 5.3 Elver distribution and production survey and rearing experiments

6. *Gracilaria* life history study and culture experiments

Facilities and Staff of Research

To facilitate the above program of study, the Tainan, Lukang and Chupei Fish Culture Stations of the Taiwan Fisheries Research Institute and the limnological laboratory of the Institute of Fishery Biology, National Taiwan University, are used as research centers. In addition, a new marine fish and shrimp propagation laboratory is established in Tungkang, where experiments on artificial propagation and culture of *Penaeus japonicus*, *P. monodon* and *Metapenaeus monoceros* and grey mullet, *Mugil cephalus*, are carried out; life history and ecological studies of the above species and other marine fishes are also to be carried out there.

Some 28 research fellows, consultants, research and administrative assistants are employed with Rockefeller Foundation Grant Funds, a small part of which is also paid as technical allowances to 22 regular technical and administrative staff members of the Taiwan Fisheries Research Institute for their cooperation in the research projects (see list of personnel).

Accomplishments

The results of the efforts made during the period July 1966 to November 1969 can be briefly described as follows:

1. Milkfish culture
   - 1.1 A general survey of culture management, techniques and problems was recently made and discussed by S. Y. Lin (Fish Culture Report No. 3, 1968).
   - 1.2 Mineral nutrients and fertilization in milkfish ponds -
     Analysis of pond water and soil was made by C. Y. Liu and the work of fertilizer application experiments by S. Y. Lin, T. H. Wang and C. M. Lai who discovered that, although N-P-K like CO_2, trace elements, vitamins and soil extracts are essential for algal growth *in vitro*, the application of inorganic fertilizers rich in N-P-K to ponds did not result in milkfish production increase. However, SiO_2 application did boost milkfish yield. Experiments on pond fertilization still continue.
   - 1.3 Primary productivity and milkfish yield -
     The relationship between primary productivity and fish yield is positive, but more data are needed to establish any definite pattern of relationship. H. C. Chen is responsible for this project.
   - 1.4 Algal pasture and bacterial growth -
     N. H. Chao observed the effect of bottom algal growth on bacteria

population in water and tried to determine whether bacteria population played an important role in the occurrence of the noxious "yellow water". Four species of bottom algae are found effective in antibacterial activities.

1.5 Identification of bottom algae -
T. P. Chang has published a part of his study in JCRR Fisheries Series No. 7, 1969.

1.6 Ecological study of wintering ponds -
Due to the lack of research personnel, the study of this subject has not yet begun.

1.7 Ecology of milkfish feeding -
This study was carried out by H. S. Lin who obtained some valuable data on milkfish feeding habits in a cycle of 24 hours, in different months and seasons, in relation to temperature, salinity, sunlight and biological conditions. A report on this subject is published in JCRR Fisheries Series No. 7, 1969.

1.8 Pure culture of bottom algae -
H. C. Chen is responsible for this work. In the past year he was able to isolate and make pure culture of *Lyngbya, Oscillatoria, Nitzschia closterium* and some other algae and to test how they responded to salinity, pH, aeration (to supply CO_2 and turbulence), macro- and micronutrients. The preliminary report on this subject will be published soon.

1.9 Chironomid pest control -
S. C. Tsai has been able, through research in the past two years, to reveal the different stages of development of the Chironomid (*Tendipes longilobus*), the advantages and disadvantages of Chironomid larva and adult midges control by pesticides. On the basis of such findings a demonstration is planned to show the possibility of eradicating this pest from the milkfish ponds by a measure taken to attack the adult midges. Meanwhile he finds Abate 50% E.C. most economical and efficient in Chironomid larval control.

1.10 Yellow water -
Preliminary investigation has been made by S. C. Tsai to find out the kinds of organisms, physical and chemical nature which cause "yellow water", oxygen deficiency and the destruction of bottom algae. In the 1969-1970 program Dr. Y. M. Chiang and S. N. Chen are planning to continue this study.

2. Shrimp culture and grey mullet propagation

2.1 Experiments on artificial propagation of *Penaeus japonicus, P. monodon* and *Metapenaeus monoceros* -
Dr. I. C. Liao, T. L. Huang, C. C. Hsieh and K. Katsutani are responsible

for this work, and satisfactory results have been obtained in the past two years. They were able to spawn the three species of shrimp and rear their larvae to adult shrimps. More experiments are required to improve the technique and commercial methods to raise the shrimps to marketable size. In order to carry out this project, a marine fish and shrimp propagation center has been established in Tungkang, Pingtung Hsien.

2.2 Grey mullet propagation -

During the period November 1968 to February 1969, grey mullet was induced to spawn by pituitary injection and the larvae were able to live for 30 days to reach 1.1 cm in length, the most successful case known in the history of grey mullet artificial propagation.

3. Freshwater pond culture

3.1 Study of the physical, chemical and biological conditions of the fertilized and unfertilized ponds -

The team working on this program consists of 6 technical staff members with Professor W. K. Liaw as team leader. It also obtained the services of Dr. Yoshihiro Satomi and Mr. Tokio Ito of the Freshwater Fisheries Laboratory in Tokyo, Japan. They were in Taiwan for three months, December 1968 to February 1969. Very significant and instructive data have been obtained to show the relationship between mineral nutrients, especially N-P and Si, phyto- and zoo- plankton population and fish yield. The findings concerning phosphorus dynamics have led us to the determination of the frequency of P application and the economical dosage of the fertilizer. Now experiments are being carried out to decide the appropriate P concentration to be applied, the value of such commercial fertilizers as zeolite, kienyusu, fly ash, acetic acid and sodium acetate. The remarkable increase of fish production in the Taoyuan Fish Farm and many fish ponds in the country for the past two years significantly proves the value of scientific experiments and the application of their findings (S. Y. Lin, 1968).

3.2 Taxonomic study of freshwater algae -

A monograph of freshwater algae in Taiwan is under preparation.

3.3 Pure culture of freshwater algae and feeding experiments -

Experiments are carried out to determine the requirements of pure algal culture. So far we have been quite successful in the culture of *Chlorella*, *Scenedesmus* and *Anabaena*. When such requirements as light, temperature, nutrients have been determined, large quantities of pure alga can be grown for feeding experiments. Knowledge obtained from such experiments will lead to the control or increase of phytoplankton growth in ponds for maximum fish yield by applying the right types of fertilizers in different seasons of the year.

3.4 Feeding habits of Chinese carps -

In this study interesting data show that the silver carp, bighead and mud carp are all plankton and detritus feeders, the difference being that silver carp is a principal feeder of the net as well as nanno-phytoplankton in the upper layer, the bighead ingests comparatively more zooplankton and the mud carp mostly diatoms and detritus. The grey mullet has a feeding habit similar to that of the mud carp.

3.5 Fish genetics and breeding -

Hybridization of the Chinese carps has been tried but with results of little value to fish culture improvement up to the present. However, the hybrids between *Tilapia mossambica* female and *Tilapia nilotica* male show better growth rate which would be of great significance if large quantities of hybrids can be produced for stocking commercial ponds. The Lukang Fish Culture Station is now working on an extension project of this hybrid.

3.6 Fish parasites and diseases -

Two research fellows are in charge of this project. C. N. Wu is making a survey of the important parasites in fish ponds and S. Y. Wu studies the bacterical diseases of *Tilapia* and grass carp. *Streptococcus pyogenes* is found to be responsible for mass killing of *Tilapia mossambica* in freshwater ponds.

4. Oyster culture

Y. S. Lin studied oyster seed collection and hardening methods fo the purposes of culture improvement and of reducing mortality in long distance transportation. He found that hardened oyster seeds endured better in long distance transportation without water and grew faster for a certain period of time when they were transplanted in new culture areas. Meanwhile Lin carried out a series of experiments on the hanging and long line methods of oyster culture. Y. W. Huang investigated the oyster drill and teredo pest.

5. Eel culture

5.1 Eel feeding experiments -

Y. S. Lai and Y. Y. Su of the Taiwan Fisheries Research Institute carried out these experiments in 1966-68 and found that the mixed feed prepared by Lai has a conversion rate of 2.4 and 1.8, and the stocking rate of 200-300 g/m^2 in static water ponds is optimum.

6. *Gracilaria* culture

Considerable efforts have been devoted to the study on collection and development of *Gracilaria* spores, and on weeds and weeding of the *Gracilaria* ponds. Dr. Y. M. Chiang, R. G. Yang, M. N. Lin and T. L. Li are responsible for this study.

I. LIST OF ROCKEFELLER FOUNDATION FISH CULTURE RESEARCH PERSONNEL

1. Joint Commission on Rural Reconstruction

Ruth Lee	Secretary (March 1968-)
Jia-shyang Su	Apparatus mechanic, part time (September 1968-)

2. Taiwan Fisheries Research Institute

Tainan Fish Culture Station

I-chiu Liao	Shrimp culturist (July 1968-)
Tsang-pi Chang	Algologist (September 1967-June 1968)
Young-meng Chiang	Consultant algologist (September 1968-)
Shan-ching Tsai	Chemist (August 1966-)
Nai-hsien Chao	Research assistant (November 1967-June 1969)
Hon-cheng Chen	Research assistant (August 1967-)
Huei-pin Chen	Research assistant (July 1969-)
Huang-sheng Lin	Research assistant (August 1966-June 1968)
Mou-chun Lin	Fish culturist, part time (September 1968-)
Lei-chiang Tseng	Research assistant (August 1969-)
Sheng-yu Wu	Research fellow, part time (July 1968-)
Chin-pao Hung	Assistant (July 1969-)
Young-jang Lu	Assistant (July 1969-)
Kunio Katsutani	Short term shrimp culture consultant (May-November 1968)

Lukang Fish Culture Station

Fore-lien Huang	Research assistant (August 1966-June 1968)
Hon-der Lin	Chemist (January 1968-)
Yao-sung Lin	Research fellow, part time (August 1966-)
Gen-chie Liu	Research assistant (September 1968-)
Yoshimitsu Ogasawara	Short term oyster culture consultant (December 1966-May 1967)

Chupei Fish Culture Station

Chang-jyi Chiou	Research assistant (August 1966-)
Choi-ping Chang	Research assistant (July 1968-May 1969)
Huu-yun Chung	Research assistant (July 1968-June 1969)
Pi-ying Chung	Research assistant (July 1969-)
Cheng-nan Lin	Research assistant (August 1966-June 1968)
Hong-siong Ong	Research assistant (July 1968-)
Huei-yau Tsai	Algal culture consultant, part time (September 1968-)

Ching-ning Wu	Research assistant, part time (October 1956-June 1969)
Tsan-yi Chen	Assistant (July 1969-)
Tokio Ito	Short term fish culture consultant (December 1968-February 1969)
Yoshihiro Satomi	Short term fish culture consultant (December 1968-February 1969)
Munenao Suginome	Short term fish culture consultant (September-October 1969)
Junichi Toi	Short term fish culture consultant (September-October 1969)

3. Limnological Laboratory, Institute of Fishery Biology, National Taiwan University

Wen-kwang Liaw	Limnologist, part time (January 1967-August, 1969)
Wah-chao Hsieh	Research assistant (July 1968-June 1969)
Chyn-yuh Jaw	Research assistant (July 1969-)
Wan Kiang	Research assistant, part time (September 1969-)
Yie-yung Lee	Research assistant (July 1968-June 1969)
Yen-pin Li	Research assistant (July 1969-)
Jung-fu Wu	Research assistant (July 1967-June 1968)

II. LIST OF ADMINISTRATIVE AND TECHNICAL PERSONNEL OF THE TAIWAN FISHERIES RESEARCH INSTITUTE RECEIVING TECHNICAL ALLOWANCE FROM ROCKEFELLER FOUNDATION GRANT

Taiwan Fisheries Research Institute

Huo-to Teng	Director
Yu-lin Lien	Accountant
Meng-chi Hsu	Personnel officer
Yuan-yu Chen	Administrative assistant
Chung-cheng Chin	Administrative assistant
Ting-chi Yu	Administrative assistant
Ru-sung Tai	Accountant, part time, Limnological Laboratory, Institute of Fishery Biology, National Taiwan University

Tainan Fish Culture Station

Shi-chin Hsieh	Acting director
Juin-kuo Liang	Director (resigned 1968)
Ching-yun Huang	Assistant specialist
Ting-lang Huang	Assistant specialist

Yun-yuan Ting	Assistant specialist
Cheng-chi Chen	Accountant

Lukang Fish Culture Station

Ho Kuo	Director
Yung-shun Lai	Director, Kaohsiung Technological Laboratory
Wen-ping Huang	Project employee
Ying-wu Huang	Assistant specialist (resigned 1968)
Ying-yau Su	Assistant specialist

Chupei Fish Culture Station

Chia-kang Liu	Director
Shuen-lien Chuang	Assistant specialist
Hon-kwong Peng	Assistant specialist
Hsin-fan Wu	Assistant specialist

烏魚人工繁殖試驗（第五報）

Artificial Propagation of Grey Mullet, *Mugil Cephalus* Linnaeus

廖　一　久*

（1969年6月20日受理）

By I-chiu Liao*

Research Fellow, Rockefeller Foundation Fish Culture Research Program

Summary

The grey mullet, *Mugil Cephalus* Linnaeus, is one of the important commercial fishes in Taiwan. From December to January, schools of grey mullet are found along the middle part of the western coast; they then move slowly southward for spawning. Most of them are 4-5 years old, measuring 42-45 cm long(1). Grey mullet are captured mainly during this spawning migratory period for their roe, which after removal from the fish is carefully dried for export mainly to Japan.

In Taiwan for stocking fresh- and brackish-water ponds, fingerlings 2 to 3 cm long are caught from river mouths and estuaries along the west coast during the period from December to March. The annual demand for such fingerlings is estimated at 6 to 7 million, but unfortunately due to unpredictable changes of oceanographic and meteorological conditions the natural supply of grey mullet fingerlings fluctuates to such a great extent that fish farmers suffer loss from the uncertainty in establishing a profitable pond stocking system.

In each of the last five years a team of workers was organized by the Taiwan Fisheries Research Institute, Taiwan Fisheries Bureau and the Institute of Fishery Biology to carry out a program of research on the artificial propagation of grey mullet with the objective to achieve constant supply of mullet fingerlings, but no satisfactory result had been obtained. This difficulty lies principally in the rearing of the mullet fry, for in 1967 only one fry out of millions survived up to 23 days.

In 1968 the same program was repeated in Tungkang Shrimp Culture Center with some improvement in technique and equipment. As a result two fingerlings 1.0 to 1.1 cm long survived up to 30 days. The procedure and results of the present study carried out from November 1968 to February 1969 are summarized as follows:

(1) From November to January, 30 spawners were obtained (body weight 1.7-3.0 kg). Among those 30 spawners, 2 died from injury in the viscera, the sex of 2 were wrongly selected for hormone injection, 7 failed to spawn and 19 did spawn after hormone treatment (2.5-4 pituitaries of mullet combined with 10-35 rabbit unit of

* 由4個單位組成"烏魚人工繁殖研究隊"，其組成人員爲漁業局林茂春及侯英物，省水試所臺南分所黃丁郎，臺灣大學漁業生物試驗所童逸修及洛氏基金臺灣水產養殖計劃洪金抱以及廖一久（筆者）等6人。

* A team of workers from four agencies was responsible for this study: M. C. Lin and Y. W. Hou of the Taiwan Fisheries Bureau, T. L. Huang of the Taiwan Fisheries Research Institute, I. H. Tung of the Institute of Fishery Biology, National Taiwan University, and C. P. Hung and I. C. Liao (the writer), Research Fellow of the Rockefeller Foundation Fish Culture Research Project in Taiwan.

Synahorin), but only the eggs of three females were successfully fertilized and hatched.

(2) The effect of hormone treatment had some relation to the fishing season. Injection at the peak of the fishing season was more effective. Healthy eggs were obtained 40 to 50 hours after the first pituitary injection.

(3) At a salinity of 32.4-32.7‰ and water temperature of 21°C, fertilized eggs took 60-65 hours to hatch, but higher water temperature up to 24°C shortened the hatching time to 44-50 hours. The hatching ratio showed no marked difference between the running water system and the still water system.

(4) The newly hatched larvae measured 3.09 mm in body length (plate 1, fig. 1) with mouth not yet open. It could not swim but lay at the bottom of the still water. On the third day, mouth formation was complete, and on the fourth day, it began to feed on minute organisms such as oyster larvae. When yolk sac was absorbed on the fifth day, it could feed on rotifera. The 19 day old fry measured 5.0 mm and fed only in the daytime. Scales began to develop on the 23rd day and body color became darker. Soft-rayed fins appeared on the 25th day and the body was covered completely with scales on the 27th day when it measured 1 cm long (plate 2, fig. 8).

(5) The larva showed phototaxis under 600-1400 lux, an instinct favorable for raising the survival rate in rearing.

(6) Mullet larva could not tolerate salinity lower than 17‰ and did not appear to adapt to frequent changes of salinity.

(7) In running water the larva survived for 9 days only. In still salt water in a larva rearing vessel which was gradually diluted with brackish pond water, two mullet fry were reared to 30 days measuring 1.0 and 1.1 cm long.

烏魚 (*Mugil cephalus* Linnaeus) 爲臺灣重要經濟魚類之一，每年12月至1月間有4～5歲大，體長 42～45 公分主羣之烏魚[1]，爲了產卵經過臺灣西海岸分批上游至中部沿海，然後再沿岸南下，故在此期間可大量捕獲。其晒乾之卵巢極爲著名，每年大量輸往日本爭取外滙。至於魚苗可在每年12月至3月間於西海岸鹹淡水相交之河口捕撈，年產量約 600～700 萬尾[2]，因其在鹹水或淡水池塘皆可放養，故於有效運用水面生產力上所扮演之角色極爲重要，並可預見將來臺灣漁業走上集約養殖時，欲理想地處理殘渣餌料者勢必借重於此魚。此魚既有上述多種優點，本應廣爲養殖，但天然魚苗往往供不應求，更無法作計劃生產。爲了達成藉助人工繁殖而得足量供應魚苗之目的起見，自民國52年 (1963) 始，臺灣水產有關單位組成“烏魚人工繁殖研究隊”，於每年此魚產卵季節，在高雄縣汕尾沿海地區實施人工繁殖試驗工作[3),4),5),6)]，迄今已五年*。雖未能育成魚苗，但第4工作年度已能把幼魚培養達23天之久[6)]。

此次本研究隊於民國57年11月至翌年2月，利用屏東縣東港鎮海濱建設中之養蝦中心繼續是項試驗工作，結果其中 2尾之生存日數達30天，其體長已達和天然烏魚苗略同大小之1.0公分及1.1公分。茲將本次試驗經過及其結果報告如下：

1. 材料及方法

種魚係由工作人員自駕裝有引擎之塑膠舢板出海，直接向漁民採購正被圍網捕獲之健康魚，移放於60×90公分之塑膠袋內（每袋各放種魚1～3尾，水量保持約 30公升），並注入適量之氧氣

* 56年 (1967) 由於人員，經費各方面之不敷中斷一年。

，然後運回蓄養池。

蓄養池（plate II, fig. 1）是仿照54年[5]，使用裝沙的草袋，在沙灘上疊成半公尺高之堤防，中間掘深約1公尺，圍成4×6公尺之長方形池四口。供水則裝置濾水管於干潮線向外延伸約10公尺之處鑿入2公尺深，用1.5馬力之馬達抽水（80公升／分），由第1口池注水，經第2, 3口池後從第4口池排出。

賀爾蒙處理亦仿照過去4年來經驗所得最好之方法[3),3),5),6)]，盡可能於放入蓄養池後之1小時內打第1針，而於此後之24小時內打第2針，每尾之總注射量爲 2.5～4 個烏魚腦下腺，混合10～35 家兎單位生殖腺刺激賀爾蒙（Synahorin）。另外，有些種魚加注 150～300 mg 油質維他命 E，並且有些種魚於注射後浸 10 分鐘於 100 ppm 金黴素（Aureomycin）液中以期消毒。

孵化方式亦仿過去分爲流水式及止水式兩種。但不同者爲此次都使用較大容器，即圓形硬質塑膠水槽（plate II, fig. 2. 3. 4, 直徑96公分，容量 0.5 噸）。流水式者掛 1～3 個吊網（plate II, fig 2. 直徑40公分）於其中，而每一個吊網下口接橡膠管，新鮮之海水即由此向上注入，俾受精卵不斷地在網內滾動；止水式者則僅給予打氣。

幼魚之培育亦採用流水式及止水式兩方式，而後者又按鹽分濃度分爲海水飼育者及海水加魚塭水飼育者兩種。

供試之餌料有煮熟蛋黃，豆漿，牡蠣幼蟲，輪蟲，劍水蚤及豐年蝦幼生等。

2. 結　　果

種　魚　自11月26日至翌年1月7日共獲種魚27尾，1月18日及19日又獲3尾合計30尾（體重 1.7～3.0 公斤，體長 53.0～63.5 公分）。其中如 table 1 所示，由於種魚體內受傷而中途死亡

Table 1. The response of spawner to hormone treatment.

Reaction	Hatch out	Ovulating but not hatching			Non-ovulating			Mistaken in sexual selection
		Naturally spawning	Fertilized without cleavage	Unfertilized	Responsive but not spawning	Injured in viscera	Non-responsive	
Number of treated spawner	3	2	6	8	4	2	3	2
%	10	6.6	20	26.4	13.2	6.6	10	6.6

者有2尾，誤認性別者亦有 2 尾。一般說來，此次由於自駕舢舨來去自由並能縮短航程，在確保種魚活力方面遠比往年順利。

賀爾蒙處理　如 table 1 所示，施以賀爾蒙處理的 30 尾種魚中達排卵階段者有19尾，其中孵出幼魚者有3尾，自行產卵者有2尾。以孵出幼魚之3尾，自行產卵中之1尾以及1月18日捕獲者中之1尾計 5 尾之對賀爾蒙處理反應情形列表則得如 table 2 所示。由表可知，種魚對賀爾蒙處理之反應隨漁季而變，其傾向爲越至晚期反應越快。雖此次試驗次數嫌少，又賀爾蒙處理量每每不同而不易作正確之比較，但由幾個很顯然的例可看出這個傾向。如種魚⑤打下第1針後經過34小時就排卵，而排出之卵又是過熟，以及早期處理的種魚①打下第1針後須58小時才排卵的兩項事實可資證實。而在漁季盛期所捕獲者，即種魚②、③、④之反應情形則顯得較爲良好。

受　精　往年都以乾導法實施之[3),4)]，此次以濕導法嘗試結果顯示此法所得之受精率亦不

Table 2. The response of spawner to hormone treatment, ovulation and hatching.

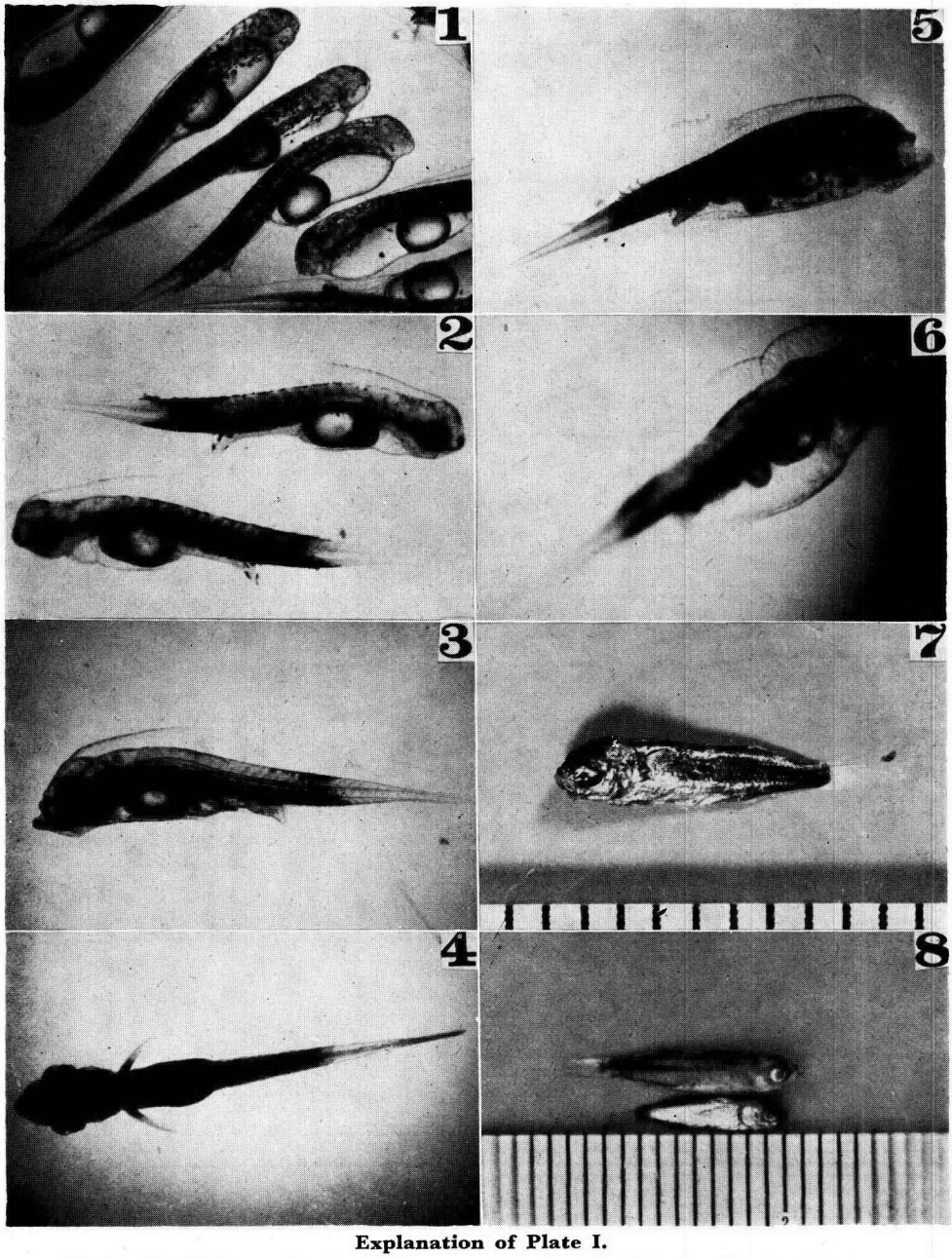
Individual No.	Injection				Ovulation		Hatching			Ovulating time after receiving the initial injection	Remarks
	1st. inj.		2nd. inj.				Fert				
	Date	Dosage	Date	Dosage	Date	%	%	Date	%		
1	Dec. 26 15:15	0.5 P.	Dec. 27 16:00	2P. + 10 RU.	Dec. 29 1:10	10	—	Dec. 31 3:00	—	58 hrs.	Under W. T. 23-24°C, S. 32.3‰, hatch out within 50 hours and live for 11 days. Ovulate again at 13:35, but unfertilized.
2	Jan. 1 16:00	1P.+ 10 RU. + 150 V.E.	Jan 2 15:15	2.5 P. + 10 RU.	Jan. 3 20:30	30	25	Jan. 6 7:00	—	52 hrs.	Under W.T. 22°C, S. 34.1‰, hatch out within 60 hours and live for 13 days.
3*	Jan. 5 11:30	1.3 P. + 10 RU.	Jan. 6 9:30	2 P. + 20 RU.	Jan. 7 10:00	100	90	Jan. 9 6:00 Jan. 10 3~4:00	80	47 hrs	Naturally spawning at 10:00, Jan. 7, immediately artificially fertilized and about 30×10^4 eggs are got. Under W. T. 23-24°C, hatch out within 44 hours, while W. T. 21°C, 65 hours.
4	Jan. 7 11:45	1.5 P. + 15 RU.	Jan. 8 8:00	2 P. + 20 RU.	Jan. 9 6~7:00	100	—	—	—	43 hrs.	Naturally spawning in aquaria.
5	Jan. 18 17:00	1.5 P. + 15 RU	Jan. 19 13:20	2 P. + 20 RU.	Jan. 20 3:35	20	—	—	—	34 hrs.	Ovulate partially but unfertilized.

P: Pituitary of mullet (pieces)
RU: Synahorin (Rabbit units)
V.E.: Vitamin E. (mg)
*: Sterilization with 100 ppm Aureomycin solution.

Table 3. The growth of larvae. (W.T. 19.7~24.9°C)

Time after hatching	Total length (mm)	Body length (The basic region of dorsal fin)	Eye diameter (mm)	Yolk sac		Oil globule		Number of specimens
				Length (mm)	Height (mm)	Length (mm)	Height (mm)	
The first day	3.0906	0.5436	0.2167	1.0062	0.3636	0.3438	0.2833	10
The fifth day	3.3804	0.6822	0.2808	0	0	0.2952	0.2376	10
The eleventh day	3.2904	0.6840	0.2952	—	—	0.0792	0.0684	6
The fourteenth day	3.4740	0.6660	0.3240	—	—	0	0	2
The thirtieth day	10.0000	2.0000	0.9720	—	—	—	—	1

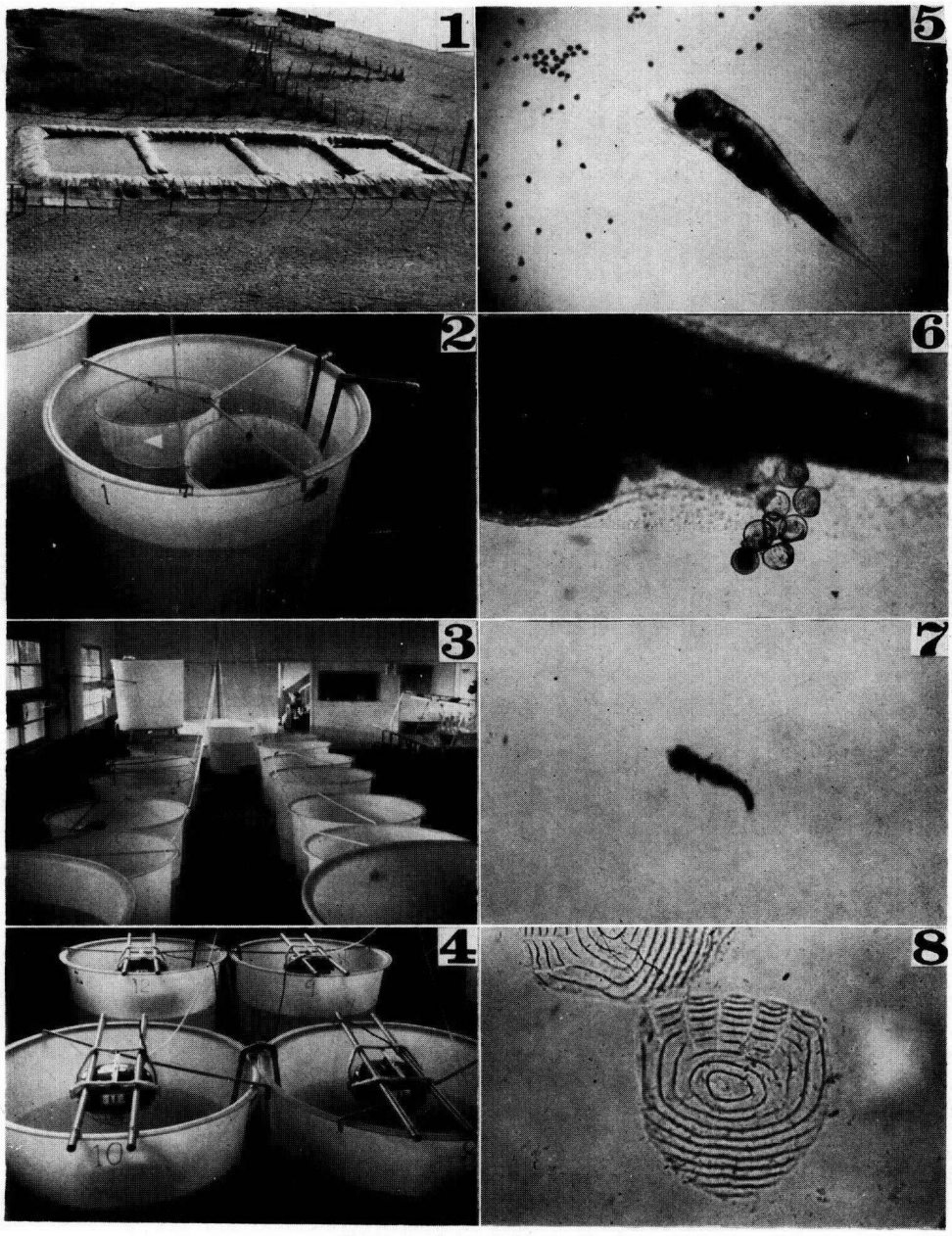
PLATE I



Explanation of Plate I.

Fig. 1. 10—12 hours after hatching.
Fig. 2. 25—30 hours after hatching.
Fig. 3. 3.5 days after hatching.
Fig. 4. 5.5 days after hatching.
Fig. 5. 9 days after hatching.
Fig. 6. 15 days after hatching.
Fig. 7. 30 days after hatching and measured 1.0 in body length.
Fig. 8. The comparison of natural fingerling (upper) with artificially propagated fingerling of present work (lower).

PLATE II



Explanation of Plate II.

Fig. 1. Aquaria for spawner.
Fig. 2. Hanging net for hatching in running water system.
Fig. 3. Indoor hatching—rearing plastic tank.
Fig. 4. Heating apparatus.
Fig. 5. Larva and oyster larvae.
Fig. 6. Discharging oyster larvae from anus.
Fig. 7. Swimming larva.
Fig. 8. Scales of the larva of 1.0 cm body length.

低於乾導法所得者*。

孵　化　孵化所須時間如 table 2 所示，在鹽分濃度 32.4～32.7‰，水溫 21°C 上下須 60～65 小時孵化，但水溫高至 24°C 上下則只須44～50小時即可孵化，而孵化率在流水式及止水式之間似無顯著之差別。

幼　魚　剛孵化之幼魚（plate I, fig. 1）全長 3.09公厘，眼無色，口未形成，耳胞胚位距眼約 100μ（萬分之 1 公分），未有游動能力，靜水狀態下則橫臥於水底。孵化後第 2 天，眼開始出現色素，耳胞距眼漸近，胸鰭原基出現，尾柄部鰭褶開始緊縮。第 3 天，口部形成，眼呈黑色，胸鰭葉發達，但鰓裂未全開。第 4 天，下顎發達，比上顎突出，鰓裂全開，開始攝食如牡蠣幼蟲第小型食物。第 5 天，卵黃消失殆盡，背鰭褶基部增厚，肛門部背鰭褶亦增高。第 11 天，油球亦消失殆盡，體長已增至3.29公厘，已能攝食較爲小型之輪蟲。第 13天，眼呈銀青色。第 19 天，已長至約5公厘，晚間不攝餌，僅於晝間攝食。第23天，部份已長出鱗片，體色開始能隨環境變化，時呈褐黑時呈銀白色，但體背部夜間皆呈黑色。到第 25 天則各鰭齊全，並具軟條，各鰭無色但背稜呈淡褐色，背部黑色，體側及腹面銀白色，眼銀色微帶青，眼球呈黑色。第27天，體長已至1公分，鱗片長滿全身，其體側部者寬 290 μ，長 200 μ，背腹部者寬 240 μ，長 160 μ（plate II, fig. 8）。

培　育　分爲流水式及止水式進行培育試驗，流水式者，盡可能在使水溫，鹽分安定之狀況下進行培育工作，但仍免不了日夜間的變化及日與日間的變化。結果室內 0.5 噸塑膠水槽中飼育者養活最長日數僅達9天即全數斃死，而室外大水槽者（4×60×.8 公尺），放養孵出後第6天幼魚約 1 萬尾，亦在移放後第 4 天全數斃死。

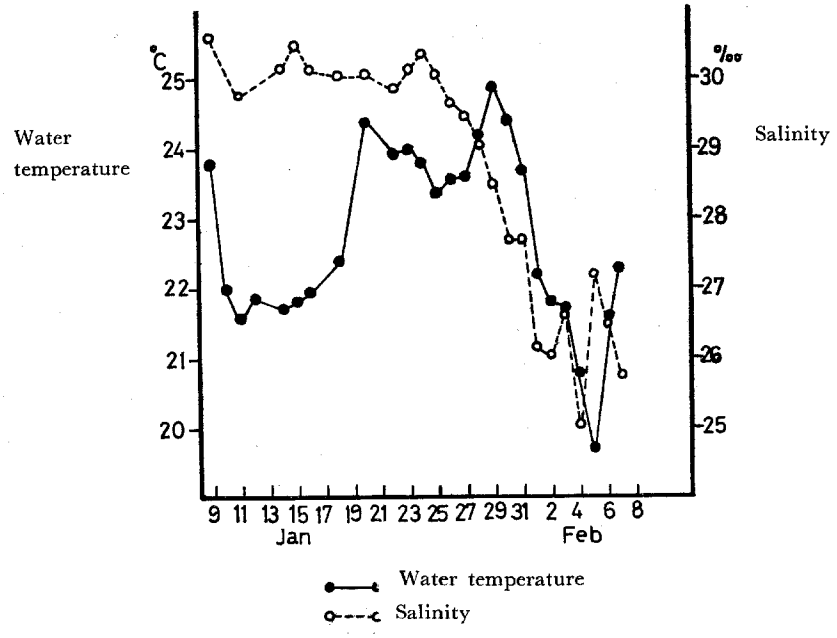


Fig. 1　Water temperature and salinity during raising period.

* 此項試驗由林紹文博士所主持，其詳細結果容後發表。

止水式方面，此次利用室內（3.0×3.3×0.8 公尺）大水槽，放養出後第 6 天幼魚約 1 萬尾，養活至孵化後第23天全部死亡，其中十數尾養活至第16天，5尾養至第20天，3尾養至第23天。

最後育成體長 1 公分者，是在 0.5 噸塑膠水槽中之較淡飼育水中放養約 3,000 尾而養活的。其水溫、鹽分之變化情形如 fig. 1 所示，飼育期間每天略加魚塩水使淡，第 15 天後，因活下來約十數尾活力很强，亞硝酸（Nitrite-N)* 也稍嫌多一點，所以多加點魚塩水，使鹽分降低至26‰左右。這期間幼魚之情形一直很好，晝間不斷地攝餌，而每每吃得很飽（plate II, fig. 6, 7)。但於第27天寒流突然來襲，水溫驟降，翌日更爲降低，雖即裝上保溫設備（plate II, fig. 4)，使水溫上昇，但已不見幼魚攝餌，體色發黑，只見幼魚不斷的在水槽上下游動，至第 30 天終告死亡，檢查其屍體呈 "Pin-head" 狀態，亦即在極度飢餓狀態下死亡。

另外，此次在培育期間觀察幼魚習性結果，發現在照度 600～1,400 lux 之範圍，幼魚具有趨光性。因此在此照度下先集聚幼魚而給餌，或可增加其攝餌機會而提高其生存率。

3. 討　　論

種魚之選購及其蓄養工作，歷經四年[3), 4), 5), 6)] 來之不斷改善，已解決了不少問題，尤以這次以自備引擎之舢舨出海，航行時間大爲縮短，搬運種魚上改善了不少。

賀爾蒙處理結果已達排卵者如 table 1 所示約佔全數之 63 %，但孵出幼魚者則僅佔全數之 10%，因此以賀爾蒙處理以期達到人工繁殖目的，仍有不少有待改進之處。不過，要作種種處理以爲比較殊非易事，烏魚洄游之期甚爲短暫，而要獲得足够的種魚作處理比較更是難上加難。此次併用維他命 E，雖未能斷定其效果，但似乎比過去能延長種魚生存之時間。另外，在打針處理後浸於 100 ppm 金黴素液中 10 分鐘，似乎減少了魚體因受擦傷而被細菌感染之虞。但此均待進一步研究證實。

孵化方面，此次試以流水及止水兩種方式比較結果，兩者之間無顯著之差別，而其孵化率皆高達 80 %以上，而過去孵化率亦復如此。所以烏魚卵在受精至孵化過程似乎已無多大問題。唯此次在孵化過程中，流水式孵化槽中之部份受精卵感染了細菌，結果受精卵呈赤橙色而腐爛。不過，感染時間爲期短暫而未釀成大災。此細菌可以 Tetracycline** 或以鹽分濃度 15‰ 以下之海水防止。至於其感染性、毒性、是否有地域性（過去在汕尾地區，未曾出現過）等問題則有待今後之研究。

總觀上述，經過四年及此次試驗結果，已能孵出多數幼魚，問題在於所孵化之幼魚只是多活幾天而未能培育成長。此次試驗主要目的亦放於如何培育幼魚上。觀察烏魚苗之生態即瞭解其有聚集於河口之習性，此乃顯示隨其長大有趨向較淡之水域生活之性質。爲了進一步瞭解此幼魚和鹽分濃度之關係，前後曾作多次預備試驗，結果顯示其生存之鹽分濃度範圍相當廣，即 17～44‰，尤其值得注意的是其對低鹽分濃度之耐度可低至17‰，不過，對鹽分濃度變化之適應性則稍嫌弱些。根據此等習性，實際工作乃着重於如何使幼魚適應較淡之海水，此次採用下述兩種方法，其一爲漸漸地減低其鹽分濃度，另一則爲着幼魚之成長逐步加淡。結果此次其獲培育 30 天而成長爲 1.0 及 1.1 公分體長之 2 尾乃屬於前者，其鹽分變化情形如 fig. 1 所示。在此過程中幼魚活力甚佳，前半段其攝餌不分晝夜而時刻都能保持滿腹狀態，到後半段則不在夜間而專於白天攝餌，其攝食活動甚爲旺盛，成長速度亦快。不料於孵化後第27天寒流來襲，水溫驟降至 17°C，此後雖添

* 用 G. R. 試藥比色測定。

** 據趙乃賢小姐之試驗，此種細菌可以 Tetracycline 2 ppm 即可抑制其生長。

裝加溫設備（plate II, fig. 4），但幼魚活力已大爲衰退，餌料在眼前亦不肯索取，而體色日漸發黑，體型消瘦以至第 30 天而死亡。檢討此失敗原因，可得如下之結論：即當初放養於此槽爲數3,000尾，而於前 10天斃殆半，或可歸因於餌料之不足。牡蠣幼蟲之可充吸收卵黃後數天內之餌料是無可置疑的（plate II, fig. 5. 6），如黑鯛，眞鯛[7),8)]等人工孵化初期之餌料亦爲牡蠣幼蟲，但此次試驗期間所能入手者，皆非良好之牡蠣，其受精情形不甚理想，因此，不但影響餌料密度，且帶來水質之惡變。其次，牡蠣幼蟲以後之餌料，雖給予大量之輪蟲，但其大小似乎還不太適合。另外，在燒杯中觀察其攝餌習性，孵化後十數天內其攝餌方式往往頭部向下尾部向上，在器底啄餌，因此像輪蟲等富於活動性者或許不易攝食，設若先將之冷却而削減在水中活動力，以期活着沈在底下或許作爲一良好之餌料。能多活上十數天則其攝餌能力更爲加强，能够追食游動的橈足類（Copepoda）而且極爲愛好。然而給予剛孵化之豐年蝦幼生則逃避之，覩其作爲餌料，大小諒已不成問題，此所以不索取之原因或許由於它帶點赤褐色而不習慣，今後當早期投入而讓幼魚習慣或可改進。此外，爲了保持水溫，加上電熱器（plate II, fig. 4），雖能達到保溫之目的，但此種方式總不够理想，免不了水溫之高低不一而影響幼魚之健康。又此次雖比過去改用大型水槽（plate II, fig. 2. 3, 0.5 噸量），但仍不够安定，易受外界變化之刺激。至於飼育中之打氣亦是今後該檢討之一項，由於打氣之影響，幼魚之鰭片尤其是尾鰭常受損傷而致死。設若在飼育過程中，能保持水質之不變惡，並能漸漸使其變淡則最好讓幼魚孵出後就在該孵化槽中成長一段時期爲最理想。烏魚苗適於較淡之海水中飼育似乎是無可置疑的，今後之問題在於如何使它在不造成過分刺激條件下，讓幼魚適應較淡之海水。

如 fig. 2 所示，孵化出時，幼魚之體長各年間有顯著的差異[3),4),5)]，且此次幼魚之成長，在孵化後15天內似乎很遲緩，而於15天後才有較爲顯著的成長，但第3次烏魚人工繁殖研究隊所得結

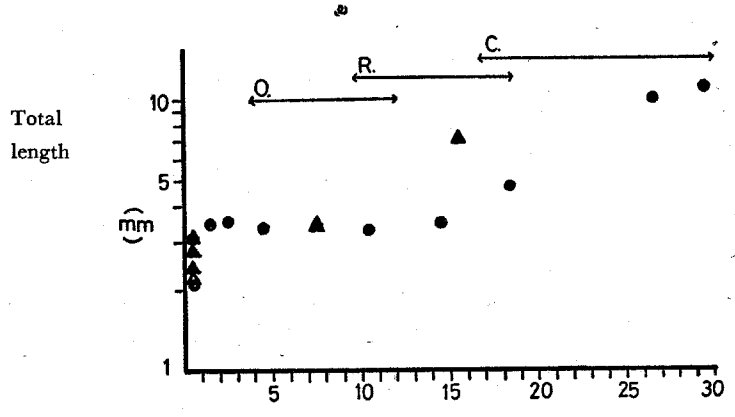


Fig. 2 The growth of larvae in relation to food.
△ : The first time of mullet artificial propagation[3)].
○ : The second time of mullet artificial propagation[4)].
▲ : The third time of mullet artificial propagation[5)].
● : The present time of mullet artificial propagation.
O : Oyster larva
R : Rotifera
C : Copepoda

果[5]，則和此次之成長傾向略有差異，係於孵化後15天前就有顯著之成長。此種成長速度及其過程之差異，是否與先天有關，抑或與後天之飼育環境有關則有待今後之研究。

另外，室內大池（3.0×3.3×0.8公尺）約放養1萬尾，結果此批中雖一小部份養至第23天，但大部份於第15天前斃死，很可能由室內光度之過低（80～300 lux）及餌料之不足，以及牡蠣不受精卵引起水質惡變所致。另外爲了作飼育比較，此次也試用流水式，結果皆於孵化後9天內相繼死亡，其最大原因乃水質，包括水溫、鹽分之變化所致。在室外大池（4×6×0.8公尺）放養約1萬尾，亦於移放後第4天皆告死亡，其原因經推想有二：一爲所蓋之尼龍膠布可能含有害原料，二爲水溫之日夜變化太大及陽光太強。由上得知，烏魚之幼魚最忌嫌環境之變化，此次流水式飼育已盡最大努力，控制此變化至最小限度，但仍然未能臻於完善之境，而此次止水式雖比流水式飼育成績來得好，但亦難於保持其水質之不惡化，因此靠此方法要大量生產，仍有其限度。總之，有待今後解決之問題，爲決定飼育水槽之最適規格及如何控制水量使不變惡。另外，此次加入魚塭水者能培育出2尾幼魚，是否和魚塭水中含有之微小生物及微量物質有關，亦爲有待今後研究之問題之一。

飼以蛋黃，豆漿者，其攝餌情形很好，但很難保持水質不惡化，而換水本身就可能給幼魚一種刺激，影響飼育。有關人工餌料之開發，乃是今後研究之重要課題之一。

最後再次檢討種魚問題。如上述靠漁船捕獲者並非易事。最爲理想者乃於魚塭中培育種魚，幸而此魚可在魚塭中飼養並可養成種魚那般大小。今後繼續從事漁船捕獲種魚之促進排卵工作固有必要，但另一方面必須着手進行魚塭中培育出之種魚之人工促進排卵工作，並且在種魚飼料方面多加研究，或可促其提早成熟。總之，設若能够自魚塭中成長之種魚採卵，受精並孵化，則其魚苗之飼育或可比採自漁船者較有成功的可能。

4. 摘　　要

於民國57年（1968）11月至翌年2月，烏魚羣作產卵洄游路徑臺灣南部近海時，選購圍網捕獲之種魚，給予賀爾蒙處理，進行烏魚人工繁殖試驗，獲得下述結果：

(1)試驗期間共獲種魚30尾，施以賀爾蒙處理（2.5～4個烏魚腦下腺，混合10～35家兎單位生殖腺刺激賀爾蒙），結果排卵19尾佔63%，又其卵能孵出幼魚者有3尾佔10%。

(2)賀爾蒙處理效果與漁季似乎有關，在漁季盛期所得之效果似乎較爲顯著，而第1次賀爾蒙處理後在40～50小時內排卵者，其人工繁殖成功之機會較高。

(3)受精卵在鹽分濃度32.4～32.7之下，水溫21°C上下約須60～65小時孵化，但水溫若高至24°C，則只須44～50小時即可孵化，而孵化率在流水式及止水式間似無顯著之差別。

(4)幼魚生存之鹽分濃度範圍甚廣，其低鹽分濃度之耐度可低至17‰，不過，對其變化之適應性則似乎不強。

(5)幼魚在照度600～1,400 lux之下，具有趨光性，而此性質或可應用於飼育上而達提高生存率之目的。

(6)此次孵出之幼魚在漸漸加入魚塭水而淡化之飼育水中，培育30天共養活2尾魚苗其體長爲1.0及1.1公分。

5. 謝　　辭

本試驗由臺灣省水產試驗所主持，而由農復會，漁業局及洛氏基金之撥款補助得以順利完成

。在試驗期間承農復會陳組長同白，林技正書顏，袁技正柏偉，漁業局陳副局長邦豪，省水試所鄧所長火土之蒞臨指導，漁業局鄭股長技修對於試驗之實施積極策劃，高雄縣汕尾蔡燕國先生之協助及水試所臺南分所謝分所長錫欽和該分所各位對本工作之進行予以莫大協助。此外，遠自曼谷回國參加此次研究隊工作之聯合國糧農組織漁業專家林紹文博士，在試驗期間，無論在技術上，精神上所給予本隊工作人員之指導及鼓勵是難以忘懷的。茲謹誌之，藉表謝忱。

6. 參考文獻

⑴童逸修：鰱魚之年齡查定，中國水產，第80期，p. 2～10, (1959)。

⑵臺灣省農林廳漁業局：56年度中華民國臺灣地區漁業年報，244 pp., (1968)。

⑶烏魚人工繁殖研究隊：注射賀爾蒙促進烏魚產卵試驗，中國水產，第136期，p. 2～9, (1964)。

⑷烏魚人工繁殖研究隊：烏魚人工繁殖試驗（第2報），中國水產，第150期，p. 2～4, (1965)。

⑸烏魚人工繁殖研究隊：烏魚人工繁殖試驗（第3報），中國水產，第165期，p. 14～17, (1966)。

⑹烏魚人工繁殖研究隊：烏魚人工繁殖試驗（第4報），中國水產，第173期，p. 2～7, (1967)。

⑺平野禮次郎，大島泰雄：海產動物幼生の飼育とその餌料について，日本水產學會誌，第29卷，第3號，p. 282～297, (1963)。

⑻笠原正五郎・平野禮次郎・大島泰雄：クロダイ人工孵化仔魚飼育とその成長について，日本水產學會誌，第26卷，第3號，p. 239～243, (1960)。

臺灣北部淡水魚池及水庫的水質及生物概況

General features of water quality and biological aspect of some freshwater fish ponds in northern Taiwan

廖　文　光

臺灣大學漁業生物試驗所

By Wen Kuang Liaw

Department of Zoology and Institute of Fishery Biology, National Taiwan University

English Summary

This report summarizes the results obtained in the past three years of studies on the chemical and biological conditions of some freshwater fish ponds in northern Taiwan. Several conclusions may be drawn in relation to problems of fish pond fertilization.

1. In determining the fertilization rate of superphosphate to certain fish pond, it is important from economic point of view that one first considers the amount of phosphorus already existing in the pondwater and in the inflow water, and the chemical characteristics of bottom mud as well.

2. Under existing pond conditions, phosphorus content of pondwater between 0.05 and 0.2 ppm seems to be sufficient for the thriving of phytoplankton. If sufficient amount of organic matter is present in the pond to serve as carbon source for the need of algal photosynthesis, phytoplankton bloom can be easily maintained for a long period of time. Therefore, application of suitable amount of organic fertilizer seems to be needed from time to time.

3. Under present pond conditions, application of nitrogen and silicon fertilizers seems unnecessary for most ponds in this area.

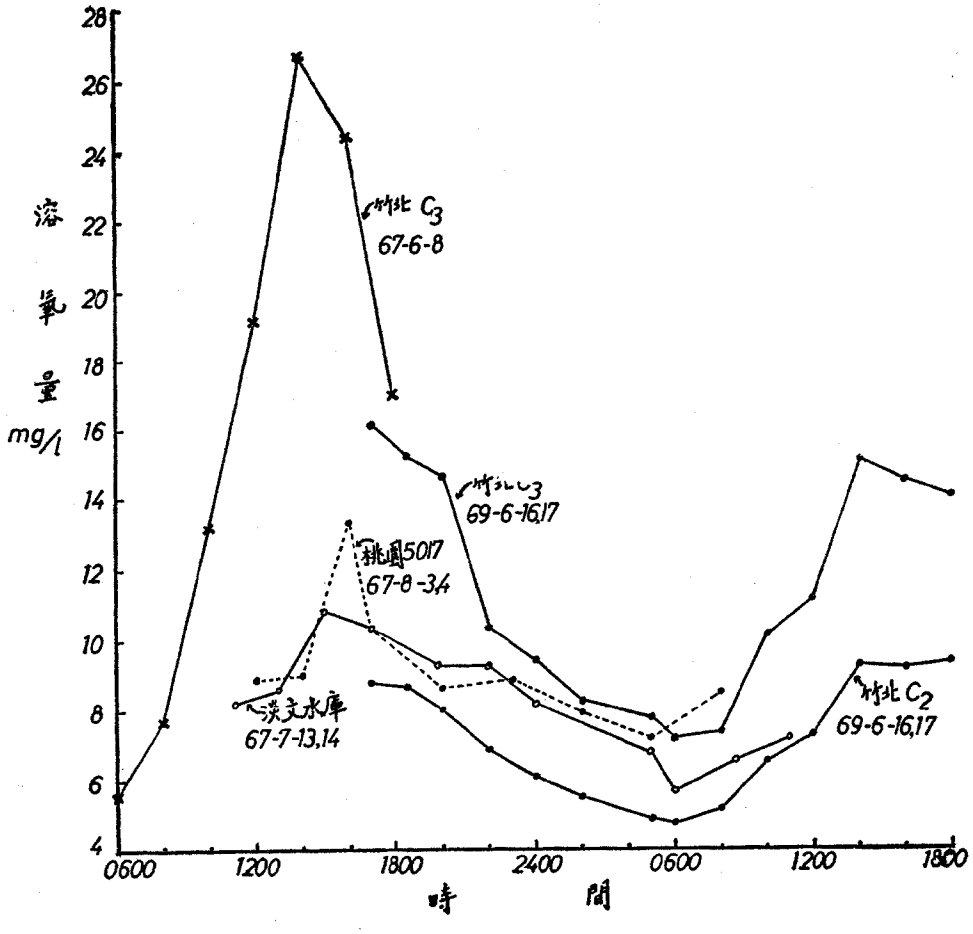
4. Primary production and chlorophyll content of pond water are useful criteria for the evaluation of the fertilization policy. Therefore, it is of interest that these data be collected systematically from selected ponds. These data can also be correlated to fish growth and yield.

臺灣淡水養殖的基礎科學研究工作，自民國五十五年獲得美國洛克斐勒基金會的補助及農復會漁業組的全力策劃及推動下，已開始向前邁進了一大步。研究計劃很多，但都是以施肥養殖爲中心。本計劃主要是與施肥的魚池的理化及生物學方面的研究。眞正工作的開始是自民國五十六年度起。第一年度的工作偏重於施肥與未施肥魚池及水庫的一般水質及生物調查。其結果已刊載於農復會漁業專輯第七期中（Liaw, 1969）。因該報告是用英文寫的，恐一般養殖業者參考不便，乃將該報告摘要合併第二年度的研究結果寫成本文，希望有可供養殖業者及有關研究人員參考之處。

一、水 質 概 說

1. 溶 氧 與 pH

魚池中溶氧的多寡， pH 的高低與藻類的多少有密切的關係，一般說來池中藻類多時，由於旺盛的光合作用消耗水中的二氧化碳，同時產生氧氣，故水中溶氧增加，常達過飽和狀態。同時 pH 值也見增高，但其改變幅度並不如溶氧那樣顯著。在所調查過的各魚池中，一日中溶氧及 pH 值都以黎明時分（六時左右）爲最低，而以下午二至四點之間爲最高（圖一）。 溶氧週日變化幅



圖一 各魚池表層水溶氧週日變化

度以藻類多的小魚池較大魚池爲大。例如竹北實驗池（0.1 公頃左右）六、七月間，天晴時二點鐘左右表層水的溶氧有高達 24.52 ppm（水溫 32°C 飽和度 365.85%）者，而黎明時（六點左右）的溶氧則爲 5.53 ppm（水溫 26°C 飽和度 69.21%）；最高最低相差達 18.99 ppm 之多。而大面積的苗栗淡文水庫（7公頃左右），在七月間所測得的週日變化中，最高爲3點鐘左右的 10.85 ppm（水溫 32.5°C，飽和度 149.24%）最低爲早上六點鐘的 5.76 ppm（水溫 31.0°C，飽和度77.63%）

，相差僅 5.09 ppm。不過最高與最低溶氧相差的大小主要還是受水中藻類多少以及其光合作用率的影響。故在未施肥的桃園1019號池中，其溶氧的週日及垂直變化均極微小，且其溶氧差不多接近飽和狀態，此乃由於水中營養鹽缺乏致藻類未能大量繁值之故。

各調查池中，氧氣及水溫的分層現象並不多見。但在天氣悶熱無風的日子亦可發現底層水缺氧的情形。這種情狀尤常發生於藻類濃密，陽光無法照到底層而使上下層水溫相差較大時的池子。例如桃園 5017 號池及埔里鯉魚潭在悶熱的夏季常有此情形發生。

根據過去Miyadi (1935), Yoshimura (1936) 及現在的資料，臺灣陸水（包括湖沼，魚池及溪流等）的 pH，除少數特殊地區如北投，陽明山等溫泉地帶及高山上小池沼外，大多爲弱鹹性或鹹性（表一）

表一　臺灣陸水之 pH 值

pH	全省各地陸水		北部魚池及水庫	
	個　數	%	個　數	%
4.0以下　(强酸性)	2	3.4	0	0
4.0— 5.9 (酸　性)	15	25.4	0	0
6.0— 6.9 (弱酸性)	2	3.4	1	6.6
7.0— 7.9 (弱鹹性)	15	25.4	4	26.7
8.0—10.0 (鹹　性)	25	42.4	10	66.7

從表中可知在所調查的各魚池中，表層水的平均 pH 值，有66%以上是屬鹹性，但 pH 大於 10 的强鹹性的情形並不常見，只有在藻類大量繁值時才有。埔里鯉魚潭的 pH 在藻類稀少時僅有 6.8（各次平均 7. 6），爲本省北部地區各魚池中之最低者，但當藻類茂盛時亦可達 9 以上。

2. 其他化學概況

本省北部地區魚池及水庫表層水的重要化學狀況的比較列於表二中。下面僅就與養魚較有關係者，略加討論。

(1)總鹹度　爲表示以 0.02N H_2SO_4 滴定至指示藥 Methyl Orange 變色時所得的水中鹽基總含量的一種方法。亦即天然水按受氫離子能力大小的一種表示方法。包括氫氧鹹度 (OH^-)，碳酸鹹度 ($CO_3^=$) 及重碳酸鹹度 (HCO_3^-) 三種。在所調查的各魚池及水庫中，重碳酸鹹度佔大部份，其次爲碳酸鹹度，氫氧鹹度則常爲零。各調查池總鹹度平均值爲 98.96 ppm，桃園魚池較平均略低爲 61.21 ppm。竹北，鹿港各池則較高均在 120 ppm 以上。埔里鯉魚潭最低僅 23.94 ppm，最高爲竹北分所的地下水，達 255.0 ppm。據文獻所載，臺灣池沼中鹹度最高的爲臺東大坡池達 347 ppm (Yoshimura, 1936)。所有調查池中有 60 % 以上的鹹度在 41.0-120 ppm 之間（表三）與日本陸水的相比，大得很多。據 Satomi (1962[a]) 的資料計算，日本池沼的鹹度有60%是在 10.0-30.03 ppm 之間。而日本河川的鹹度平均亦僅爲 31.0 ppm (Sugawara, 1961).

水中鹹度與魚產有關的報告，在文獻中並不少見。例如 Satomi (1962[b]) 及 Moyle (1946) 等均曾有鹹度大的湖沼或池子，其魚產量也大的報告。這可能是因爲在鹹度大的池中，CO_2 大部份以 $CO_3^=$ 及 HCO_3^- 的狀態存在水中，大氣中的 CO_2 可大量溶入水中，而使水中藻類行光合作用所需的 CO_2 的供應充足的緣故。如果拿各調查池的魚產量和其鹹度做一比較，雖亦可發現

表二　臺灣北部地區魚池及水庫表層水化學概況比較

（民國56年2月至58年6月間各次測定值之平均單位爲 mg/ℓ）

地區		總鹼度 (as $CaCO_3$)	總硬度 (as $CaCO_3$)	Ca	Mg	Na	K	Cl	PO_4-P	NO_3-N	NO_2-N	SiO_2	電導度 ($\mu\sigma$/cm 20C°)	$KMnO_4$ 消耗量	水色 (Pt 單位)
桃園魚池	5017 池	42.44	72.40	15.18	8.37	—	—	20.06	0.074	0.345	0.059	2.509	233.7	24.77	14.5
	5017 入	51.64	70.07	17.60	6.31	—	—	15.58	0.125	0.268	0.165	3.051	244.2	36.19	31.0
	8103 池	32.03	52.33	15.12	4.14	—	—	13.54	0.191	0.002	0.031	3.628	159.3	20.16	9.5
	8103 入	36.55	64.19	17.56	4.93	—	—	14.90	0.045	0.109	0.025	7.340	197.5	19.11	11.5
	8004 池	72.60	91.57	16.05	12.42	—	—	9.25	0.136	0.010	0.125	4.467	215.1	35.22	12.5
	8004 入	73.14	107.85	28.22	9.06	—	—	10.68	0.017	0.057	0.028	5.121	200.2	9.44	4.5
	2012 池	120.00	115.00	27.00	11.54	—	—	14.10	0.052	0.040	—	3.272	319.0	—	—
	8019 池	118.00	130.00	24.00	17.00	—	—	5.60	0.047	0.019	—	5.386	273.0	—	—
	1019 池	44.50	84.13	20.64	7.90	—	—	16.72	0.009	0.002	0.015	2.128	204.0	19.52	6.0
竹北試驗池	A_1	108.33	146.40	46.80	7.14	—	—	14.50	0.070	0.047	0.011	3,101	—	17.57	12.0
	A_2	94.14	149.87	46.43	8.21	—	—	13.75	0.097	0.039	0.288	3.542	—	46.46	21.0
	A_3	119.90	155.27	42.93	11.65	—	—	11.90	0.048	0.153	0.042	6.751	—	14.96	14.0
	A_4	117.33	143.73	42.67	8.76	—	—	14.00	0.058	0.095	0.033	2.960	—	23.85	15.0
	A_6	117.35	142.60	40.88	9.81	—	—	11.10	0.051	0.020	0.005	2.801	—	17.36	14.0
	C_1	132.36	152.80	45.68	9.38	—	—	16.50	0.402	0.029	0.078	6.583	—	14.56	12.0
	C_2	115.01	147.09	32.52	16.08	14.20	—	—	0.111	0.016	0.010	10.560	443.5	41.52	18.0
	C_3	91.57	118.13	29.71	10.66	13.77	—	16.50	0.204	0.044	0.004	9.979	344.4	46.37	19.0
	C_4	85.75	127.85	33.88	10.49	14.42	—	17.40	0.052	0.090	0.031	6.746	382.7	20.77	15.0
	C_5	115.01	144.67	42.69	9.22	—	—	18.40	0.038	0.067	0.004	0.771	—	18.49	14.0
	水源（地下水）	255.00	208.00	41.60	25.27	—	—	16.50	0.019	—	—	9.000	401.0	—	—
鹿港試驗池	鰻魚池	157.55	97.23	13.93	15.16	—	—	—	0.472	—	—	6.588	293.7	—	20.0
	其他	188.73	183.95	25.65	29.11	—	—	—	0.234	—	—	2.014	1,157.0	—	24.0
	地下水	194.73	77.48	23.93	4.04	—	—	—	0.932	—	—	—	373.8	—	8.0
板橋厚生工廠鰻魚池		158.14	55.52	9.26	7.87	—	—	—	0.276	0.329	0.039	13.158	390.6	7.65	8.0
臺大魚池		34.97	52.91	12.97	4.99	8.92	1.84	—	0.007	—	—	—	184.6	—	—
埔里鯉魚潭	A 池	24.19	19.12	4.62	1.84	—	—	3.30	0.035	0.053	0.033	3.966	61.3	18.95	11.0
	B 池	23.94	18.90	4.41	1.90	—	—	4.04	0.028	0.030	0.013	4.831	60.2	19.14	10.0
苗栗淡交水庫	上游	109.29	101.87	23.29	10.48	—	—	—	0.120	0.022	0.186	2.647	287.9	31.12	22.0
	下游	108.08	112.67	25.96	11.60	—	—	24.50	0.106	0.030	0.081	3.936	287.9	34.72	25.0
石門水庫	下游	58.81	83.31	19.28	11.42	5.70	0.95	9.58	0.021	0.037	0.010	4.375	207.8	7.98	2.5
日月潭		106.67	153.29	39.15	13.46	—	—	5.21	0.022	0.059	0.030	5.576	315.2	5.57	1.0
平均	桃園	61.21	87.50	20.15	9.07	—	—	13.38	0.077	0.095	0.064	4.100	227.3	23.49	12.8
	竹北	122.88	148.76	40.53	11.52	—	—	15.06	0.104	0.060	0.051	5.708	392.8	26.19	15.4
	鹿港	180.34	119.55	21.17	16.10	—	—	—	0.546	—	—	4.301	608.2	—	17.3
	全地區	98.96	109.04	26.76	10.33	—	—	13.23	0.132	0.077	0.056	5.062	301.6	22.98	13.9

註：入—注入水

池—池　水

表三　臺灣北部地區魚池及水庫之鹹度

總鹹度（ppm $CaCO_3$）	池　數	%
0 — 20.0	0	0
21.0— 40.0	6	19.4
41.0— 80.0	5	16.1
81.0—120.0	14	45.2
120.0以上	6	19.4

鹹度大的池子生產量亦高的情形，但鹹度並不很大生產量却很大的池子亦有。這可能是因爲各池受人爲干擾太多（如施肥及鄉村廢水的注入 ）而使兩者間之關係不明顯之故。

(2)磷　磷酸鹽磷卽可溶性無機磷的含量，全地區平均爲 0.132 ppm，桃園魚池較低，平均 0.077 ppm. 竹北及鹿港試驗池分別爲 0.104 及 0.546 ppm，池水中含磷量變異極大，如不施肥或無含磷較豐之水源則水中含磷量極低，而成爲限制藻類生長及大量繁殖的一極大因素。如未施肥的桃園 1019 號池及臺大魚池，其含磷重分別爲 0.009 及 0.007 ppm，爲各魚池中之最低者。含磷量最高的爲鹿港分所之地下水，達 0.932 ppm 。大多數魚池的含磷量與世界其他地區的（0.005-0.050 ppm 之間）比較可說相當高。根據磷的含量及其肥沃度（Yoshimura, 1932 之分類法，引自 Moyle, 1946）各調查池及水庫亦可分爲若干等級，如表四所示。

表四　臺灣北部各魚池及水庫之含磷量及磷肥沃度

魚　池　或　水　庫	含　磷　量	磷肥沃度
桃園1019；臺大魚池	0　—0.020	差
桃園8019；竹北 A_3, C_5；鯉魚潭；石門水庫；日月潭	0.021—0.050	尙可
桃園5017，2012；竹北 A_1, A_2, A_4, A_6, C_4	0.051—0.100	好
桃園8103，8004；竹北 C_2；淡文水庫	0.110—0.200	甚好
竹北 C_1, C_3；鹿港試驗池及鰻魚池	0.200以上	過量

從表中可知，臺灣北部魚池的磷肥沃度絕大多數都相當好，根據調查期間的觀察，以現有的魚池狀況，水中磷的含量能保持 0.05 ppm 以上的池子，其藻類的生長及大量繁殖似無問題。另一值得注意的是，桃園魚池中魚產及基礎生產量很高的 5017 及 2012 號池其含磷量並不比生產較差的 8013 及 8004 大。這可能是因爲前兩個池子的注入水中除經常含有較多之磷外亦經常含有較多的有機質（$KMnO_4$ 消耗量大）。而有機質的腐爛所生的 CO_2 可供藻類行光合作用之需。換言之水中經常保持足够的磷及充足的碳源可能是導致這兩魚池有較高生產量的重要因素。除了藻類及其他生物的吸收外，池底泥亦能吸收及吸附水中的磷，故施磷肥後，磷在水中的消失甚快。在所調查的桃園及竹北的若干魚池中，大約經過五天左右卽降至施肥前的濃度。現行的施肥方法是根據此一原則五天施放一次，但如人力許可，設法經常保持池中磷於一定濃度而不使其降至施肥前之含量，可能更有助於藻類之生長及大量繁殖。桃園5017號池可能是一很好例子。

(3)硝酸鹽氮　各魚池中的含量變化極大，全地區平均爲 0.056 ppm，桃園魚池平均爲 0.064 ppm，較平均略高。各魚池硝酸鹽氮的含量與藻類的生長與繁殖之間的關係，似不如磷的那麼明

顯，也許現有的含量足够繁殖之需。此外池中若干藍綠藻及氮化細菌（據觀察竹北魚池，池水中及底泥中氮化細菌約佔嗜氧細菌總量之5.6%）或能固定大氣中氮或能將生物代謝作用所排出之含氮廢物轉變爲藻類所能利用之硝酸鹽。故若非新池，一般魚池氮的來源並不如磷那樣常會缺乏到限制藻類大量繁殖的程度。

(4)矽酸　矽酸的含量除竹北 C_5 號池有過較世界一般淡水矽酸含量爲低（0.771 ppm）外，其他各池含量雖不算很高（平均 5.062 ppm），但相信對藻類大量繁殖並不構成一限制因子。

(5)鈣與鎂　鈣與鎂爲淡水中含量最多的陽離子，對湖沼及魚池的生產亦有密切的關係，因鎂爲藻類葉綠素分子中的一重要成份。通常鈣的含量要較鎂爲多，鹿港的試驗池則爲一例外。如按照德國的湖沼學家 W. Ohle (1934) 的分類（引自 Reid, 1961），臺灣的湖沼，魚池及水庫等陸水，都是含鈣量頗豐的生產力高的水（表五）。埔里鯉魚潭爲所有魚池中含鈣量最少的，僅有 4.41 mg/ℓ。據 Yoshimura (1936) 的資料，臺東大坡池爲臺灣含鈣量最多的池子，達 69.6 mg/ℓ。一般說來，含鈣量多硬度大的水，生產量高，而含鈣量少的軟水生產量則低。

表五　臺灣北部地區魚池及水庫含鈣量

含　鈣　量　等　級	魚　池　數	%
低 10 mg Ca/ℓ 以下	3	9.7
中 10-25 mg Ca/ℓ	11	35.5
高 25 mg Ca/ℓ 以上	17	54.8

二、生　物　概　況

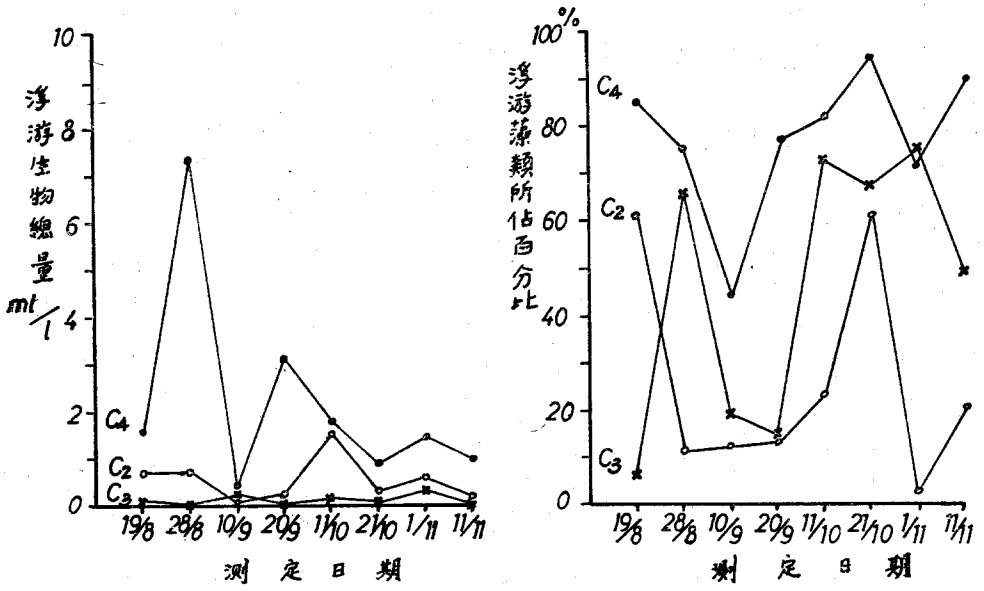
1. 浮游生物

比較施肥與未施肥魚池或水庫，得知在未施肥魚池中，浮游動物的數量要比浮游植物爲多。而原生動物中的雙鞭毛類，*Ceratium hirundinella*則爲一很普通的種類。輪蟲通常爲浮游動物中質量最多的一類。其中以 *Keratella* 及 *Brachionus* 二屬最爲常見。前者包括 *K. cochlearis* 及 *K. valga* 兩最普通種類，以較深的水庫如石門水庫及日月潭等處爲多；後者包括 *B. diversicornis, B. regularis* 及 *B. forficula laevis* 等種，則以水淺的魚池爲多。枝角類（Cladocera）及撓脚類（Copepoda）等較大型浮游動物，有時雖大量發生，但種類及數量通常都不多。

浮游藻類方面，在未施肥的魚池或水庫中，通常以綠藻類（以 *Pediastrum* 及 *Scenedesmus* 爲主）及硅藻類（以 *Synedra, Melosira* 及 *Navicula* 等較爲常見）爲主。在施肥魚池或水庫中則經常有大量的藍綠藻發生，其中尤以 *Anacystis, Anabaena, Spirulina* 及 *Oscillatoria* 等最爲常見。當施肥魚池中藻類大量繁殖時，種類頗爲單純，絕大部份均屬一種。同時浮游動物在整個浮游生物中的比例亦見減少。這種情形可從57年在竹北數個魚池中，所做的半年的觀察中看出（圖二）。

2. 基礎生產量及葉綠素濃度

拿年魚產量與其年施肥量做比較，求出一魚池的最經濟的施肥率的方法（Lin 1968），就養魚而言，當然是一最直接而實用的方法。不過魚產量除了與施肥有關外，其他尚有很多無法預知



圖二：竹北分所三試驗池，1968年下半年浮游生物產量及浮游藻類所佔百分比變化。C_3 池在測定期間有大量大形絲狀藻（以 Chaetophora 爲主），故浮游生物極少。

表六　臺灣北部若干魚池及水庫的毛基礎生產量 (gross primary production) 及葉綠素 (chlorophyll *a*) 濃度

魚池或水庫	測定日期	mg $O_2/m^3/hr$	mg $C/m^3/hr$	g $O_2/m^2/day$	g $C/m^2/day$	chlorophyll *a* mg/m³	mg c/mg chl/hr
桃園1019	67-6-23	65.0	24.4	0.86	0.32	—	—
桃園8103	6-20	198.7	74.5	2.62	0.98	—	—
桃園8004	6-21	333.3	125.0	4.40	1.65	—	—
桃園5017	6-20	402.8	151.0	5.31	1.99	—	—
桃園5017	9-28	970.0	363.8	12.80	4.80	137.0	2.66
桃園5017	10- 2	475.7	178.4	6.28	2.36	115.0	1.55
竹北 C_3	11- 4	817.0	306.4	10.78	4.04	—	—
竹北 C_3	69-6-17	1,343.0	503.6	16.67	6.25	76.8	6.56
竹北 C_2	69-6-17	977.4	366.7	9.65	3.62	34.6	10.59
淡文水庫	67-6-13	223.3	83.7	2.95	1.11	—	—
淡文水庫	9-14	328.3	123.1	4.33	1.62	—	—
石門水庫	8- 2	107.3	40.2	1.42	0.53	1.16	—
平　均		520.2	195.1	6.51	2.44	72.91	2.65

註：(1) 1967年用暗瓶法測定，1969年改用水中溶氧週日變化法測定。前者測定時間大多在1000至1600時之間，據粗略估計此時間內的基礎生產量約爲全日生產量之 68.33%。後法所得之單位面積日生產量比前法所得者略高，一般認爲是較能代表自然狀況下之眞正基礎生產量。

(2) 石門水庫之單位面積生產量實際上要比表中所列數值爲大，因該數值只計算到 1.5 m 水深而實際上該水庫之生產深度遠超過此數。其葉綠素含量爲1969年3月27日所測定者，與測定生產量日期不同，故無法計算單位重量葉綠素之生產量。

的因素。因此除非有多次的重複及相當長期的觀察資料，往往不易找出魚產量與施肥量之間的眞正關係來，此外此法做一次實驗通常需要一年的時間，資料無法大量收集。基於這些理由，筆者以爲如果能够配合以基礎生產量與葉綠素濃度的測定，則可於較短期內做多次重複的觀察，也許可能找出施肥量與魚產量間的眞正的關係。北部魚池所放養的主要爲鰱，鯪等直接攝食浮游生物的魚類，故如無其他特殊的不利因素，則魚的生長及產量大致會與基礎生產量及葉綠素濃度成一正相關的。關於這方面的資料目前所有的雖不多（表六），但也大概可以看出好壞魚池之間，基礎生產量的差異；也可拿這些資料與世界其他地區魚池或湖沼的生產量做一比較，看看我們魚池的基礎生產究竟是到那一程度。

表七是直接錄自現有文獻上的原來資料，或根據其原始數據計算而得的，世界各地區魚池湖沼的基礎生產量及葉綠素*a*的濃度。比較表六與表七得知，臺灣北部各施肥魚池的基礎生產量與以色列地區的魚池的甚爲接近，而且都已接近甚或超過一般認爲的淡水基礎生產量的極限（約在 12-15 g $O_2/m^2/day$ 或 4.5-5.6 $C/m^2/day$ 之間）。故具有最高基礎生產量的竹北 C_3 號池的平均含磷量（0.2 ppm），也許可做爲決定其他魚池最大施肥量的參考。

表七　其他地區魚池及湖沼的毛基礎生產量（gross primary production）及葉綠素（chlorophyll *a*）濃度

地　　區	g $C/m^2/day$	Chlorophyll *a* mg/m^3	mg C/mg chl/hr	著　　者
以色列魚池				Hepher 1962
未施肥池（1960夏季）	1.31—1.81	8.8—115.5	1.6—7.8（平均 4.0）	
施肥池（1960夏季）	3.29—6.43	103.4—212.3	4.1—11.5（平均7.6）	
日本湖沼				Ichimura
富營養湖	0.20—1.70	—	—	1964
中營養湖	0.05—0.30	—	—	（引自 Aruga,
貧營養湖	0.03—0.10	—	—	1968）
美國喬治亞州				Welch, 1968
Athens 的一魚池				
夏季平均	3.75（可高達5.6）	—	—	
冬季平均	0.90	—	—	
美國 Canyon Ferry Reservoir				Wright, 1959
各月平均	0.85—1.62（平均 1.44）	2.1—16.7（平均 8.9）	—	

結　　論

目前有關臺灣北部地區魚池的水質及生物的資料雖仍十分有限，不過亦可根據這些資料，做成下列幾點結論。也許可做爲今後魚池施肥的參考。

(1)某一魚池施肥量的決定，應先考慮該池水本來的含磷量，池底泥吸收及吸附磷的能力以及

注入水的含磷量的大小等問題。

(2)就現有各魚池情況而言，水中含磷量如能經常保持 0.05 至 0.2 ppm 之間，則浮游藻類的大量繁殖當不成問題。如能使池水中有適量的有機質，使藻類光合作用時所需之 CO_2 的來源不虞缺乏，則更能保證浮游藻類之繁茂不衰。故魚池於藻類大量繁殖時，施適量之有機肥料似有必要。

(3)以現有魚池之理化及生物狀況而言，若非新池，施放氮肥似無必要；又除非有大量硅藻繁殖過後，也似無必要施放含硅酸之肥料。

(4)由魚池基礎生產量及葉綠素濃度之測定值，可以概略估計魚產量；亦可做爲評定施肥量之是否適當的有力參考。故對這兩項因子，應選定數個魚池做有系統的測定，以便將來與魚產量比較。

謝　　辭

本研究計劃之得以順利進行，而完成此一初步結果，全賴農復會漁業組陳組長同白及該組林顧問書頴之全力爭取美國洛氏基金會之補助，以及時加殷切策勵與指導所致。筆者謹代表參與本計劃之所有人員向兩位先生致至深謝意。本計劃之實際測定工作全靠全體助理研究員之合作及辛苦工作而得完成。筆者只不過負責全計劃之推動，最後之資料整理，以及撰寫報告而已。直接參與本計劃之助理研究人員，第一年度有林正男、吳榮富、邱長吉等；第二年度有謝華兆、黎宜榮及江婉等。此外竹北分所各位同仁及該所洛氏基金助理研究員等亦時予協助，謹此一併致謝。

引　用　文　獻

Aruga, Y. 1968. Technical problems for measuring primary production in the sea and inland waters and the data reported from various areas (in Japanese with English summary). Bull. Plankt. Soc. Japan, 15 (1):19-22.

Hepher, B. 1962. Primary production in fishponds and its application to fertilization experiments. Limnol. Oceanogr. 7 (2):131-136.

Liaw, W.K. 1969. Chemical and biological studies of fish ponds and reservoirs in Taiwan. JCRR Fisheries Series: No. 7, 1-43.

Lin, Shu-yen. 1968. Pond fish culture and the economy of inorganic fertilizer application. JCRR Fisheries Series: No. 6, 37 p.

Miyadi D. 1935. Limnological investigation of Formosan Lakes. Japanese J. Limnol. 5 (3):71-86. (in Japanese).

Moyle, J. B. 1949. Some indices of lake productivity. Trans. Am. Fish. Soc., 76th Annual Meeting, pp. 322-360.

Reid, G. K. 1961. Ecology of inland waters and estuaries. Reinhold Publishing Co., New York. 375p.

Satomi, H. 1962a. Untersuchungen über der Alkalinität des Süsswassers. II. Über den untergesuchten Werte und seinen Schwankungen in japanischen hauptsächlichen Seen und Flüssen. Bull. Freshw. Fish. Res. Lab., 12 (1):51-64 (in Japanese with German summary)

_____. 1962b, Über der Bedeutung der Alkalinität als Indikator für Binnenfischerei-Produktion. ibid, 65-74 (in Japanese with German summary).

Sugawara, K. 1961. Na, Cl and Na/Cl in inland waters, Japanese J. Limnol. 22: 49-65. (in Japanese).
Welch, H. E. 1968. Use of modified diurnal curves for the measurement of metabolism in standing water. Limnol. Oceanogr. 13 (4):679-687.
Wright, J. C. 1959. Limnology of Canyon Ferry Reservoir. II. Phytoplankton standing crop and primary production. Limnol. Oceanogr. 4 (3):235-245.
Yoshimura, S. 1936. Chemical composition of the lake waters (Inland waters of Formosa II). Japanese J. Limnol. 6(1):27-32. (in Japanese).

黃水細菌與虱目魚塭藻類之抗菌力研究

Yellow Water Bacteria and Antibacterial Activity of Four Algal Extracts in Milkfish Ponds

洛氏基金臺灣水產養殖計劃助理研究員

趙　乃　賢

By Nai-hsien Chao

Research Assistant

Rockefeller Foundation Fish Culture Research Program

Summary

Milkfish culture needs clear water with abundant bottom algal growth for successful production, but unfortunately yellow water usually occurs from June to November and becomes very harmful to the growth of milkfish. This is caused by a kind of microplankton bloom which cuts light penetration to the bottom and thus stops bottom algal growth. Many measures have been taken to prevent yellow water development, such as replacing totally or partially the yellow water with fresh sea water, and applying organic and inorganic fertilizers or pesiticides, but none of them have proved to be effective. However, there is a phenomenon in which whenever abundant growth of blue-green algae, especially the *Enteromorpha*, is found in a pond, yellow water never develops. This phenomenon may be a key to the solution of yellow water problem and it is of interest, therefore, to study the effect of, first of all, the antibacterial activities of the algal extracts in milkfish ponds.

1. Yellow water is a result of overgrowth of microorganisms in milkfish ponds.

2. Yellow water gives rise to high turbidity and low dissolved oxygen content.

3. Twelve strains of yellow water bacteria are isolated. They are yellow or white in color, rod-like, coccus, staphylococcus and streptococcus in form. The surface of colonies are smooth or rough, dull or glistening; circular, irregular or rhizoid in shape; the elevation, flat, raised or convex. All of them bear no spores. Four possess capsule and two possess flagella, however, the examination of cultures for motility gives all positive reaction.

4. Y 103, Y 110 and Y 112 are Gram negative and the others are Gram positive.

5. Y 103 and Y 105 are acid fast

6. All strains cannot produce indole from tryptophan.

7. Y 103, Y 104, Y 110 and Y 111 can hydrolyze the gelatin.

8. Y 101, Y 104, Y 107, Y 108, Y 109, Y 110 and Y 112 can hydrolyze starch.

9. All strains can ferment maltese and sucrose, but not all can ferment glucose and lactose.

10. All of them produce catalase.

11. All of them cause reduction of nitrate except Y 105.

12. Only Y 101, Y 106 and Y 108 cannot use citrate as carbon source.

13. The litmus milk tests of Y 103, Y 107 and Y 110 give positive reaction with the production of acid.

14. All strains are lactic acid bacteria.

15. The methyl red tests of Y 103, Y 107 and Y 110 give positive reaction.

16. In the Voges-Proskauer tests, half of them are positive reaction, while the other half are negative reaction.

17. The disc assay shows that *Enteromorpha* sp., *Chlamydomonas* sp., *Lyngbya* sp., and *Phormidium* sp. have antibacterial activities.

18. The antibacterial activity of *Enteromorpha* sp. is highest among the four algae mentioned.

一、前　　言

虱目魚（*Chanos Chanos* Forskal）之養殖已有三百年，爲本省養殖歷史最久者。此魚屬於廣鹽性溫水魚類，於海水魚塭養殖者，靠其塭中下等藍藻類生長繁茂而保持塭水清澈，通常水質，水色作不斷之變化，概與水中生物之消長有關[1]；至於水質變惡，則可歸因於下述數項，微細動植物常會消耗大量氧氣，又水中有機質如腐植質、殘存之餌料、排泄物、死體等均利用細菌使之發酸腐敗，而分解作用必消耗氧氣，同時，於分解之際，每每發生有毒氣體如二氧化硫、硫化氫、氨、甲烷等，因而酸鹼度常會爲之低降[2]。普通虱目魚塭於每年6，7月及10，11月最忌發生所謂黃水現象，卽塭水黃濁且微生物繁生使塭水黏稠、腐臭甚而水面形成條紋、皮膜模樣；此等由於微生物之大量繁生而改變水色的現象，溯沼學稱之爲水華（Waterbloom），其中黃色水華常係細菌矽藻有以致之[2]。

虱目魚塭發生黃水現象是不規則性的，依各塭每年情況不同而有異，或發生或不發生，迄今未有能預先測知者。據觀察結果，塭水發生異常後，數日之內或許情況好轉，水色復歸清澈而未變爲更深之黃濁；否則日益嚴重，久之，虱目魚浮頭斃死，有不可遏止之勢。一般施救之策爲換水或施放農藥；換水係將虱目魚趕入鄰塭，排出黃水，換注新鮮海水，然而非萬不得已，塭主皆不願施行此法，概因肥水外流且藻床易爲破壞；至於施放各種農藥則不見著效，偶或有少數機會得以挽救。據多年經營虱目魚塭之塭主謂當此黃水現象發生時期，俗謂虎藻或麵線藻（*Enteromorpha*）一類之藻類大量繁生，則見塭水逐漸澄清而復歸正常云云。筆者據聞，甚感興趣並有鑑於近年來從事具有抗菌之藻類的研究日益增多[3] [4] [5] [6] [7] [8] [9]，此等發現非但具有學術上的意義，果能有日施之於應用，則可望對臺灣虱目魚養殖有所貢獻。筆者自57年6月至58年6月得有機會研究有關黃水現象各種情形，而得些許心得，茲將本次試驗概況及其結果報告於下。

二、方　　法

此次試驗方法可大別爲黃水細菌形態上及生化上之試驗及虱目魚塭藻類抗菌力試驗二大部分：

（一）黃水細菌形態上及生化上之試驗

57年10月至11月間觀察省水產試驗所臺南分所虱目魚塭九號池及道東魚塭一口發生的黃水現象，每日採水檢驗並以之和未發生黃水之正常塭水就所含菌種作比較，卽將採得之塭水於細菌培

養基[10]上倒盤，放在 30°C 恒溫培育箱內使其繁殖生長，經過一天至二天即見培養基上長出菌落（Colony）無數，將之各別挑出再接種於新培養基上，如此多次分離後，選擇黃水之與正常塭水有異各菌落作純種培育(Pure culture)，共得十二菌株(Strain)，編號爲 Y101、Y102、Y103、Y104、Y105、Y106、Y107、Y108、Y109、Y110、Y111、及 Y112。其後則依下述十七種方法觀察其形態、生長情形並每月作例行接種以便接續作各菌株之生化定性實驗。

1. 形態之觀察

(1) 菌落之形性：圓形、根莖狀或不規則。

(2) 菌落之大小：測其直徑以爲比較。

(3) 菌落之色澤：顏色、亮澤之記錄。

(4) 菌細胞之形狀：使用高倍油鏡俾便檢視。

(5) 菌細胞之大小：以測微計度量。

(6) 菌細胞之動力：滴一小滴菌液於四周塗有凡士林蓋玻片，迅速翻轉覆蓋於凹窩玻片上，如此形成之垂懸小滴既不易揮發，又可在封閉系統內不受外界影響地檢視是否具有動力而能自行運動。

2. 芽胞染色 (Spore stain)

於載玻片上作塗抹標本 (Smear culture)，浸入孔雀綠液 (Malachite green) 染色，次以0.25%番紅 (Safranin) 作對比染色，以油鏡檢視[11]。

3. 莢膜染色 (Capsule stain)

塗抹標本以 Leifson 氏鞭毛染法[11] (Leifson's flagella stain) 或印度墨染法[11] (Indian ink stain) 染之，可得紅藍或白黑對比色組，易於分辨莢膜之有無。

4. 鞭毛染色 (Flagella stain)

採用 Leifson 氏鞭毛染法[11]。

5. 革蘭氏染色 (Gram's stain)

以培養廿四小時內之新鮮菌 (Young culture) 作塗抹標本，依革蘭氏染法處理。染上紫色者係因其細胞壁及細胞質的構造使結晶紫 (Crystal violet) 與碘結合後不易爲乙醇分離析出，屬革蘭氏陽性菌（Gram positive，簡稱 G+）；反之，染上粉紅色者係革蘭氏陰性菌（Gram negative，簡稱 G−）[12]。

另據 Ryu[13] 制定之苛性鉀試法 (Caustic potash method)，可更簡易分辨該等黃水細菌之爲 G+或 G−；比與前法兩方印證，相得益彰。

6. 明膠之水解 (Gelatin Hydrolysis)

配製 Frazier 氏明膠基[11]，以劃線法接種 (Streak inoculation)，培育約二星期後，以酸性氯化汞溶液滴加於各明膠基上，若產生白色沉澱即表示明膠仍存在，而呈現透明區者係因其中之明膠已爲該供試細菌水解。

7. 耐酸性 (Acid fast stain)

依 Ziehl-Neelson[11] 法染色，耐酸菌染上紅色，非耐酸菌染上藍色；耐酸菌細胞因具高成分脂肪物質，染藥一經染上即不易爲酸所褪色，故稱之爲耐酸菌。

8. 靛基質試驗 (Indole test)

配製含色氨酸 (tryptophan) 之蛋白腖水 (Peptone water)，各接種十二黃水菌株之新鮮菌，以便測知是否能將色氨酸分解生成靛基質；加 Kovac 氏靛基質試劑或 Ehrlich-Böhme 氏

試劑，顯出深紅色或紫紅色者表示已生成靛基質[11]。

9. 澱粉水解 (Starch hydrolysis)

澱粉瓊脂基 (Starch agar)[11] 加倒於冷凝之滋養瓊脂基 (Nutrient Agar) 上，培育接種於其上之各黃水細菌；欲測知澱粉是否已爲之水解時，可滴加碘液，呈藍色者表示澱粉仍存在，否則已爲 β-amylase 所分解而呈透明[14]。

10. 醣類之發酵 (Fermentation of carbohydrates)

使用德耳罕氏管 (Durham's tube) 並以1%之 Andrade's indicator[11] 當指示劑，發酵後產生酸可使培養液變紅色，易於檢視；若有氣體產生可在德耳罕氏管發現氣泡之存在。

11. 觸醣試驗 (Catalase test)

培養於營養瓊脂基或營養肉汁 (Nutrient broth) 之黃水細菌，滴加過氧化氫會起泡或呈乳白色者表示已產生觸醣。大部分的細菌在供給空氣的情況下培育，均會有這種酵素產生，是好氣菌 (Aerobic bacteria)；而嫌氣菌 (Anaerobic bacteria) 則不然[12]。

12. 硝酸鹽還原試驗 (Nitrate reduction test)

硝酸鹽蛋白腺水 (Nitrate peptone water) 分裝於德耳罕氏管培育細菌[11]，以 Griess-Ilosvay 氏試劑[11] 試之而變紅色者表示其中硝酸鹽已被還原成亞硝酸鹽，或加鋅粒而不起作用，不變色者亦然。至若在德耳罕氏管內可見氣泡者，是該細菌已更進一步將之還原成氨的結果[11]。

13. 枸櫞酸鹽之利用 (Citrate utilization)

先配製 Koser 氏枸櫞酸鹽培養液[11]，接種培育後變混濁者即表示該菌能利用枸櫞酸鹽爲其生長所需之碳素而繁殖，未能利用者則不能繁殖生長。

14. 石蕊牛奶之作用 (Action on litmus milk)

在一升脫脂奶水中加 10 ml 4%的石蕊試液可得淡紫色之石蕊牛奶，每天蒸三十分鐘，連續多天，試以確知完全無菌後即可接種，培育二星期，每日檢視其變化情形並作記錄。石蕊牛奶遇酸變粉紅色、酸多則凝塊、褪色表示還原作用，氣體之產生與否亦可明白看出[11]；上述四種情形之發生分別予以 A、AC、R，及G之記號來表示。

15. 葡萄糖產生二氧化碳之試驗 (Carbon dioxide production from glucose)

配製 Gibson 氏半固態蕃茄汁培養基[11]，分裝入試管，待冷却至 45°C 而來凝固時即接種黃水細菌，之後，加倒一層滋養瓊脂基使固封於其上。乳酸菌將葡萄糖逐步分解產生二氧化碳者[14]，可在培養基內查出氣泡，甚至有時氣體衝破上層滋養瓊脂基而使裂開。

16. 甲基紅試驗 (Methyl red test)

本試驗使用葡萄糖磷酸鹽培養液 (Glucose phosphate broth)，並加甲基紅液 (Methyl red solution)[11] 當指示劑。接種並培育後變紅色者即表示其 pH 值已降至酸性之4.5或更低，是爲正反應，記錄爲 "+"；反之，其負反應呈黃綠色記爲 "−"。

17. 服潑二氏反應 (Voges-Proskauer test)

此試驗用以試知供試細菌可否使由葡萄糖產生 Acetylmethylcarbinol。採用試藥 (1) O'Meara's modification 及 (2) Barritt's modification[11]，結果生成紅色或粉紅色者爲正反應。

(二) 虱目魚塭藻類之抗菌力試驗

虱目魚塭藻類繁多[15]，此次選取較重要之四種，即 *Enteromorpha* sp.，*Chlamydomonas* sp.，*Lyngbya* sp. 及 *Phormidium* sp.[16] 作純種培養。培養液經試用 Guillard's "F" solution

[17]，SS CHR solution，及 Benecke's solution[18]，結果以前者具最佳效果。藻類培養瓶內加以打氣，並置放於玻璃溫室 (Green house)，務期於最適生長情況下作純種培育，收集後以下列方法施行淬取。

1. 放在眞空乾燥器行眞空抽氣使之乾燥，取其定量，加水以攪拌器（Blender）打碎，取濾液待用。

2. 如上法加以乾燥後，取其定量以索氏脂肪抽出器 (Soxhlet extraction apparatus) 淬取，淬取時所用之溶劑乙醇可於 40°C 水浴並水壓抽氣 (Water bath with water pump) 的裝置下蒸發[19]。

3. 以蒸餾水及80%甲醇液浸漬定量之乾藻，並置於 37°C 恒溫培育箱中，則可使藻類內含物溶出，而甲醇於室溫中可隨室內氣流揮發[20]。

以上法淬分之藻液可使用 Sintered-glass bacterial filter 過濾之[19]，取來試於培養皿中之細菌以知其是否具有抗菌力。此所謂 Disc assay[11] 之方法係採用東洋二號濾紙 (Toyo filter paper, No. 2) 以打孔機打成直徑 0.6 公分的圓形小濾紙片，即所謂之 Disc，用來飽吸藻類淬出液。培養基上接種足量菌液並以消毒之彎曲玻璃棒使之均勻分佈，隨後放上經處理過之 Disc，如此，各不同藻類淬出液配合各種黃水細菌作交互試驗，於恒溫培育箱內培育後檢視其生長情形。具有抗菌能力者，其 Disc 周圍顯現透明區域 (Clear zone)，因細菌受其抑制未克生長，而且抗生力愈强者，受其影響所及而產生之透明區域愈大，可由其直徑之大小加以比較。

三、結　　果

此次採水自發生黃水現象的省水產試驗所臺南分所虱目魚塭九號池及道東魚塭一口，以上述之方法加以培養及多次分離後作純種培育，經過觀察並試以多種生化定性實驗，結果共得十二菌株，其形態學上及生化學上的特性如第一表及第二表。

第一表　黃水細菌之形態學特性

Table 1. Morphological characteristics of "yellow water" bacteria.

Item \ Strain No.	Y101	Y102	Y103	Y104	Y105	Y106	Y107	Y108	Y109	Y110	Y111	Y112
Agar colonies: Color	W	M	Y	Y	Y	M	Y	Y	W	W	W	W
Agar colonies: Surface	G	G	G	D	G	G	D	D	D	G	D	G
Agar colonies: Size	X	S	S	?	S	X	?	?	S	S	X	X
Agar colonies: Elevation	C	C	Ra	Rh	Ra	Ra	Rh	Rh	Ra	Ra	X	X
Form	R	R	SR	SR	R	R	Sta	Co & R	Str*	Co	Str**	Co
Size(μ)	6×1	6×1	1.5×1	1.5×1	6×1	6×1	?	X	?	Z	?	Z
Spore	−	−	−	−	−	−	−	−	−	−	−	−
Capsule	+	−	−	−	+	+	+	−	−	−	−	−
Flagella	−	−	−	−	+	+	−	−	−	−	−	−
Motility	±	±	±	±	±	+	±	+	+	+	±	±

* 13 or 14 cells in one chain　　** about 10 cells in one chain

W : White　　S : Small colonies　　Rh : Rhizoid　　SR : Short Rod
M : Milky white　　X : Irregular　　− : Negative reaction　　Co : Coccus
Y : Yellow　　? : Test not applicable　　+ : Positive reaction　　Sta : Staphylococcus
D : Dull　　C : Convex　　± : Slightly positive　　Str : Streptococcus
G : Glistening　　Ra : Raised　　R : Rod

第二表　黃水細菌之生化學特性

Table 2. Biochemical characteristics of "yellow water" bacteria

Item \ Strain No.	Y101	Y102	Y103	Y104	Y105	Y106	Y107	Y108	Y109	Y110	Y111	Y112
Gram stain	+	+	−	+	+	+	+	+	+	−	+	−
Gelatin hydrolysis	−	−	+	+	−	−	−	−	−	+	+	−
Acid fast	−	−	+	−	+	−	−	−	−	−	−	−
Indole test	−	−	−	−	−	−	−	−	−	−	−	−
Starch hydrolysis	+	−	−	+	−	−	+	+	+	+	−	+
Glucose fermentation	+	−	+	+	+	−	+	+	+	+	+	+
Lactose fermentation	−	−	−	+	+	−	−	−	+	+	+	+
Maltose fermentation	+	+	+	+	+	+	+	+	+	+	+	+
Sucrose fermentation	+	+	+	+	+	+	+	+	+	+	+	+
Catalase test	V(+)	V(+)	+	+	+	V(+)	+	+	+	+	+	+
Nitrate reduction	+	+	+	+(NH_4)	−	+	+(NH_4)	+	+	+	+	+
Citrate test	−	+	+	+	+	−	+	−	+	+	+	+
Litmus milk test	−	−	−	−	−	−	+(A)	−	−	−	+(AC)	+(AC)
Carbon dioxide from glucose	+	+	+	+	V(+)	+	V(+)	+	+	+	V(+)	+
Methyl red test	−	−	±	−	−	−	±	−	−	+	−	−
Voges-Proskauer test	−	−	−	+	−	−	+	+	+	−	+	+

+ : Positive reaction.
± : Slightly positive.
− : Negative reaction.
V(+) : Variable, most are positive.
+(NH_4):Nitrate is reduced into gas ammonium.
+(A) : Positive with acid production.
+(AC) : Positive with acid production and clotting.

Enteromorpha sp.，*Chlamydomonas* sp.，*Lyngbya* sp.，及 *Phormidium* sp. 四種藻類萃出液對十二株黃水細菌之抗菌力試驗，經量其透明區域直徑，則得第三表。

第三表　四種藻類萃出液對十二黃水菌株之抗菌力

Table 3. Antibacterial activity of four algae extracts of milkfish pond

Strain No. / Algae	Y 101	Y 102	Y 103	Y 104	Y 105	Y 106	Y 107	Y 108	Y 109	Y 110	Y 111	Y 112	Ave.
Enteromorpha sp.	0.89	0.83	1.05	1.13	1.05	1.10	1.10	0.90	1.19	1.05	1.15	1.03	1.04
Chlamydomonas sp.	0.97	0.98	0.93	0.97	0.92	1.00	1.02	0.97	1.18	0.97	1.10	0.86	0.99
Lyngbya sp.	0.89	1.14	0.96	0.94	0.84	0.89	0.96	0.86	0.89	1.06	1.05	0.86	0.95
Phormidium sp.	0.82	0.87	1.10	0.92	0.84	0.81	0.90	0.94	1.08	0.89	0.93	0.99	0.92

1. 數字表透明區域之直徑 (cm)
2. 本記錄是 2 g 乾藻溶於 100 ml 萃取溶劑之試驗結果

四、討　　論

於夏、秋之季，偶或有水溫上昇的情形發生，若其水溫及氣象條件均適宜於水中微生物迅速繁殖，有機物亦盛行分解，於是日間植物同化作用旺盛，水中氧氣甚至可高達 200%，但一到夜間日光照射停止，同化作用因之中斷，而水中動植物的呼吸作用及細菌的分解作用急遽消耗氧氣，直至翌晨日出；而日出前後之水中溶氧量往往降至甚低量 0.3 cc/ℓ。氧氣與食物同爲虱目魚維持生命、生長及活動所需，氧氣既爲活動能力之來源，更與蛋白質、碳水化合物、脂肪、水份等同爲生命之物理基礎；食物可以一次攝餌而貯存體內多時，但氧氣却無時不可或斷，否則短時間內卽浮頭致死[21]。溶氧量對魚之食物消耗量、攝食、活動與食慾有極大影響，黃水現象一經發生，水色黃濁，溶氧量白天極高，而淩晨極低，其變動之大，影響虱目魚至鉅，甚或致死，而於此時採水於高倍顯微鏡或電子顯微鏡檢視，可發現有異於正常之大量微生物，其中細菌部分已作試驗如上述。

各種培養黃水細菌用之培養基，於調配後必在當天以高壓殺菌斧 (Autoclave) 消毒，一俟冷却後將之保存於 5°C 冰箱內備用，否則易爲雜菌汚染而敗壞，各菌株之保存亦須存放於 5°C 冰箱內，唯每隔一月必接種於新斜面瓊脂基 (Agar slant) 上一次，以防老化。

Disc assay 中，曾試以接種足量菌液，放入恒溫培育箱，待細菌長出後才放上飽吸藻類萃出液之 Disc；與本實驗所採行方法，卽接種後立卽置放 Disc，再送入恒溫培育箱一法，比較其結果，前者未能符合本實驗目的，想係因已長滿細菌之培養基欲合其產生透明區，必爲具有分解細菌 (Bacterialysis) 能力之生理活性物質 (Physiological active substance)，而非本實驗所欲測知之具有抗菌 (Antibacteria) 能力者。又若欲作 Disc assay 時，應把飽吸藻類萃出液的 Disc 先予以風乾方用於試驗，否則其吸附之水份每每使 Disc 上也因擴散滲透作用而長滿細菌，失去實驗意義。

抗生素對革蘭氏陽性菌和陰性菌作用有別，通常只對陽性菌有作用[20]。本實驗分離所得之十二株黃水細菌中，Y103、Y110、Y112 等三株爲陰性菌，餘九菌株爲陽性菌，亦卽能受藻類萃出液所含之抗生素作用者，而此次實驗結果亦大體符合此說。又此次採用之四藻類萃出液皆具抗菌力，能抑制細菌生長，而以 *Enteromorpha* sp. 爲最強，正如一般田間觀察的現象。

對藻類淬出液所含抗生素一項，擬在更進一步研究中作較深入研討，比方把定濃度淬出液加入培養液或培養基，接種定濃度之供試菌，如此培育後的結果以光電比色值或菌落計數表示，或可得較精確之定量比較數值，另外，亦可作對照實驗而以制菌單位（coli dilution units，簡稱CDU）表示，凡量足以阻止大腸桿菌（Escherichia coli）生長達18小時者，稱爲具有 1 CDU。又，該等生理活性物質之分離，鑑定亦有待作化學上之分析。

此次分離所得十二黃水細菌株之定名，筆者鑑於細菌分類學頗爲艱深[22]，而未敢貿然爲之，亟待有志者一同研商討論。

總之，此次研究重點放在黃水細菌之採集，分類及其生化定性，並作四種虱目魚塭藻類淬出液對此等黃水細菌之抗菌力比較，得到上述之結果。對黃水現象之研究，作如上之攻法(Approach)在學術上固有其價值，但果能進而提取有效抗菌素作爲黃水現象之防治藥劑，將對虱目魚養殖有莫大之貢獻自不待言。然而，據筆者此次實際從事此項工作後之心得，除上述之攻法外，應同時配合此工作著手進行黃水發生原因之解析，若能把握住黃水之發生原理（Mechanism），則可未雨綢繆，此種類似預防醫學之研究，爲今後研究之主要課題。

五、摘　　要

觀察省水產試驗所臺南分所虱目魚塭九號池及道東魚塭一口的黃水現象，並試以培育，經多次分離作純種培育結果得十二黃水細菌株，繼而試以生化定性實驗以知菌株間的差異，另外，比較虱目魚塭中較重要之四種藻類之淬出液對十二菌株之抗菌力，獲得下述結果：

1. 黃水現象爲虱目魚塭中微生物大量繁生的結果。
2. 黃水混濁度高，溶氧量低；若不經處理，其色日益加深，且易使虱目魚斃死。
3. 本試驗分離出黃水細菌共十二菌株。
4. 十二菌株概爲黃色或白色，大部分爲桿菌，少數爲球菌、鏈球菌及葡萄球菌，具或不具光澤，菌落形狀則爲中凸及平凸圓形或根莖狀皺褶形。
5. 黃水細菌皆缺芽胞，四株具有莢膜，兩株能見鞭毛，但皆具動力。
6. 除 Y103、Y110，及 Y112 爲革蘭氏陰性菌外，餘皆爲革蘭氏陽性菌。
7. Y103 及 Y105 爲耐酸菌。
8. 十二菌株對靛基質之反應皆爲負反應。
9. Y103、Y104、Y110、Y111 能使明膠水解。
10. Y101、Y104、Y107、Y108、Y109、Y110，及 Y112 能使澱粉水解。
11. 十二菌株皆能使麥芽糖及蔗糖發酵，但對葡萄糖及乳糖則不盡然。
12. 十二菌株或多或少皆能產生觸酶。
13. 除 Y105 外皆能使硝酸鹽還原。
14. Y101、Y106、Y108 不能利用枸櫞酸鹽生長。
15. 能利用蕊牛奶生成酸的有 Y107、Y111 及 Y112 等三菌株。
16. 十二菌株皆爲乳酸菌。
17. 甲基紅試驗中，Y103、Y107 及 Y110 爲正反應。
18. 服、潑二氏反應的結果，十二菌株中，正、負反應者各居其半。
19. 虱目魚塭中之藻類 *Enteromorpha* sp.，*Chlamydomonas* sp.，*Lyngbya* sp. 及 *Phormidium* sp. 等確具有抗菌力。

20. 上述四種藻類中，以 *Enteromorpha* sp. 抗菌力最高。

六、誌　　謝

筆者進行本實驗期間，承蒙農復會漁業組陳組長同白、林技正書顏、袁技正柏偉、李技正潤德時予督促策勵，省水產試驗所鄧所長火土、臺南分所諸同仁及洛氏基金水產養殖計劃研究員廖博士一久、蔡山慶先生、助理研究員陳弘成先生提供諸多材料上、書籍上、工作上各方面的協助，因是有成；在在均使筆者由衷感激，無時或忘，謹於此一併致謝。另外，東海大學生物系 Dr. Paul S. Alexander，陳賢芳教授及胡秉權副教授的鼓勵與賜助、臺灣大學植物系吳聲鈺先生的指點也是筆者欲藉此一申謝忱的。又，本實驗係獲洛氏基金會補助在其水產養殖計劃項下完成。

七、參　考　文　獻

1). 周清溪：談魚池水色。中國水產，第47期，pp. 20-21. (1956).
2). 艾祥生：談魚池水質變惡的原因及其處理方法。中國水產，第19期，pp. 15-16. (1954).
3). Katayama, Teruhisa: Volatile constituents of algae. XX. Pharmacological action of volatile constituents and biochemical significance of the existence of acrylic acid. Kagoshima Daigaku Suisan Gakubu Kiyo 13, pp. 58-72. (1964).
4). Katayama, Teruhisa: The volatile constituents of seaweed. XIV. On the volatile constituents of *Laminaria*. Nippon Suisan Gakaishi 24, pp. 925-32 (1959).
5). Oleson, Paul E., A. Maretzki and Luis A. Almodovar (Columbia Univ., Palisades, N. Y.): An investigation of antimicrobial substances from marine algae. Botan. Marina 6 (3-4), pp. 224-32 (1964).
6). Kochler, W., H. Thrum and R. Schlegal (Dent. Akad. Wiss., Berlin): Antibacterial range of action of nonaktin with particular consideration of Corynebacteriaceae. Zentr. Bakteriol., Parasitenk., Abt. I. Orig. 194 (4), pp. 457-61 (1964) (Ger.)
7). Walters, Bruno (Tech. Hochschule, Brunswick, Ger.): Antibiotic and toxic substances from algae and mosses. Planta Med. 12(1), pp. 85-99 (1964).
8). Steeman-Nielseen: Papers Marine Biol. Oceanog. Deep Sea Research, 3 (suppl.) p. 281 (1955).
9). Sieburth, and Burkholder: Abstr. of Comm. to Intern. Oceanog. Congr., p. 33 (1959).
10). Difco Manual of Dehydrated Culture Media and Reagents for Microbiological and Clinical Laboratory Procedures. 9th ed. Difco Laboratories. 350 pp. (1967).
11). Harrigan, W. F. and Margaret E. McCance: Laboratory Methods in Microbiology Dept. of Bacteriology, The West of Scotland Agricultural College Auchincruive, Ayr, Scotland pp. 7-68, 197-228, 257-301 (1966)
12). Smith, David T., Norman F. Conant and Hilda Pope Willett: Zinsser Microbiology 14th ed. Appleton-Century-Crofts, Division of Meredith Corporation, New York, pp. 23, 107. (1968).

13). Ryu, E.: On the Gram differentiation of bacteria by the simplest method II. The caustic potash method. Jap. Journ. Vet. Sci. **1**: 209 (1939).
14). Umbreit, Wayne W.: Modern Microbiology. Rutgers. The State University, p. 119, 158. (1962).
15). Chang, T. P.: Algae of Tainan milkfish ponds. Chinese-American Joint Commission on Rural Reconstruction. Fisheries Series: No. 7, pp. 91-135 (1969)
16). Prescott, G. W.: How to know the fresh-water algae. Michigan State University, Wm. C. Brown Company Publishers, Iowa. 272 pp. (1954).
17). 岩崎英雄：微細藻類の分離と培養。日本水產資源保護協會。55 pp. (1967).
18). 田宮博、渡邊篤：藻類實驗法。南江堂，東京，455 pp. (1965).
19). Davidson, Floyd F.: Antibacterial activity of Oscillatoria formosa Bory extract. Baylor University, Waco, Texas. (Reprint)
20). Allen, M. B. and E. Y. Dawson: Production of antibacterial substances by benthic tropical marine algae, Journal of Bacteriology 79. (1960).
21). Lin, S. Y.: Milkfish Farming in Taiwan. A Review of Practice and Problems. Fish Culture Report No. 3, 63 pp. The Taiwan Fisheries Research Institute. (1968).
22). Breed, Robert S., E. G. D. Murray and Nathan R. Smith: Bergey's Manual of Determinative Bacteriology, 7th ed. The Williams and Wilkins Company. 1094 pp. (1957).

The Relationship between Nitrifers and Fish Pond Water in Chupei

by
Hua-chau Hsieh
and
Yie-yung Lee
Research Assistants, Rockefeller Foundation
Fish Culture Research Program

Introduction

Since nitrogen is considered to be one of the most important limiting factors in the development of phytoplankton, which in turn is an important fish feed, we have therefore studied the relationship between nitrifers and fish pond water.

Under laboratory conditions, certain bacteria, actinomycetes and fungi have been shown to convert ammonium to nitrite or occasionally to nitrate, but we did not choose actinomycetes because of their slow growth and late appearance. Fungi are commonly present but we have omitted them due to the fact that the number appearing on agar plates represented only a small percentage of the total count. As a result of all the above stated reasons, bacteria are therefore chosen to be used in this experiment.

All the nitrifying bacteria are classified in the family Nitrobacteriaceae of the order Pseudomonadales. Seven genera are recognized in the family: *Nitrosomonas, Nitrosococcus, Nitrosospira, Nitrosocystis, Nitrosogloea, Nitrobacter* and *Nitrocystis.* Of the seven, only *Nitrosomonas* and *Nitrobacter* are the major nitrifying bacteria. *Nitrosomonas* can oxidize ammonia to nitrite, and *Nitrobacter* can oxidize nitrite to nitrate.

To enumerate the nitrifying bacteria and to separate them from other soil organisms, advantage was taken of their chemoautotrophic properties. In the case of *Nitrosomonas,* the dilutions of soil was inoculated into an inorganic medium containing ammonium as the source of nitrogen. When *nitrosomonas* was present in viable form in the inoculum, growth would occur and nitrite would be produced. We used potassium nitrite as the source of nitrogen in *Nitrobacter*, and nitrate would be produced when *Nitrobacter* was present in the inoculum.

Materials and Methods

1. Water and Soil Samples

The water and soil samples used in this experiment which was conducted during the 24th of March to the 13th of May, 1969 were collected from the fish ponds of Chupei Fish Culture Station.

The soil samples were collected from the bottom of the fish ponds at about 3 - 5 cm depth, and the water samples were obtained from the surface of the fish ponds. The samples were then taken back to the laboratory immediately. If the samples were not used on the day of collection, they could be stored in the refrigerator, to be used within 24 hours.

2. Preparation of Materials

a. Ammonium-calcium carbonate medium for *Nitrosomonas*

$(NH_4)_2\ SO_4$	0.5 g
K_2HPO_4	1.0 g
$FeSO_4$	0.03 g
NaCl	0.3 g
$MgSO_4 \cdot 7H_2O$	0.3 g
$CaCO_3$	7.5 g
Distilled Water	1000 ml

b. Nitrite-calcium carbonate medium for *Nitrobacter*

$NaNO_2$	0.008 g
N_2HPO_4	1.0 g
NaCl	0.3 g
$MgSO_4 \cdot 7H_2O$	0.1 g
$FeSO_4 \cdot 7H_2O$	0.03 g
$CaCO_3$	1.0 g
$CaCl_2$	0.3 g
Distilled Water	1000 ml

c. Ammonium-calcium carbonate agar

Ammonium-calcium carbonate media	1000 ml
Agar powder	15-20 g

d. Nitrite-calcium carbonate agar

Nitrite-calcium carbonate media	1000 ml
Agar powder	15-20 g

3. Water Analysis

With the use of Uvispek Photo-Electric Spectrophotometer MK 9 (H700), analytical procedures of nitrite and nitrate were followed as those given in the twelfth edition of the Standard Method for the Examination of Water and Waste Water (American Public Health Association, 1961).

4. Bacterial Count

A 1 ml portion of freshly agitated suspension of the dilution prepared (water samples were 10^{-1} and soil samples were 10^{-3}) was transferred to each of the 5 sterile petri dishes by means of a sterile 1 ml pipette. 12 ml of agar was poured into each seeded petri dish, and they were then kept in a humidified incubator at 28°C for 14 days.

5. The study of the change of nitrite and nitrate

An enrichment culture of two groups with two flasks each was prepared. A 15 ml of water sample and 15 ml of 1% soil sample were transferred separately into the two flasks of the first group each containing 50 ml of sterile ammonium-calcium carbonate medium, and the process was again repeated on the two flasks of the second group containing nitrite-calcium carbonate medium. The flasks were incubated at 28°C, and every 2 or 3 days, a 2 ml portion was extracted and diluted to 50 ml. Then measurements of its nitrite and nitrate concentration were taken.

6. Soil pH

pH value of the soil was measured with a Glass Electrode pH Meter (Mitamura Riken Kogyo Inc.), and the procedure was followed as those given in "Method of Soil Analysis" Chemical and Microbiological Properties, Part 2, edited by C. A. Black.

Results

1. Chemical Condition of Chupei Fish Ponds

Nitrite nitrogen occurring in the ponds was investigated to be in the range between 0.001 and 0.008 ppm. The concentration of nitrate nitrogen varied from 0.012 to 0.086 ppm. The results are presented in table 1 (see attachment). From table 1, it can be seen that the lowest values are found in A-3 pond.

2. Bacterial Plate Counts

The result of bacterial plate counts conducted during 24th of March to the 13th of May, 1969 is represented in table 2 (see attachment). The average counts of *Niterosomonas* in the soil and in the water were 133.2×10^3 organism/g and 581 organism/ml, and the average counts of *Nitrobacter* were 119.8×10^3 organism/g and 529 organism/ml, respectively.

3. Changes in the Nitrite Concentration

There was no nitrite in the ammonium-calcium carbonate medium before seeding the samples; but after seeding (as illustrated in Materials and Methods, Section 5) the soil sample for 4 days and the water sample for 8 days, the concentration of nitrite slightly changed and after 10 to 12 days, the increase

of the same was remarkable as shown in table 3 (see attachment).

The nitrite concentration of nitrite-calcium carbonate medium was 3.75 ppm; 8 days after seeding the soil sample and 12 days after seeding the water sample, the concentration of nitrite remarkably decreased as shown in table 4 (see attachment).

4. Soil pH in Water

The pH of soil in the ponds was neutral to slightly alkaline, as presented in table 5 (see attachment).

Discussion

Nitrification is seasonal and is affected by temperature, pH and oxygen content. The following are some of the affecting factors: The rate of nitrification appears to proceed most rapidly in the early part of May and is very slow when below 5°C and above 40°C; and the nitrification process is also sensitive to pH and occurs less rapidly, or in extreme cases not at all in acid water.

The bacteria counts of surface water are apt to show great variations, particularly true in the spring and fall, the season of heavy rain and melting snows.

We know from many laboratory reports that the count of aerobic bacteria by the agar plate method varied from 1000×10^3 to 800×10^1 organism/g of soil. In the Chupei Fish Ponds the total number of nitrifying bacteria ranged from about 100×10^1 to 400×10^3 organism/g of soil, comprising about 5.6% of the total aerobic bacteria count.

From table 5 (see attachment) we can observe that neutral or slightly alkaline soil has the largest population of nitrifying bacteria.

From table 3 (see attachment) we can see that the seeded bacteria are not of pure culture. When the nitrite concentration reaches its highest value, it starts to decrease rapidly almost reaching zero point. We believe that this is due to the fact that the two groups of nitrifiers almost always accompany each other, and when *Nitrosomonas* oxidizes almost all of the ammonia to nitrite, the remaining *Nitrobacter* then has a source of nitrogen, where it also oxidizes nitrite to nitrate, and the nitrite concentration reaches a very low point.

According to our investigation, there is no significant relationship between the number of nitrifying bacteria and nitrite and nitrate concentration. For instance, the Chupei A-3 Fish Pond had the highest count of nitrifying bacteria number, but the nitrite and nitrate concentration of pond water was very low. This result is shown in tables 1 & 2 (see attachment) which indicates that the nitrifying bacteria did not make a major contribution to the ecosystem as primary producers, and this incidentally, corresponds with the results of the experiment

conducted by a research team in the area of the Lake of Mendota, in 1925, as shown in figure 1.

Summary

1. The bacterial distribution of fish pond depends on many factors, such as the place where the sample is collected and the treatment of the sample. Therefore it is difficult to say that the result of this study can be applied to other samples from other places. However, this result can serve as reference to others who are performing similar experiments.
2. In the Chupei Fish Ponds, the total number of nitrifying bacteria comprises about 5.6% of the total aerobic bacteria count.
3. The concentrations of nitrite-nitrogen and nitrate-nitrogen were the lowest in Chupei A-3 pond, but the pond contained the highest count of nitrifying bacteria.
4. The neutral and slightly alkaline soil had the largest population of nitrifying bacteria.
5. The nitrifying bacteria did not make a major contribution to the ecosystem as primary producers.

Acknowlegments

The writers of this report would like to take this opportunity of expressing their heartfelt thanks to Mr. Wen-Kuang Liaw, Associate Professor of the Zoology Department, National Taiwan University for his kind guidance in this study; to Mr. T. P. Chen, Chief, and Professor S. Y. Lin of the Fisheries Division, Joint Commission on Rural Reconstruction (J.C.R.R.) for reading the manuscript and their constant encouragement.

Table 1. Chemical conditions of Chupei Fish Ponds. Concentrations are in mg per liter.

Pond / Date	A - 3		A - 5		B - 1		B - 4	
	NO_2-N	NO_3-N	NO_2-N	NO_3-N	NO_2-N	NO_3-N	NO_2-N	NO_3-N
3 - 24 - 1969	0.001	0.020	0.003	0.063	0.006	0.043	0.003	0.047
4 - 9 - 1969	0.002	0.012	0.004	0.063	0.004	0.055	0.008	0.027
4 - 24 - 1969	0.001	0.039	0.003	0.055	0.004	0.047	0.004	0.043
5 - 13 - 1969	0.002	0.031	0.003	0.086	0.003	0.051	0.002	0.039

Table 2. The average number of nitrifying bacteria in various fish ponds in Chupei

Pond	Organism/g of Soil×10^3		Organism/ml of Water	
	Nitrosomonas spp.	Nitrobacter spp.	Nitrosomonas spp.	Nitrobacter spp.
A - 3	212.7	191.8	737	515
A - 5	158.9	137.5	759	604
B - 1	106.0	81.7	408	516
B - 4	55.2	68.1	419	481

Table 3. Changes of nitrite in ammonium-calcium carbonate medium. Concentrations are in mg per liter.

Pond	Days after Seeding						
	4	6	8	10	12	14	16
A - 3 (S) *	0.127	0.381	3.769	9.867	16.339	0	0
A - 5 (S)	0.219	4.804	5.940	8.132	15.284	0	0
B - 1 (S)	0.026	0.087	1.700	5.859	9.816	12.382	16.238
B - 4 (S)	0.006	0.056	2.156	6.265	7.838	9.552	12.849
A - 3 (W) **	0	0	0.006	0.016	0.117	5.839	10.455
A - 5 (W)	0	0	0.046	2.978	8.040	9.613	10.110
B - 1 (W)	0	0.006	0.006	0.980	2.653	6.336	10.972
B - 4 (W)	0	0	0.006	0.056	0.077	0.117	0.208

* Soil Sample
** Water Sample

Table 4. Changes of nitrite in nitrite-calcium carbonate medium. Concentrations are mg per liter.

Pond	Days after Seeding						
	4	6	8	10	12	14	16
A - 3 (S) *	3.414	2.207	0.949	0.016	0.016	0	0
A - 5 (S)	3.313	1.872	0.148	0.087	0.026	0.016	0
B - 1 (S)	3.719	3.120	1.640	0.168	0.168	0.087	0.087
B - 4 (S)	3.617	3.171	1.081	0.117	0.077	0.066	0.066
A - 3 (W) **	3.739	3.739	3.739	3.698	3.120	2.501	0.016
A - 5 (W)	3.566	3.485	3.414	3.364	3.110	0.695	0.016
B - 1 (W)	3.739	3.739	3.739	3.739	3.272	3.019	2.816
B - 4 (W)	3.516	3.465	3.313	3.313	3.009	2.704	2.400

* Soil Sample
** Water Sample

Table 5. The pH value of soil and the number of nitrifying bacteria by agar plate count in Chupei Fish Ponds (5-13-1969).

Pond	pH	Organism/g of Soil×10^3	
		Nitrosomonas spp.	Nitrobacter spp.
A - 3	7.40	251.3	230.6
A - 5	7.12	185.6	139.3
B - 1	6.81	84.0	74.3
B - 4	6.95	81.0	86.0

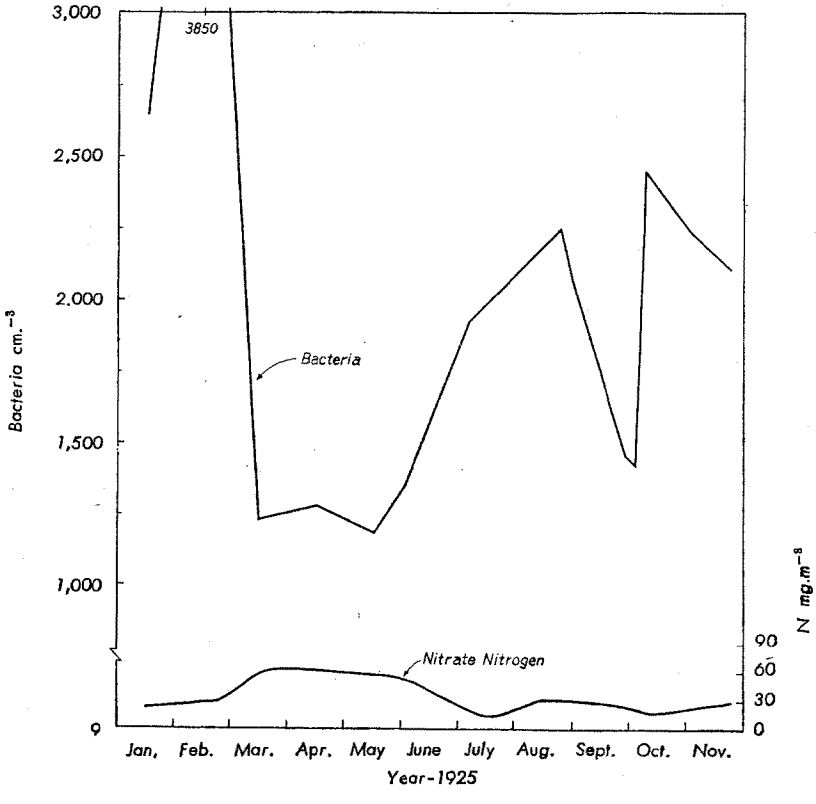


Figure 1. The annual changes of bacterial counts and nitrate nitrogen concentration in surface-water samples of Lake Mendota, 1925. (after Domogala, Fred, and Peterson.)

Literature Cited

Alexander, M. 1961. Introduction to Soil Microbiology. John Wiley & Sons, Inc., New York, 459 pp.

American Public Health Association 1961. Standard Methods for the Examination of Water and Waste Water. Including Bottom Sediments and Sludges. American Public Health Association, Inc., New York. 626 pp.

Black, C.A. 1965. Method of Soil Analysis. Chemical and Microbiological Properties, Part 2. American Society of Agronomy. Wisconsin.

Felton, M. 1966. A Quantitative Study of the Bacteria of a Temporary Pond. The Journal of General Micrology Vol.47, Part 1, April 1967, pp.25 - 31.

Hayes, F.R. and E. H. Anthony. Lake Water and Sediment VI. The Standing Crop of Bacteria in Lake Sediment and Its Place in the Classification of Lakes. Limnology and Oceanography Vol. 4, 1959. pp. 299-315.

Hutchinson, G. E. 1957. A Treatise on Limnology Vol. 1 Geography, Physics and Chemistry. John Wiley & Sons., Inc., New York. 1015 pp.

Liaw, W.K. 1969. Chemical and Biological Studies of Fish Pond and Reservoir in Taiwan. Reports of Fish Culture Research Supported by Rockefeller Foundation, Taiwan. Fisheries Series No.7, pp.1 - 43

Lin, S.Y. 1966. The Source and Effects of Nitrogeneous Fertilizer in Fish Ponds. China Fisheries. No.165, pp.2 - 6 (in Chinese)

Murray, R.G.E. and S.W. Watson 1965. Structure of Nitrocystis oceanus and Comparison with Nitrosomonas and Nitrobacter. Journal Bacteriology 89: 1594 - 1609.

Pope, L.M., D.S. Hoare and A.J. Smith 1969. Ultrastructure of Nitrobacter agilis Grown Under Autotrophic and Heterotrophic Conditions. Journal Bacteriology. 97: 936 - 939.

Reid 1961. Ecology of Inland Waters and Estuaries. Reinhold Publishing Co., New York. 340 pp.

Salle, A.J. 1967. Fundamental Principles of Bacteriology.

Strickland J.D.H. and T. R. Parson 1960. A Manual of Sea Water Analysis. Bulletin No.152. pp.61 69.

The Feeding Habits of Silver Carp, Bighead and Mud Carp

By S. Y. Lin

Fisheries Biologist, Joint Commission on Rural Reconstruction and Professor of Fish Culture, National Taiwan University

Abstract

Through the studies of the digestive tract contents of the silver carp, bighead and mud carp, and of the plankton successions in ponds, it is revealed that silver carp ingests principally net phytoplankton as well as nannophytoplankton and detritus particulates but very little zooplankton. The bighead feeds on zooplankton, net phytoplankton and detritus, while the mud carp, being a bottom dweller, feeds chiefly on organic detritus and diatoms. The type and size of food organisms and detritus ingested depend on the structure of the gill-rakers and the position of the mouth, but the quantity of each kind of suspending particulates to be ingested depends on their abundance in different seasons. The silver carp and bighead do not appear to possess any mechanism to select the food of preference, although the mud carp is capable of picking up the preferred kind of detritus together with diatoms for food.

Introduction

Polyculture of such Chinese carps in freshwater ponds as listed below is a long established practice in China:

Silver carp (*Hypophthalmichthys molitrix*)
Bighead (*Aristichthys nobilis*)
Mud carp (*Cirrhina molitorella*)
Grass carp (*Ctenopharyngodon idella*)
Black carp (*Mylopharyngodon piceus*)
Common carp (*Cyprinus carpio*)

The advantages of such practice evidently lie in the economy of space and the full utilization of food resources in the ponds. It is generally known that silver carp and bighead staying in the upper layer of water all the time depend on *Shui Wei*, water bloom or "substances in water" for nourishment. These substances, in modern scientific terms, would mean precisely the phytoplankton, zooplankton and other organic particulates suspending in water. The mud carp, the black carp and the common carp are principally bottom dwellers, but they have entirely different feeding habits. The mud carp, with an inferior mouth, picks up food particles consisting of small bottom flora, fauna and detritus near or on the bottom, but such feeding activity would never disturb the bottom

mud. The black carp, a carnivore feeding on snails, clams and other molluscs and crustaceans living at the bottom, is also peaceful; but the common carp, on the contrary, has the habit of sucking mud into its mouth where nourishing detritus and benthos consisting especially of Chironomid larvae that come in with the mud are retained and swallowed, while the sand and mud are spit out. In this manner if there is a large number of common carp present in the pond, the water is bound to become very muddy and thus rendered unhealthy for other domestic fishes in association to thrive. The fish farmers having learned this from experience never stock a polyculture pond with a large number of common carp fingerlings, although they find it profitable to stock a few for the purpose of scavenging on any food residues from supplementary feeding. Another advantage of stocking a small number of common carp in polyculture is that the common carp serves as a unique agent to turn into fish meat the Chironomid larvae which are always abundant in ponds. The grass carp is an active fish roaming everywhere in search of floating duckweed (*Spirodela*), filamentous algae and rooted aquatic vascular plants. Meanwhile it would prey on small fish, insects and devour any kind of organic matter when it is hungry.

However, the feeding habits of the black carp, common carp and grass carp are not difficult to observe, especially that of the common carp which has been well studied; information on the feeding activities of the silver carp, bighead and mud carp is still insufficient for a clear understanding of their relationship to food resources in polyculture. For example, one would ask whether the silver carp is a pure phytoplankton-feeder, the bighead a zooplankton-feeder and the mud carp a detritus-feeder. If so, what is the most nourishing phytoplankton for the growth of silver carp and how can a selective propagation of a particularly nourishing phytoplankton be made? How fine a phytoplankton can the silver carp filter for food? Can the silver carp filter nannophytoplankton? Is the bighead feeding on phytoplankton as well as Copepods and Cladocera? How about Protozoa? Does the mud carp devour bottom flora as well as fauna? Which ones are preferred? How about detritus (residue of supplementary food and faeces of grass carp and other fishes)? Many more questions like these can be asked, but none of them can be answered satisfactorily at present, although for proper management of polyculture, full information is required.

Fang (1928) studied the gill-rakers of silver carp and bighead, and discovered that they were the efficient mechanisms for filtering plankton out of water for food. Since the gill-rakers of silver carp are fused to form thin spongy plates, they can filter out very small plankton and other organic particulates; but those of the bighead which are numerous, closely set but separate from one another are capable of filtering large planktonic crustaceans, Rotatoria and algae only.

Fang's study led, in later years, to many more experiments carried out to determine the feeding activities, food digestibility, relationship between feeding habits, feedstuff application and fertilization in mono-and polyculture of Chinese carps in the different countries. Kobayasi (1929 a and b) in Taiwan carried out experiments on the rearing of grass carp, silver carp and common carp in association and again Chen (1934) in Canton studied the polyculture of mud carp and silver carp in one series of experiments and of grass carp and mud carp in another and found that mud carp responded to peanut meal feeding but not the silver carp. Also grass carp grew rapidly when fed with artificial feedstuff. They then concluded that grass carp and mud carp fed on artificial feedstuff such as rice bran, peanut meal and bean meal, but silver carp was a plankton feeder.

In 1962 and 1963, E.A. Savin* of All-Union Research Institute for Pond Research, USSR, carried out two series of experiments on the feeding of silver carp - one in aquariums and the other in ponds - and found diatoms, especially *Cyclotella* to be the most preferable and easily digested food for the fish, next the *Euglena* and Protococcaceae, but such blue green phytoplankton as *Oscillatoria, Anabaena, Coelosphaerium* and *Merismopoedia* were indigestible. The silver carp tends to spit out filtered material consisting principally of blue green algae. Savin further observed that in ponds where the biomass of phytoplankton contains a high percentage of Protococcaceae (*Pediastrum* and *Coelastrum*) and diatoms, the grass carp grows faster than in ponds containing more blue green algae (*Merismopoedia*).

With an aim to verify Savin's observations, the present experiments were designed and in addition attempts were made to determine (1) precisely what the silver carp, the bighead and mud carp eat, (2) the fish growth rate in response to seasonal development of planktons, (3) the role of supplementary feed in the feeding activities of these three Chinese carps, (4) the food of preference if there is any for each of the three Chinese carps, and (5) the physical, chemical and biological factors that might influence the feeding habits and consequently the growth of the fish.

Methods and Material

Two principal steps were taken in trying to answer the above questions. The first was to analyze the contents of the digestive tracts and secondly to make qualitative and quantitative studies of the biota in the ponds each month for comparison with the stomach contents. Fishes required for stomach content examination were identically stocked in two ponds (A and B) each 1,000 m^2

* A translated version of Savin's report entitled "The feeding of the white *tolstolobik* (silver carp) was sent to the writer by Dr. C. F. Hickling from London. The original paper was not seen by the writer himself.

in superficies and the number of specimens of each species removed each month for examination are as follows:

Species	Stocking rate (No. of fingerlings)	No. of fish to be removed for study each month
Mud carp	500	20
Silver carp	100	8
Bighead	50	4
Grass carp	20	0

To only one of these experimental ponds supplementary feed in the form of rice bran and peanut meal was applied at the rate of 3 to 5 kg of each once a day. Superphosphate was given at a rate of from 4 to 6 kg once every 5 to 10 days and a similar amount of zeolite (containing 78% SiO_2) was also given at the same frequency to each of the ponds for the purpose of creating and maintaining a desirable degree of water bloom. Since the development of planktonic algae is important to serve as food for the fish and further to prevent the growth of the undesirable *Chaetophora* by cutting light penetration, the application of an adequate quantity of inorganic fertilizers at the right moment is necessary.

The removal of fish for digestive tract examination each month was done in 10 months only (February to November), because January and December were too cold for active feeding of the fishes.

Contents from three sections of the digestive tract, namely, (1) the section of esophagus, (2) the long intestine and (3) the rectum were separately preserved for each species, but in order to save time in examination, the contents of similar sections of the same species removed each month from the same pond were thoroughly mixed. From such mixture samples were taken for identification and quantitative study of biota and detritus according to the microtransect method as described by Lackey (1938).

Water samples of the two ponds A and B were taken twice a month from August to November, 1968. Each time five liters of water were taken with a sampler from each pond. Immediately after the samples were taken, formalin was added (to approximately 3%) to preserve the biota for examination.

In an aquarium two mud carp of about 15 grams were placed and fed with peanut and soybean meal and rice bran for direct observation.

Results and Discussion

So far as quality is concerned almost identical algae, Protozoa, zooplankton and detritus are found on one occasion or another in the digestive tracts of all the three Chinese carps under study, but the quantity of each kind varies to a very great extent in different fish and seasons. The plants, animals and detritus

found in the digestive tracts of the silver carp, bighead and mud carp are as follows:

A. Phytoplankton

1. Chlorophyta (green algae)

Spirogyra, Scenedesmus, Ankistrodesmus, Pediastrum, Protococcus, Characium, Tetraedron, Chotatella, Cosmarium, Dictyosphaerium, Chlorella, Closterium, Selenastrum, Coelastrum, Gloeocystis, Crucigenia, Golenkinia, Oocystis, Staurastrum, Kirchneriella, Ulothrix, Xanthidium, Quadrigula, Actinastrum, Tetrastrum, Hydrodictyon, Pleurotaenium, Chaetophora, Coccomyxa, Penium, Arthrodesmus, Stigeoclonium, Westella. Schroedria, Tetraspora, Nephrocytium, Polyedriopsis, Oedogonium, Pemicom, Botryococcus, Actinospherium, Elakatothrix, Euastrum, Asterococcus, Closteriopsis, Sphaerocystis, Micractinium, Dimorphococcus, and Mestaemium.

2. Bacillariophyta (diatoms):

Navicula, Melosira, Frustulia, Synedra, Cyclotella, Pinnularia, Fragilaria, Stephanodiscus, Nitzschia, Amphora, Cymbella, Meridion, Surirella, Achnanthes, Cymatopleura, Eunotia, Diatoma, Tabellaria, Gyrosigma, Climacosphenia, Gomphonema, Neidium, Suniella, Bacillaria,

3. Cyanophyta (blue green algae)

Aphanocapsa, Microcystis, Anabaena, Oscillatoria, Phormidium, Merismopedia, Chroococcus, Ceolosphaerium, Dactylococcopsis, Gloeotrichia, Spirulina, Gloeothece, Lyngbya, Aphanothece,

B. Zooplankton:

Chlamydomonas, Phacus, Lepocinclis, Stentor, Filinia, Tintinopsis, Nassula, Asplanchna, Keratella, Trichocerca, Lepodella, Asphanckna, Copepoda (*Cyclops,* etc.), *Eudorina, Arcella, Bosmina, Daphnia, Malleo-ramate, Difflugia, Gymnozyga, Euglena, Lecane, Acanthocystis, Volvox, Rotaria Brachionus, Tarchelomonas, Monostyla, Paramecium, Actinosphaerium, Aphacus,*

C. Detritus

Organic particulates chiefly from fish faeces, decayed peanut cake, soybean cake, rice bran, dead leaves and aquatic or land plants.

Among all the chlorophyta listed above, *Scenedesmus* is found the most abundant in the digestive tracts of the three Chinese carps, especially during the months of May to September. Then next in abundance are *Spirogyra, Ankistrodesmus, Pediastrum* and *Cosmarium.* Of the Bacillariophyta, *Melosira* is the most common and abundant; *Navicula, Frustulia, Cyclotella, Synedra* and *Nitzschia* are often seen, but not in such large quantities as *Melosira.* Of the Cyanophyta,

Aphanocapsa and *Microcystis* (*Anacystis*) are the most abundant. *Anabaena, Oscillatoria, Phormidium* and *Coelosphaerium* are found in all the digestive tracts examined.

The plankton in pond A and B from August to November, 1968 is shown in figure 1. The following is a list of plankters found in the water samples.

Chlorophyta—*Scenedesmus, Pediastrum, Ankistrodesmus, Schroederia, Tetraedron, Selenastrum, Crucigenia, Chodatella, Tetrastrum, Actinastrum.*
Bacillariophyta—*Melosira, Navicula, Synedra, Eunotia, Nitzschia.*
Cyanophyta—*Merismopoedia, Microcystis* (*Anacystis,*) *Anabaena.*
Protozoa—*Eudorina, Euglena, Phacus, Trachelomonas.*

It is interesting to note that the plankton organisms identified from water samples are much fewer in kind than those from the intestinal contents. This signifies that the silver carp and bighead are extremely efficient in filtering out the plankton developing in the ponds, while the water samplers can trap only the most abundant ones and miss the less common ones. Many Protozoa or nannoplankton are commonly found in the water samples, but they cannot be identified from the digestive tract contents, probably because they have been partly or totally destroyed by the digestive enzymes.

Table 1. Percentage of number of cells or particulates in the digestive tract of silver carp in different months:

POND A WITH ARTIFICIAL FEEDING

Type of feed	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.
Chlorophyta	18	21	12	48	84	29	54	30	25	21
Bacillariophyta	12	25	4	10	1	36	5	8	13	8
Cyanophyta	10	5	66	8	5	5	6	6	8	5
Zooplankton	0	6	2	9	1	6	8	12	4	5
Detritus	60	43	16	25	9	24	27	44	50	61
Total	100	100	100	100	100	100	100	100	100	100

POND B WITHOUT SUPPLEMENTARY FEEDING

Type of feed	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.
Chlorophyta	10	7	10	4	29	17	12	17	2	5
Bacillariophyta	12	26	8	7	11	5	4	2	0	0
Cyanophyta	75	62	54	69	49	61	73	72	92	63
Zooplankton	1	1	4	2	2	3	3	3	2	2
Detritus	2	4	24	18	9	14	9	6	4	30
Total	100	100	100	100	100	100	100	100	100	100

Table 2. Percentage of number of cells or particulates in the digestive tract of bighead in different months:

POND A WITH SUPPLEMENTARY FEEDING

Type of feed	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.
Chlorophyta	18	22	13	13	66	23	24	19	5	5
Bacillariophyta	29	9	4	27	6	19	7	9	9	5
Cyanophyta	5	31	12	9	3	12	8	8	3	3
Zooplankton	1	4	2	11	3	5	21	6	8	5
Detritus	47	34	69	40	22	41	40	58	75	82
Total	100	100	100	100	100	100	100	100	100	100

POND B WITHOUT SUPPLEMENTARY FEEDING

Type of feed	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.
Chlorophyta	9	14	8	8	12	13	2	3	1	2
Bacillariophyta	11	19	1	1	12	2	1	0	0	0
Cyanophyta	56	35	68	68	61	63	87	83	75	55
Zooplankton	11	2	9	8	4	8	5	7	7	7
Detritus	13	30	14	15	11	14	5	7	17	36
Total	100	100	100	100	100	100	100	100	100	100

Table 3. Percentage of number of cells or particulates in the digestive tract of mud carp in different months:

POND A WITH SUPPLEMENTARY FEEDING

Type of feed	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.
Chlorophyta	8	5	10	10	40	29	23	17	13	13
Bacillariophyta	66	51	10	14	3	14	18	18	6	10
Cyanophyta	9	12	2	4	4	4	10	4	4	5
Zooplankton	0	1	2	2	2	3	2	3	3	5
Detritus	17	31	76	70	51	50	47	58	74	67
Total	100	100	100	100	100	100	100	100	100	100

POND B WITHOUT SUPPLEMENTARY FEEDING

Type of feed	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.
Chlorophyta	12	4	8	14	17	16	12	15	14	13
Bacillariophyta	53	60	26	28	15	14	6	11	6	3
Cyanophyta	17	3	6	13	6	29	17	9	10	22
Zooplankton	0	1	1	2	1	4	3	4	2	2
Detritus	18	32	59	43	61	37	62	61	68	60
Total	100	100	100	100	100	100	100	100	100	100

Table 4. Comparison of intestinal contents of silver carp, bighead and mud carp in pond A and B. Data obtained in February to November, 1968. Artificial feed was applied to pond A, but not to pond B.

Kind	Digestive tract contents (% cell/fish)					
	Silver carp		Bighead		Mud carp	
	Pond A	Pond B	Pond A	Pond B	Pond A	Pond B
Chlorophyta	34.1	11.3	20.8	7.2	16.8	12.5
Bacillariophyta	12.2	7.4	12.4	4.7	21.0	22.2
Cyanophyta	12.3	67.0	9.4	65.1	6.2	13.2
Zooplankton	5.2	2.3	6.6	6.8	2.0	2.0
Detritus	36.2	12.0	50.8	16.2	54.0	50.1
Total	100	100	100	100	100	100

From the analysis of the contents of the digestive tracts, the first thing to be noted is that all the silver carp, bighead and mud carp ingested autochthonous and allochthonous detritus, the majority of which evidently derive from supplementary feeds as well as from animals and plants grown in the ponds. As shown in tables 1-4, the digestive tract of the bighead from pond A with artificial feeding contains 22 to 75% of detritus, whereas that from pond B, to which no artificial feeding has been applied, contains only 5 to 35% of detritus. Similar situation is also found in the case of silver carp. But the mud carp appears to consume more organic detritus than small plants and animals and are indifferent to the application of artificial feed, possibly due to the fact that in both pond A and B decayed organic material is equally abundant. As diatoms (Bacillariophyta) are inclined to sink to the bottom, comparatively more of them are consumed by the mud carp (table 4).

It is observed that plankton feeders are generally provided with spongy gillrakers like those of the silver carp or with numerous long, closely set ones like those of the bighead and goldfish, so that planktonic organisms and organic particulates in pond water, usually at a concentration of less than 2 ml/l can be concentrated through the process of filtration at the gill-rakers. But, in the case of the mud carp, an entirely different condition exists. Here the gill-rakers of the mud carp are very short and rather widely set, a structure obviously not adaptable for filtering planktonic food and yet a considerable quantity of the phytoplankton (especially diatoms) is always found in the digestive tract. It is hard to explain in this instance how it is possible for the diatoms and other algae to pass into the stomach in quantity without first being concentrated by a suitable mechanism in the mouth cavity.

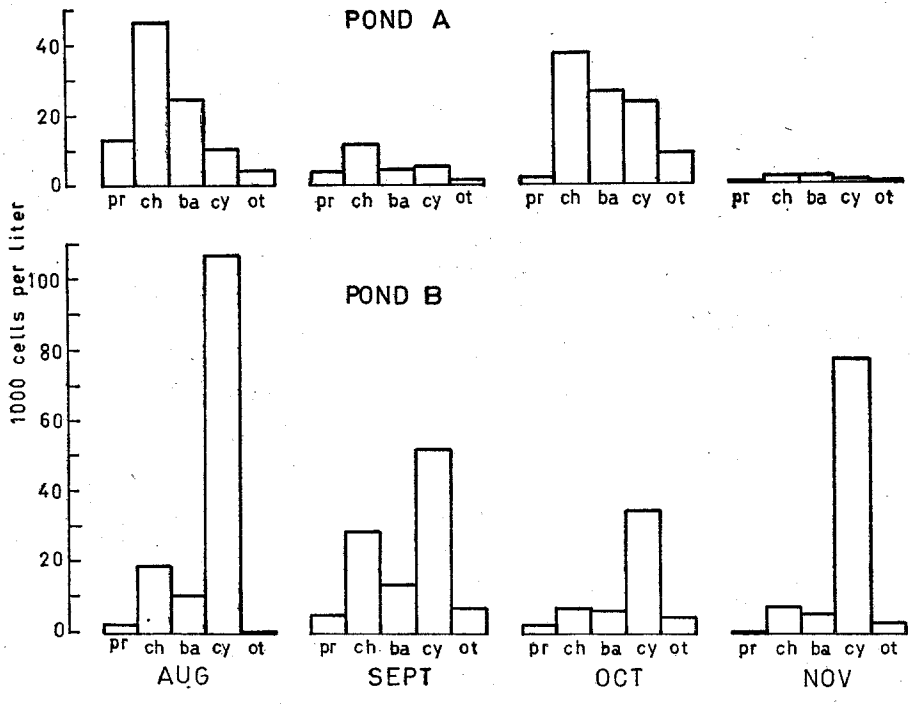


Figure 1. Plankton succession in Ponds A and B from August to November, 1968. ***pr***, Protozoa; ***ch***, Chlorophyta; ***ba***, Bacillariophyta; ***cy***, Cyanophyta; ***ot***, others.

When figure 1 and table 4 are compared, it becomes immediately evident that all these three Chinese carps do ingest whatever plankton that grow and stay in the different layers of water where the fish inhabit. In the upper layer of pond water, for example, many species of plankton develop and the artificial feedstuff applied stay in suspension. Both the silver carp and bighead have had them filtered out and ingested apparently without making much effort in selectivity and at the bottom similar feeding activity is also observed with the mud carp. This aspect of feeding is best illustrated by pond B where Cyanophyta bloom developed straight from May to November and so was found the highest percentage of *Aphanocapsa*, *Microcystis* (*Anacystis*) and *Anabaena* in the digestive tracts of all the three carps.

Figures 2-7 show that the phytoplankton ingested by the three Chinese carps varies not only in quality, but also in quantity according to seasonal successions of phytoplankton in pond water. In pond A where artificial feeding was administered, Chlorophyta bloom began in May when the temperature rose above 22°C and continued till October. In this period the silver carp and bighead had plenty of Chlorophyta and Bacillariophyta for nourishment and as a result they attained rapid growth. The rate of food ingestion of mud carp

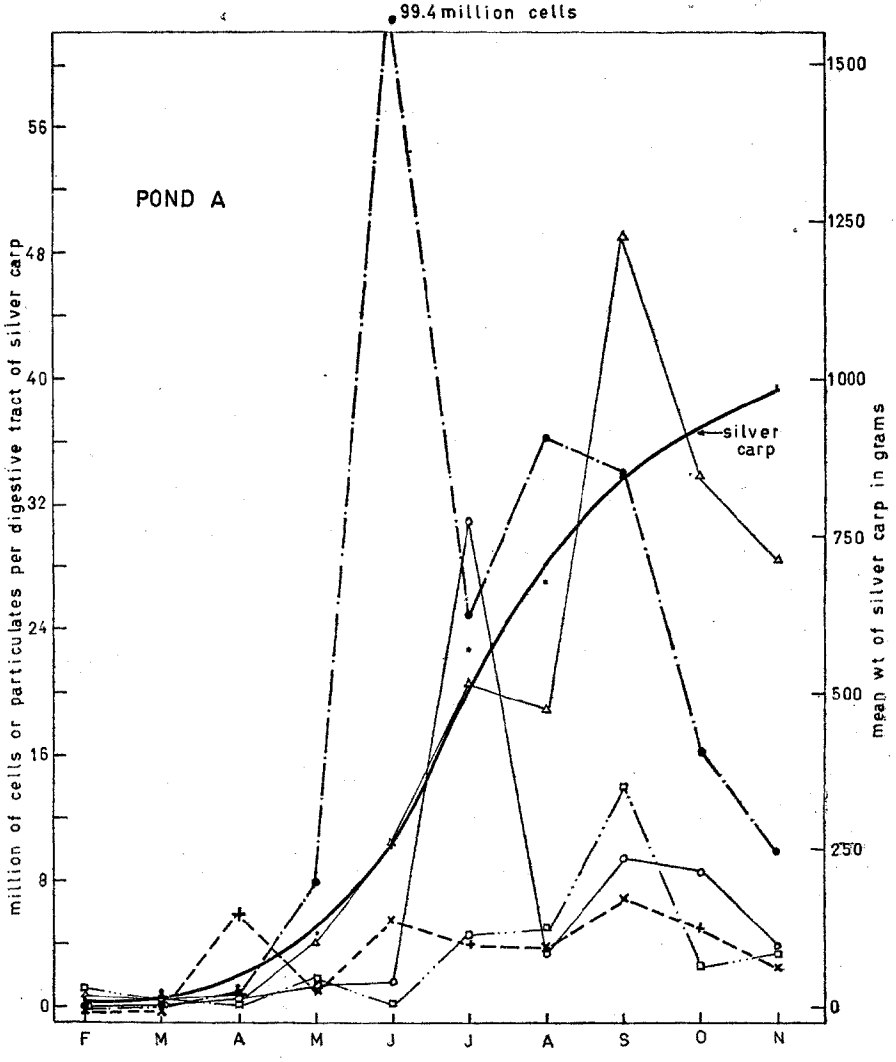


Figure 2. Relationship between Chlorophyta (●), Bacillariophyta (○), Cyanophyta (×), Zooplankton (□) and detritus (△) contents in the digestive tract of silver carp and its growth rate in Pond A. The growth curve of silver carp is smoothed by eyes.

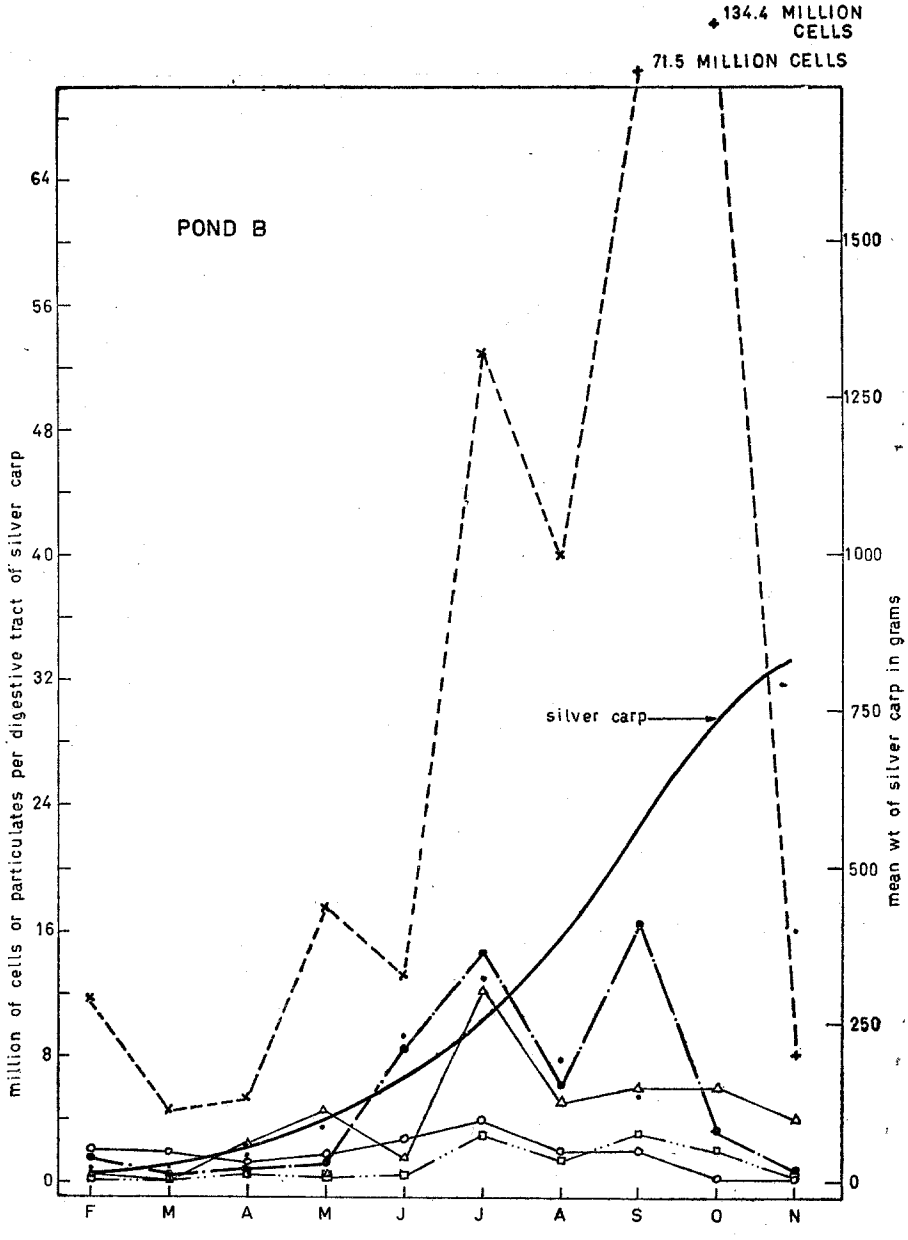


Figure 3. Relationship between Chlorophyta (●), Bacillariophyta (○), Cyanophyta (×), Zooplankton (□) and detritus (△) contents in the digestive tract of silver carp and its growth rate in Pond B. The growth curve of silver carp is smoothed by eyes.

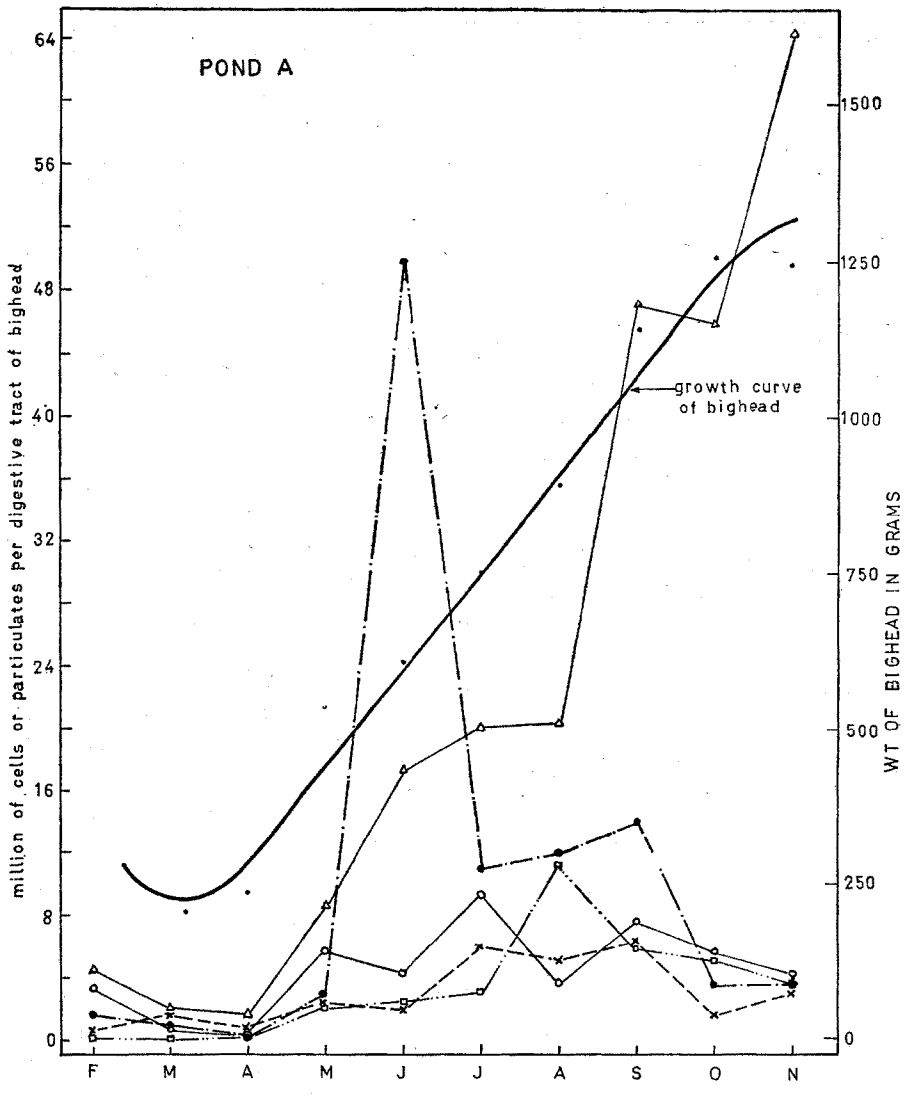


Figure 4. Relationship between Chlorophyta (●), Bacillariophta (○), Cyanophyta (×), Zooplankton (□) and detritus (△) contents in the digestive tract of bighead and its growth rate in Pond A. The growth curve of bighead is smoothed by eyes.

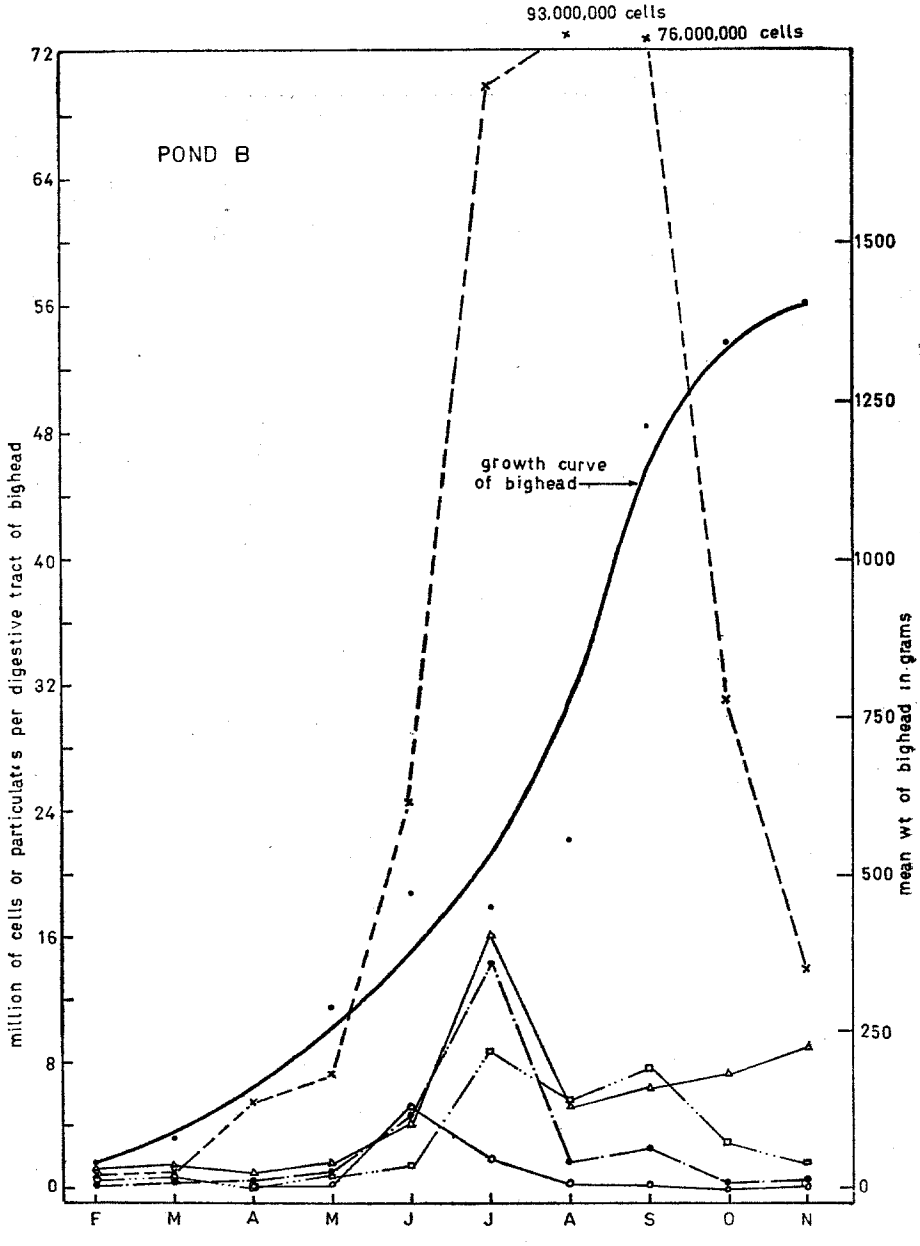


Figure 5. Relationship between Chlorophyta (●), Bacillariophyta (○), Cyanophyta (×), Zooplankton (□) and detritus (△) contents in the digestive tract of bighead and its growth rate in Pond B. The growth curve of bighead is smoothed by eyes.

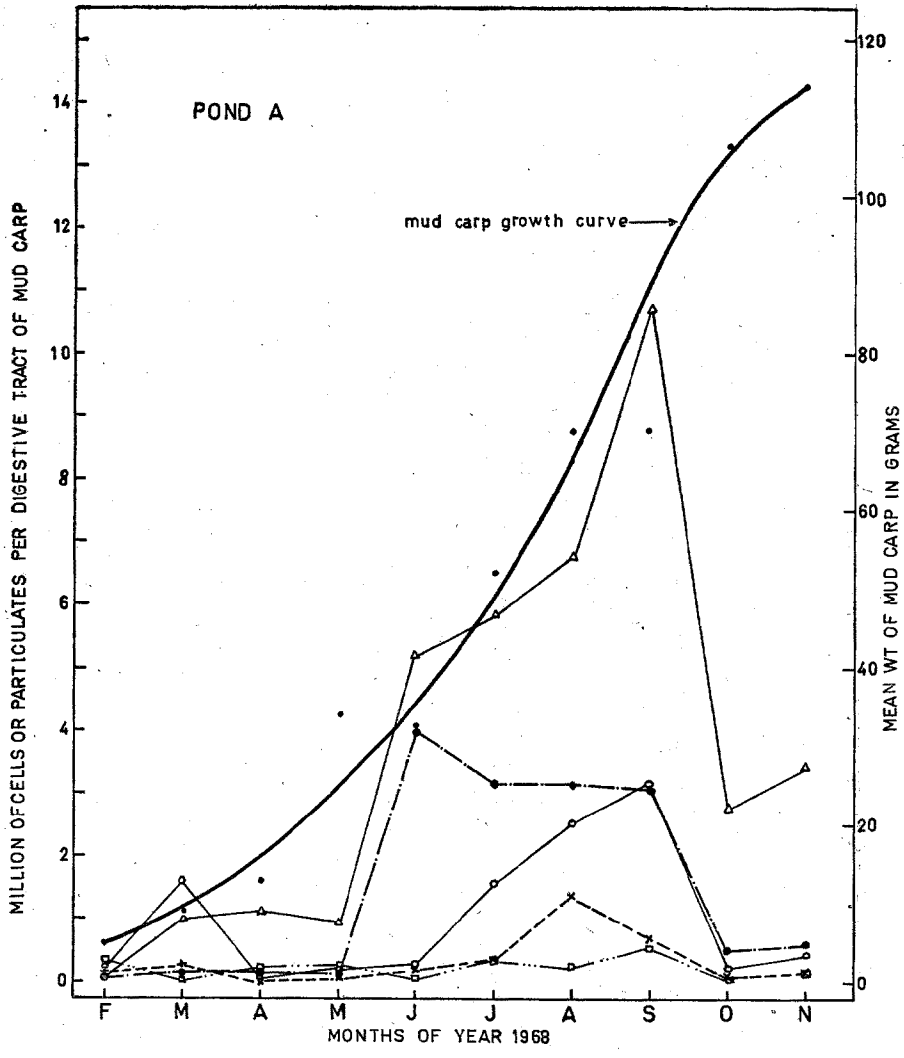


Figure 6. Relationship between Chlorophyta (●), Bacillariophyta (○), Cyanophyta (×), Zooplankton (□) and detritus (△) contents in the digestive tract of mud carp and its growth rate in Pond A. The growth curve of mud carp is smoothed by eyes.

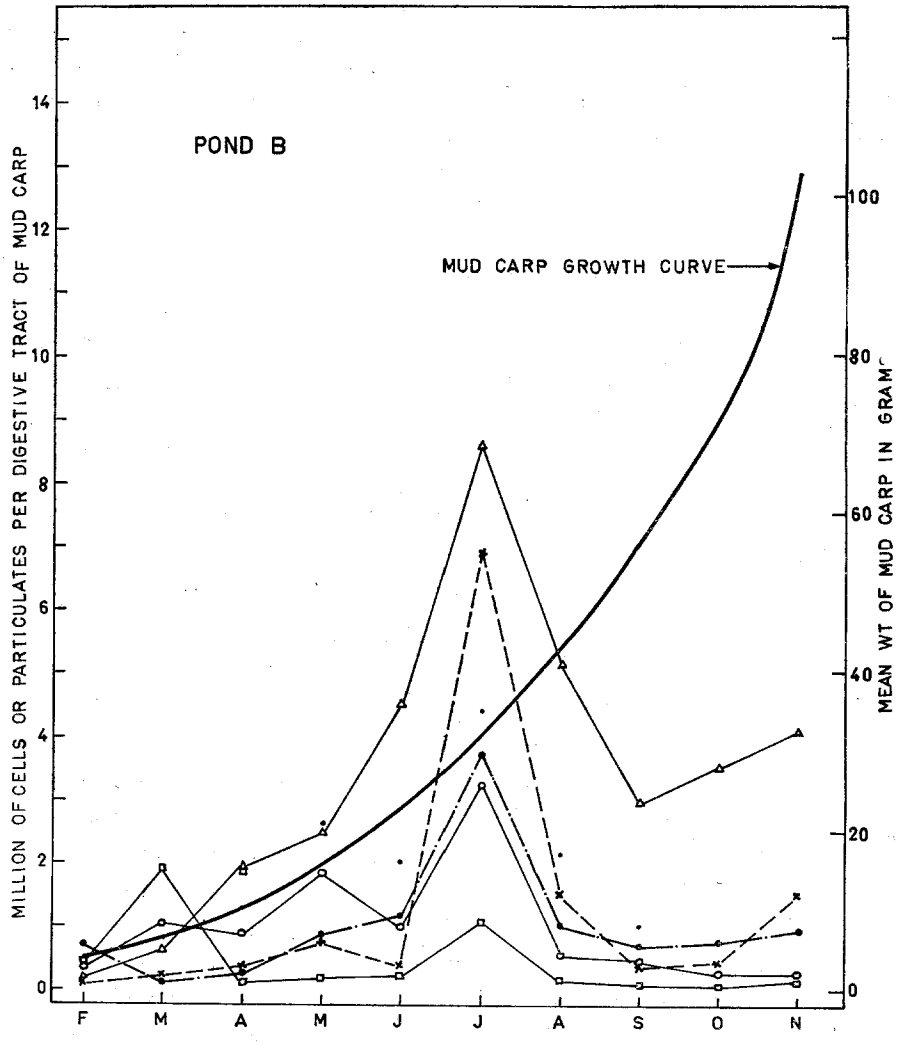


Figure 7. Relationship between Chlorophyta (●), Bacillariophyta (○), Cyanophyta (×), Zooplankton (□) and detritus (△) contents in the digestive tract of mud carp and its growth rate in Pond B. The growth of mud carp in this pond was very irregular, because most of the fish escaped in August and they were replaced by smaller fingerlings.

also increased as water temperature rose (as shown by the increasing number of plankton cells and particulates in the digestive tract during the summer months) and fish growth accelerated correspondingly (fig. 6).

As previously discussed, the structure of the gill-rakers is the mechanism that governs the type of food to be eaten by the fish. The silver carp with broad, sponge-like gill plates is most likely capable of filtering the nannoplankton, Protozoa and minute organic particulates of less than 10μ in size in addition to net plankton. The bighead, on the contrary, has long, fine, separate but closely set gill-rakers which appear to be capable of filtering only the net plankton, especially zooplankton (table 4) and organic detritus. This postulation, though based on general observations but without any actual count of digestive tract contents to prove it, is strongly supported by circumstantial evidence. One of the facts is that in any freshwater ponds with application of inorganic fertilizers, the production of silver carp and bighead is always at the ratio of 2-5:1. The stocking rate for silver carp and bighead, therefore, should be in the proportion of 5 : 1 in terms of fingerlings, for the bighead will grow to two or three times as heavy as the silver carp. For example, the Taoyuan Fish Farm, having 850 hectares in pond superficies, produces annually about 50% in weight of silver carp and 20% of bighead (in a total production of 480,000 kg). The actual production of silver carp and bighead in all ponds does vary from case to case, but the percentage of silver carp production is always higher than that of the bighead, never *vice versa*. This leads naturally to the belief that silver carp feeds on net (large) phytoplankton as well as nannoplankton, the total population of which is many times that of zooplankton in ponds.

In comparing the condition of growth (figures 2-7) it appears that the fish, especially the silver carp and bighead, in pond A grow faster and healthier than those in pond B and this is possibly attributable to the superabundance of Cyanophyta in the latter, which are generally considered as algae of low digestibility, whereas in the former Chlorophyta and Bacillariophyta are more abundant.

Fish gain weight mostly in the months from May to October as shown in table 5, in which the silver carp is found to have the highest weight gain (5-6.8 grams/day) in July and August, and the bighead 15.7 g/day in September, while the mud carp's growth is extremely slow.

Instances are known that mud carp can thrive mainly on peanut cake, soybean cake, rice bran and cornmeal, but no experiments have ever been carried out to feed silver carp and bighead in all possible ways with artificial feed and see how they grow, probably because such endeavor would be of no economic importance.

Although the digestive tract content analysis was made for three sections, the stomach, intestine and rectum, the data obtained so far are not relevant at

Table 5. Meanweight gain in g/day in the two experimental ponds

Month	Silver carp	Bighead	Mud carp
March	1.0	1.0	0.1
April	1.0	1.6	0.1
May	2.2	2.9	3.0
June	4.5	4.2	1.0
July	6.8	0.8	0.6
August	5.0	3.2	0.5
September	3.2	15.7	1.0
October	1.7	4.8	1.0
November	0.5	0.5	2.0

all with respect to the food of preference and digestibility, because in our analytical procedure no effort had been made to establish the degree of digestibility for each group of phytoplankton in the intestine and rectum.

Summary

1. In the digestive tracts of silver carp, bighead and mud carp, phytoplankton, zooplankton and detritus are found in different proportions. Phytoplankton is generally dominant in the digestive tracts of silver carp and bighead, while detritus is dominant in that of the mud carp. The bighead's digestive tract, however, contains a higher percentage of zooplankton than those of the silver carp and mud carp.
2. In the aquarium the mud carp gains weight on such feedstuff as peanut cake, soybean cake and rice bran.
3. The silver carp, bighead and mud carp all consume artificial feedstuffs as well as natural plankton. The type and size of particles to be ingested depend a great deal on the structure of the gill-rakers.
4. On the basis of information obtained in this study and that available in literature, it can be concluded that silver carp feeds chiefly on net plankton as well as nannoplankton; the bighead on net phytoplankton and zooplankton; the mud carp on detritus and phytoplankton.
5. Although the digestibility of different food may not be the same, there is no way to determine the food of preference in the present study. All the three Chinese carps appear to ingest whatever is available in the pond, provided the size of food particles is suitable for ingestion.
6. As the silver carp and bighead definitely grew faster in pond A where Chlorophyta and Bacillariophyta were dominant, than those in pond B where Cyanophyta were superabundant, inference can be made that green algae and diatoms are more nutritious to these two fishes than blue green algae.

7. The growth of fish and the development of plankton in ponds depend on temperature, nutrients from fertilizers, application of feedstuff and the types of plankton autochthonous and allochthonous in ponds.

Acknowledgement

The present experiment was designed and supervised by the writer and was carried out in the Chupei Fish Culture Station of the Taiwan Institute of Fisheries Research with financial support from the Joint Commission on Rural Reconstruction and the Rockefeller Foundation. S. L. Chiung, assistant fish culturist of the Institute was responsible for the general operation of the experimental ponds including water level control, feed and fertilizer application. H. S. Ong, research assistant (in biology) employed by the Rockefeller Foundation Grant Fund, carried out all the work of digestive tract analysis including the collection of fish samples, removal of digestive tracts, preservation of their contents, and the qualitative and quantitative studies of the biota and detritus of the contents. W. Kiang who is also research assistant in biology presently employed by the Rockefeller Foundation Grant, studied the biota of the experimental ponds from August to November 1968. To all these three research workers, all merits should be credited, for without their contributions in supplying basic data, the writing of this paper would not have been possible. Finally the writer wishes to thank Ruth Lee for helping read, correct and type the manuscript.

Literature cited

Chen, T.P., 1934. A preliminary study on association of species in Kwangtung fish ponds. Lingnan Sci. Jour. 13(2): 275-283. Canton.

Fang, P.W., 1928. Notes on the gill-rakers and their structures of *Aristichthys nobilis* and *Hypophthalmichthys molitrix*. Contrib. Biol. Lab. Sci. Soc. China, 4(5):1-30, fig. 1-13. Nanking.

Kobayasi, Hikosilo, 1929a. An experiment on the rearing of *Ctenopharyngodon idella* and *Cirrhina molitorella* in association. Report of the Freshwater Fish Culture Station, Bureau of Propagation and Production, Taiwan, No. 7, p. 73-82 (in Japanese).

Kobayasi, Hikosilo, 1929b. An experiment on the rearing of *Hypophthalmichthys molitrix*, *Cirrhina molitorella* and *Cyprinus carpio* in association. Report of the Freshwater Fish Culture Station, Bureau of Propagation and Production, Taiwan, No. 7, p. 93-98 (in Japanese).

Lackey, J. B., 1938. The manipulation and counting of river plankton and changes in some organisms due to formalin preservation. U. S. Public Health Report, 53:2080-2093.

Lin, S. Y., 1968. Pond fish culture and the economy of inorganic fertilizer application. JCRR, Fisheries Series No. 6, 37 pages. Taipei.

草蝦繁殖試驗

Summary of A Preliminary Report on Artificial Propagation of *Penaeus monodon* Fabricius

廖一久・黃丁郎・勝谷邦夫

(1968年10月1日受理)

By

I-chiu Liao

Research Fellow, Rockefeller Foundation

Fish Culture Research Program

Ting-lang Huang

Specialist, Tainan Fish Culture Station

and

Kunio Katsutani

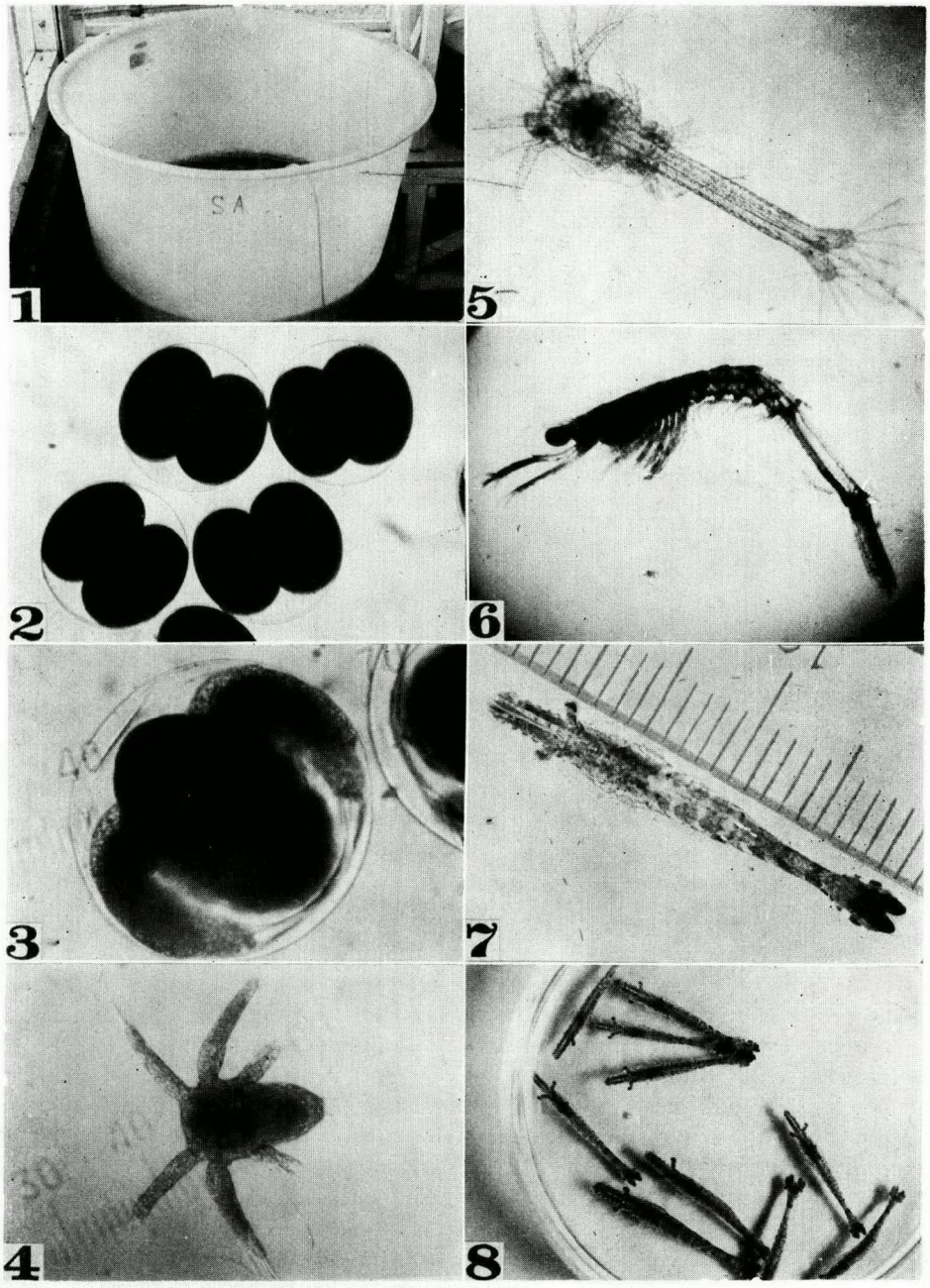
Consultant, Taiwan Fisheries Research Institute

Summary

Penaeus monodon Fabricius is a large prawn that fetches a high price in the Taiwan market. It is cultivated in ponds in combination with milkfish, *Chanos chanos* Forskal; prawn larvae are collected from river mouths and estuaries from April to November and reared in small ponds to-small shrimp for stocking purpose.

The present study is an attempt to propagate this prawn artificially in the hope of making young prawn for stocking independent of the natural supply. The following is a summary of the results in the present study:

1) Three mature female prawns were collected and transported live to the laboratory from a shrimp trawler; two of them spawned successfully giving about 12×10^4 eggs.
2) The egg is spherical and isolecithal, its diameter measures about 0.25 mm, its membrane is colorless and transparent. Newly laid eggs sink to the bottom like those of *P. japonicus*.
3) The cleavage is holoblastic and almost equal, and it takes 12 or 13 hours from the spawning of the egg to the hatching of the larva at temperature of 29.2°-30.5°C, salinity 34.20-34.49‰.
4) The body length of the newly hatched nauplius measures 0.32 to 0.33 mm; nauplius molts six times; by each molting it grows larger and the number of setae at the tip of the appendages (except the mandible) and that of the furcal spines increase.
5) The zoea of 0.91 mm in length appears 22 to 25 hours after hatching and the larva begins to take food such as diatom, *Skeletonema costatum*, and molts three times during this stage.
6) By the third molting of the zoea, the mysis stage is attained. The body length of the first sub-stage of the mysis measures about 3.4 mm, second 3.9 mm and that of the third 4.4 mm. They are fed with the naupli of the shrimp (*Artemia salina*).



Explanation of Figures (*Penaeus monodon*)

Fig. 1 The culture tank used for this experiment.
Fig. 2 Eggs at the end of 1st cleavage.
Fig. 3 Nauplius in egg-shell immediately before hatching, 12 hours after spawning.
Fig. 4 1st nauplius.
Fig. 5 2nd zoea.
Fig. 6 3rd mysis.
Fig. 7 Postlarva, 2.3 cm in length (29 days after hatching).
Fig. 8 Young prawns.

7) The first post-larva measures 5.2 mm in body length, about 3×10^4 first-post-larvae being obtained from about 12×10^5 fertilized eggs. The larvae were reared indoors in two tanks each of 500 l capacity, and fed with minced clam, *Meretrix lusoria*, after 5th post-larva stage.
8) The 20th post-larva measures 20mm in body length. Only about 6,000 of them are left because of the shortage of fresh sea water in the Tainan laboratory.

一、引　　言

草蝦（*Penaeus monodon*）生長迅速且生活力强，爲本省重要蝦類之一，唯其蝦苗完全賴於天然所孵化而游至岸邊者，因此常受自然環境諸多影響，無法作計劃性之生產而仍然阻滯於混養階段的粗放性生產。爲發展本省養蝦事業，必先從人工繁殖蝦苗開始着手，使得能够大量供應蝦苗而早日走上計劃性的企業化之經營態勢。

在前述目的之下，筆者等從事草蝦之人工繁殖試驗而獲得若干成果，茲將經過情形及結果，概略地報告如下，做爲今後人工繁殖草蝦之參考。

二、材料及方法

種蝦（體重77.6公克、108.2公克116.7公克等 3 尾）採自高雄縣白沙崙漁港，係託漁民將活的母蝦用水桶帶回，再由筆者等把它放於裝有氧氣之塑膠袋中帶回臺南分所，而收容於室內1噸塑膠水槽（直徑120公分、實際水深40公分）。收容之當晚未見其產卵，但翌日夜晚二時許，3尾之中2尾產卵。

試驗期間予以充分打氣俾增加水中之溶氧量，所用之海水是取自鯤鯓內海而經過沙層過濾者，其鹽分爲 34.20～34.49‰，水溫爲 29.2～30.5°C。

三、結　　果

卵（egg）：所產之卵和班節蝦卵大小略同爲 0.25公厘，呈球形是一沈性卵，因此要數卵時必攪拌水底使其浮上。卵膜無色透明，胚膜非常薄而帶淺黃褐色。屬均黃卵其分裂則爲全裂型。

無節幼蟲（Nauplius）：孵化所須時間，在水溫 29°C 前後約爲12～13小時，剛孵出之無節幼蟲其體長爲 0.32～0.33 公厘，靠其三對附屬肢作時斷時續游泳，此期內雖不求食物，但具有很强之趨光性。欲推測產卵數以及作此後之生存率之計算，則測定此期之幼蟲數較爲上策，輕輕地攪拌槽內數下後，以1000 毫升之玻璃燒杯作隨意取樣數其中之無節幼蟲，作數次，取其平均值以推測全尾數，結果約爲 12×10^4 尾，此次所產之卵大都爲健全之卵，因此平均一尾所產之卵數可推測約爲 6×10^4粒。

眼幼蟲（Zoea）：第一期眼幼蟲之體長約爲0.91公厘，而從這期開始捕食小型浮游生物。筆者等有意試幾樣小型浮游生物，其結果飼以矽藻之成績最爲良好。人工繁殖之是否會成功其最大關鍵就在此期是否能够適時供給適當之大量餌料而決定其大半。

糠蝦期幼蟲（Mysis）：這期之體長約爲 3.4～4.4 公厘，其體形已略具成蝦之體形，對外界之環境因素比方水溫、鹽分之變化比前期來得具有適應力。此期目前之主要餌料爲豐年蝦（brine shrimp），但其他同大小之動物性浮游生物如橈脚類（Copepoda）亦無不可。

後期幼蟲（postlarva）：第一後期幼蟲*（the first postlarva）之體長約爲 5.2 公厘，這期之餌料宜用豐年蝦或其他橈脚類諸類之動物性浮游生物及切細的貝肉。筆者等經過種種之培育，試驗共飼育了約 3×10^4 尾之後期幼蟲。據筆者等之過去之培育經驗，草蝦苗比班節蝦苗較易於培育從卵到此期之生存率要達40%以上亦不算很困難。

大部份之稚蝦在第5後期幼蟲前後就開始進入底棲或"倚壁"** 生活，第20後期幼蟲時之體長已達 20 公厘，而於體長約爲 25 公厘時其額角之上緣生 7 棘、下緣 3 棘和成蝦之形態變成完全一樣。

這次試驗由於缺乏充足之新鮮海水，無法在流水式之狀況下飼育而在於一種閉鎖式之環境下飼育之關係，變成第 20 後期幼蟲之稚蝦只有約 6,000，即生存率降低至 5%。

四、討　　論

作蝦類之人工繁殖，目前最爲重要者爲如何才能得到活的抱卵的種蝦，由於這次經驗，筆者等深覺單靠天然之種蝦非常困難，因此，應該早日設法研究種蝦之培育問題。其次，是如何識別卵之成熟度的問題，由於草蝦之體色爲淺黑帶紫，不易透過外殼以肉眼識別其卵巢之成熟度，有待於今後之研究易於識別之方法。

這次試驗所用之種蝦共 3 尾，其中一尾於收容後之該晚脫皮，其他 2 尾於翌日夜晚產卵其數根據推測約爲 12×10^4 粒，則一尾產 6×10^4 粒，產卵後解剖其中之一尾其結果所剩下之卵巢爲 2.9 公克，約爲體重之 2.5%，也就是說所抱之卵大部份都告排完，但一尾所抱之卵想來不會少到 6×10^4 粒，據藤永[1] 指出體長 20 公分之班節蝦約產 70 多萬粒之卵，又連等[3] 指出體重 100 公克之熊蝦約抱 40 多萬粒之卵，由此推想草蝦之產卵不爲一次而分爲數次產卵之可能性大。

有關確立飼育技術之問題，雖然這次試驗結果只獲得 6,000 尾之第 20 後期幼蟲，但這是爲了作種種試驗以及缺乏充足之新鮮之海水，無法換水所以致之。飼育技術上所須注意者爲如何適時供給眼幼蟲之初期餌料爲最大關鍵，本次試驗係於無節幼蟲之後期即開始着手繁殖大量之矽藻而得到了良好結果，只要能够充分打氣供給水中之氧氣的話，宜多培養矽藻之類之植物性浮游生物對水質之保持是有益而無害的。另外，草蝦苗對光線非常敏感，予一點點刺激就會跳動，而易於沾住在高出水位之水槽壁而告乾死，因此宜於在浮游生物繁殖甚豐之水槽培育，並檢討是否有必要供給像人工海藻之類之掩避物供給它作爲棲息地。這次試驗中死於這種原因之尾數也不算少數，有待於早日根據其生態、生理方面之問題而想出對策。

這次試驗結果僅得到和藤永等[2] 所作之班節蝦大量生產時之同等密度即10尾／升，不過，今後再加以有充分之新鮮之海水可資換水，則高出這個密度是不太成問題的。

五、摘　　要

㈠ 本試驗旨在作草蝦之人工繁殖，觀測其發生過程並作種種培育試驗，以便作爲草蝦大量人工繁殖之基本資料。

(2) 本試驗爲了大量生產，產卵、孵化同使用一個塑膠水槽（直徑 120 公分、實際水深 40 公分）於其中收容 3 尾抱卵之種蝦，結果 3 尾之中 2 尾於翌日夜晚產約 12×10^4 粒卵。

---

* 筆者等爲了方便起見，變成後期幼蟲後第幾天，就稱爲第幾後期幼蟲。

** 稚蝦之停靠在水槽壁之現象，筆者等稱之爲"倚壁"。

(3) 卵爲球形、沈性卵、其直徑爲0.25公厘，在水溫29.2～30.5°C，鹽分 34.20～34.49‰ 之下約12-13小時就開始孵化。

(4) 孵化出之無節幼蟲 (Nauplius) 之體長爲 0.32～0.33 公厘，此期不食任何餌料，經過 6 次脫皮而成體長 0.91 公厘之第一期眼幼蟲 (the first zoea) ， 此期之最適餌料爲矽藻之一種 *Skeletonema costatum*，眼幼蟲經過3次脫皮即成糠蝦期幼蟲 (Mysis)，其第一期之體長爲 2.7公厘，而此期之體形已略似成蝦之體形 ，餌料爲豐年蝦及一些動物性之浮游生物如橈脚類 (Copepoda)。

(5) 第一後期幼蟲 (the first postlarva) 之體長約爲5.2公厘，此次試驗共培育約 3×10^4尾之此期幼蟲，後來經取出作種種試驗及無充分之新鮮之海水可資換水之下培育約6,000尾之第20後期幼蟲，其體長約爲20公厘。

(6) 此次試驗之培育密度和日本之大量生產班節蝦時之密度相同爲10 尾／升，今後，筆者等有意繼續此項試驗，以期早日達到更高的培育密度。

六、謝　　辭

本試驗之所以進行得順利，乃蒙洛氏基金之資助，白沙崙漁會、東港漁會之各有關人員惠助，以及臺南分所工作人員之多方協助和洪金抱君之鼎力協助，特此敬謝。

參　考　文　獻

(1) Hudinaga, M.: Reproduction, Development and Rearing of *Penaeus japonicus* Bate，日本動物學輯報 10(2)，305～393 (1942)。

(2) 藤永元作・橘高二郎：クルマエビ幼生の變態と餌料，日本プランクトン研究連絡會報，第13號，83～94 (1966)。

(3) 連俊國・丁雲源：臺灣食用蝦類生活史初步調查，臺灣省水產試驗所試驗報告，第14號，135～144 (1968)。

砂 蝦 繁 殖 試 驗

Summary of
A Preliminary Report on Artificial Propagation of *Metapenaeus monoceros* (Fabricius)

廖一久・丁雲源・勝谷邦夫

(1968年10月1日受理)

by

I-chiu Liao

Research Fellow, Rockefeller Foundation

Fish Culture Research Project

Yun-yuan Ting

Specialist, Tainan Fish Culture Station

and

Kunio Katsutani

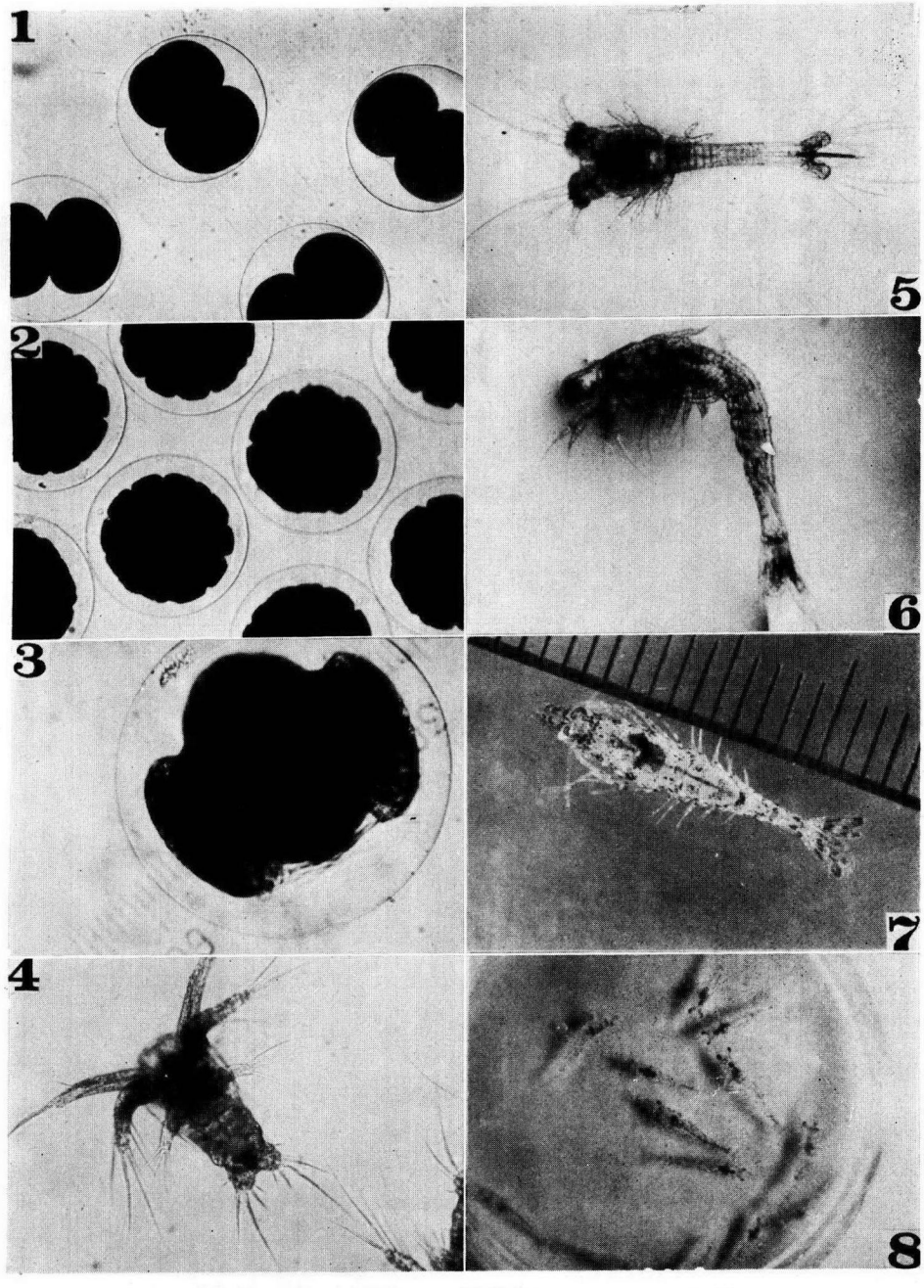
Consultant, Taiwan Fisheries Research Institute

Summary

The prawn, *Metapenaeus monoceros* (Fabricius), is an important crustacean for culture in association with milkfish in ponds. However, little work has been done with regard to its artificial propagation.

In the present work an attempt is made to propagate this species artificially and the results obtained are summarized as follows:

1) Nine fully ripe prawns were collected live from a shrimp trawler and kept in plastic tanks of 500 liters with constant aeration. The next day four of them spawned giving 28 x 10^4 free separate eggs.
2) The egg is spherical, isolecithal, its cleavage being holoblastic and equal just like that of the other Penaeidae and its diameter 0.26 mm.
3) Its cleavage takes 12 to 13 hours from spawning to hatching at temperature of 29.2° - 30.8° C, salinity of 31.11 - 32.47‰.
4) The body length of the first nauplius is 0.27 mm, the first zoea 0.78 mm, the first mysis 2.3 mm and the first postlarva 4.8 mm.
5) Present workers found *Metapenaeus monoceros* hardier than *Penaeus monodon*. At a stocking density of 25 larvae/l, the nauplius developed to young prawn satisfactorily without renewal of fresh sea water.
6) Finally 4960 young prawns were obtained.



Explanation of Figures (*Metapenaeus monoceros*)

Fig. 1 Eggs at the end of 1st cleavage.
Fig. 2 Embryo, 6 hours after spawning.
Fig. 3 Nauplius in egg-shell, 11 hours after spawning.
Fig. 4 5th nauplius.
Fig. 5 2nd zoea.
Fig. 6 1st mysis.
Fig. 7 Postlarva, 1.4 cm in length (32 days after hatching)
Fig. 8 Young prawns.

一、引　　言

砂蝦（*Metapenaeus monoceros*）可和虱目魚混養，體型雖比草蝦小，但生長快且生活力强。爲本省重要蝦類之一。但其蝦苗全賴採自河口，因此其產量每每受到天然因素影響而不能配合放養的需要。

有關砂蝦之人工繁殖曾有船田[2]，連等[3]做過，前者曾育成606尾稚蝦，後者則培育至眼幼蟲(Zoea) 第2期而告失敗，此今，筆者等實施此蝦之人工繁殖而獲得若干成果，茲將其概要報告如下，作爲今後研究此蝦之人工繁殖之參考。

二、材料及方法

種蝦（體重12.4～27.9公克）9尾採自屏東縣東港漁港，係託漁民將活的母蝦用水桶帶回，然後把它放於裝有氧氣之塑膠袋中帶回臺南分所，而收容於室內0.5噸圓形硬質塑膠水槽（直徑100公分，實際水深30公分）。收容之當夜卽見9尾之中4尾產卵。

所用之海水取自鯤鯓內海，而把它分爲經過沙層過濾以及不經過濾而直接用於試驗（眼幼蟲以後用之）之兩種。其鹽分爲31.11～32.47‰，水溫爲29.2～30.8°C。試驗期間予以充分打氣俾利增加水中之溶氧量。

三、結　　果

卵：所產之卵和其他班節蝦科（Penaeidae）之卵大小略同爲0.26公厘，呈球形，卵膜無色透明，胚膜帶淺黃褐色爲沈性卵，屬均黃卵其分裂爲全裂型。水溫 29°C 左右，鹽分32‰左右的情況之下約12～13小時就孵化。

無節幼蟲（Nauplius）：孵出之無節幼蟲其體長約爲 0.27 公厘，靠其三對附屬肢作時斷時續之游泳，此期內不求食物，但具有强裂之趨光性。欲推測此期幼蟲數，以1000毫升之玻璃燒杯，輕輕地攪拌槽內數下後，作隨意取樣數其中之幼蟲數，作數次取其平均値以推測全尾數，結果約爲 28×10^4尾，又此次所產之卵並不見有凝集沈澱之現象而大都爲健全之卵，因此平均一尾所產之卵數可推測約爲 7×10^4 粒。

眼幼蟲（Zoea）：第一期眼幼蟲之體長約爲 0.78 公厘，從這一期開始捕食小型浮游生物。筆者等把所得之上述無節幼蟲分爲2羣，卽用水桶作隨意取樣把一半連同海水移入另一槽，此羣飼以取自臺南分所近旁虱目魚塭中之呈綠色浮游生物（大部分爲 *Chlamydomonas* sp. 及 *Chilomonas* sp.），另外之一羣卽在剩下無節幼蟲約一半之原水槽中予以人工培育之矽藻，*Skeletonema costatum*,（原種係採自高雄港，經人工施肥大量培育，其濃度約爲 2.5×10^4 細胞／毫升），結果飼以 *Chlamydomonas* sp. 等之一羣其成長度較爲遲緩，相比之下飼以矽藻者成長度顯得快。幼蟲之是否攝食餌料可以肉眼觀察，視其尾部拖糸狀之糞便與否而定。前者所拖之糸狀糞便亦不短於後者，但其成長度來得遲緩，這可能由於前者所食之餌料不易消化所致。此次雖試以二種餌料不便於下結論，不過，矽藻易於大量培養且用於飼育可得較好之成長度，因此可視爲此蝦在眼幼蟲期之良好餌料。

糠蝦期幼蟲（Mysis）：這期第一期之體長約爲 2.3 公厘，對外界之環境因素諸如水溫、鹽分等之變化較前期來得具有適應力。體形比草蝦、班節蝦同期之體形較小，因此，特別是此期之初期餌料宜給與比豐年蝦（brine shrimp）更小形之動物性浮游生物，另一方面繼續給與 *Skele-*

tonema costatum 之類之植物性浮游生物爲上策。

後期幼蟲（postlarva）：第一後期幼蟲*（the first postlarva）之體長約爲4.8公厘，這期初期之餌料宜用豐年蝦及其他橈脚類(Copepoda)諸類小型動物性浮游生物，此蝦之後期幼蟲較草蝦更早營底棲生活，而幼蟲之大小變動範圍很大，雖然在同一個水槽中飼育有的第20後期幼蟲早已變成體長15公厘，但有的還小得只有7～8公厘之體長。

這次試驗結果，飼以虱目魚塭中之綠色浮游生物，卽 *Chlamydomonas* sp. 之類的一羣，先由於該類之不盡適於作餌，後因供給該類時參與魚塭水中而一道導入飼育槽中之 Gobies(蝦虎類)及 *Caridina denticulata*（五鬚蝦）等之卵孵化長大此幼蟲爲之吃掉，而告失敗，另一槽之用濾過之海水並飼以矽藻之一羣，則育成第20後期幼蟲共4960尾。

四、討　　論

矽蝦在本省七、八、九月間產量最豐，欲獲得活的抱卵的種蝦遠比草蝦來得容易，而且其成熟度易於以肉眼觀察，因此在本省從事此蝦之人工繁殖將比草蝦來得容易。

這次試驗所使用之種蝦共9尾，其中4尾於收容之當晚產卵，其產卵數根據無節幼蟲之數推測平均一尾約爲7×10^4粒，此孕卵數要比池末[2]所指出之 $12.5\sim49.4\times10^4$粒(頭胸甲長 27.3～37.5公厘)之孕卵數要少，但比船田[1,3]之平均一尾$310\times^4$粒多一倍多。有關臺灣產矽蝦之孕卵數有連等[4]之調查報告，但其樣品數爲3尾，有待今後之繼續調查。

至於確立飼育技術問題，由於此次使用未經過濾之海水而參入了蝦虎及五鬚蝦等之卵於水槽中，這些害敵孵化長大之速度遠比矽蝦快進而捕食大量之矽蝦幼蟲，其爲害甚大，今後採用魚塭海水，宜過濾爲宜。其次，採用虱目魚塭中於此季大量繁殖之各種浮游生物亦無不可，但，此次試驗期間於臺南分所近旁魚塭大量繁殖者爲 *Chlamydomonas* sp. 一類之綠色浮游生物，此類矽蝦幼蟲會吞食，但或許由於不易消化抑其他有關營養問題未能使其成長得良好，而飼以矽藻之一羣其成長快，故知眼幼蟲期宜用矽藻爲善。矽蝦之糠蝦期因體形較小，宜繼續飼以矽藻並漸漸增加橈脚類（Copepoda）一類動物性浮游生物之百分率，而不宜短期內改飼全動物性浮游生物。

此次飼育中發現此蝦之成長度極爲參差不齊，此所以致之，諒必和餌料之量有關係，但很少發現由於大小參差不齊而發生同類互相殘食之現象。

這次試驗結果，飼育密度達25尾／升，而第20後期幼蟲共育成4960尾。但整個試驗過程中由於缺乏新鮮海水未能充分換水，今後，努力改進這一點勢必能高出這個培育密度。

五、摘　　要

(1)本試驗旨在作矽蝦之人工繁殖，並觀測其發生過程，俾利今後作矽蝦人工繁殖之參考。

(2)本試驗爲了大量生產，產卵、孵化，同使用一個圓形硬質塑膠水槽（直徑100公分，實際水深30公分）於其中收容9尾抱卵之種蝦，結果9尾之中4尾於收容當晚產卵約28×10^4粒。

(3)卵爲球形，沈性卵，其直徑爲0.26公厘，在水溫 29.2～30.8°C，鹽分34.11～32.47‰之下，約12～13小時就開始孵化。

(4)孵化出之無節幼蟲（Nauplius）之體長爲 0.27公厘，此期不食任何餌料。眼幼蟲（Zoea）之第一期體長爲0.78公厘，此期開始攝食如矽藻之一種 *Skeletonema costatum* 以及較小之其他

* 筆者等爲了方便起見，變成後期幼蟲後第幾天，就稱爲第幾後期幼蟲。

植物性浮游生物。糠蝦期幼蟲（Mysis）之第一期體長爲2.3公厘，此期宜繼續飼以植物性浮游生物而漸漸增加動物性浮游生物如橈脚類（Copepoda）一類之混合率。第一後期幼蟲（the first postlarva）之體長爲 3.5 公厘，此蝦進入底棲生活，爲期似較草蝦之幼蟲要早，並且雖飼在同一個水槽中其成長度之參差程度，即體形之大小之變動範圍很大。

⑸此次試驗結果培育成4960尾之第20後期幼蟲，今後，筆者等將繼續此項試驗，以期早日確立此蝦之大量人工繁殖技術。

六、謝　　辭

本試驗之所以進行得順利，乃蒙洛氏基金之資助，東港漁會之各有關人員惠助，以及臺南分所工作人員多方協助和林金生氏、洪金抱君之鼎力協助，特此敬謝。

參　考　文　獻

⑴池末彌：有明海におけるエビ・アミ類の生活史，生態に關する研究，西海區水產研究所研究報告，第30號，pp124 (1963)。

⑵船田秀之助，ヨシエビの種苗生產研究，京都府水產試驗場業績，第27號，71～79 (1966)。

⑶連俊國・丁雲源：臺灣食用蝦類人工繁殖，臺灣省水產試驗所試驗報告，第14號，127～134 (1968)。

⑷連俊國・丁雲源：臺灣食用蝦類生活史初步調查，臺灣省水產試驗所試驗報告，第14號，135～141 (1968)。

嘉義養蚵之生態研究

Biological Study of Oyster Culture in Chiayi

林曜松*

By Yao-sung Lin

Research Fellow (Part Time), Rockefeller Foundation Fish Culture Research Program

Summary

(1) The temperature of Chiayi oyster beds ranges between 16.5-30.5°C which is suitable for the gonad development and spawning of oyster the year round.

(2) The critical temperature for oyster spawning is 20°C in Japan and America, but it is lower in the Chiayi area, anywhere between 16-20°C. Whenever the temperature rises 2-3 degrees above the existing temperature, spawning always occurs.

(3) Gonad development in hardened seed oyster is slower than that of ordinary seed oyster in the first two months of culture, after which it becomes similar in both cases.

(4) August is the hottest month in Putai during which oyster seed collection is impossible. The most favorable season for oyster seed collection is from September to April.

(5) Oyster usually becomes thin after spawning. It is advisable therefore to harvest marketable oysters before spawning.

(6) In Chiayi the oyster grows fast in the period between April and August. It slows down or stops growing from September to January. In a period of 9 months, oyster can grow to 6-7 cm (shell height), a growth condition similar to that in Hiroshima, Japan.

(7) During hardening period, the growth of seed oysters is very slow, but when they are transplanted to culture beds, their growth becomes faster than that of ordinary oysters. When the shell height of the hardened seed oysters reaches 5-6 cm, the growth rate becomes the same as that of the ordinary seed oysters.

(8) In 1967, the mortality of oysters in Putai was about 36.8%. This was probably due to poor seed oyster quality, parasite attack and production of H_2S from the bottom mud.

(9) In 1968 oyster mortality was much reduced in Putai and Wanglin. But the mortality of Yenshuishi oyster reached 37.6% in May 1968, attributable probably to low specific gravity.

(10) In areas where oyster grows fast, mortality is always high, probably due to sudden weakening by spawning of the fat and healthy oysters.

* This study was supported by grants from the Joint Commission on Rural Reconstruction and the Rockefeller Foundation, and was submitted as partial fulfillment of requirements for a degree of Master of Science in the Institute of Zoological Science, National Taiwan Uuiversity.

引　　言

本省養殖蚵 *Crassostrea gigas* (Thunberg) 年產一萬一千餘公噸，價值近一億元，其數量與價值均佔淺海養殖總數的90%。本省養蚵方法，一向以插竹式爲主。自1960年本省始有垂下式養蚵法的推廣，其單位面積的生產量或蚵體形的大小，均比插竹式爲佳。唯受天然的限制，垂下式養蚵產量只佔 3.2%，其主要場所有高雄港、布袋港、東港和臺南。東港與臺南兩地規模甚小，高雄港由於污水關係，養蚵前途黯淡。布袋港的養蚵面積日益擴大，而有養殖過密的現象發生，其他如異狀死亡、排卵過勤、附苗過多等均足以影響養蚵的收益。有關這些問題與生態環境因子的關係及改進對策，乃是本篇研究的目的。

本省養蚵歷史頗久，已有二百多年之記載。筆者自1967年承中國復興委員會之協助，於布袋港從事養蚵研究。當年5月自高雄之新竹港移種苗至布袋港養殖，由於種苗及環境之不適，至7月便開始陸續死亡，至10月每母殼之平均着蚵數只有2.8個，布袋百姓之養殖蚵之死亡率亦高達36.8%。故自1968年開始「抑制種苗」的養殖試驗。依 Ogasawara 等 (1962) 之研究，它可減低蚵的死亡率、抑制生殖巢的發育和增進蚵的生長度。但在本省的環境下可否達到同樣的效果，亦是此次試驗之要點。

養殖試驗地點

本次試驗包括3個場所：1. 布袋港，2. 網寮溝，3. 鹽水溪。其位置如圖1所示。

布袋港之養蚵區是利用漁船出入港口兩旁之航道水淺處，於退潮時，該航道寬約 50—200 公尺，水深2—6公尺。航道兩旁是海埔地，退潮時全部露出水面，其中有散地式、插竹式養蚵及蛤蜊之養殖。

網寮溝在布袋港之北邊，該溝內通網寮內陸，外通大海，水深只有2—3公尺溝寬30—50公尺，只能通行竹筏。溝內之養蚵規模遠較布袋港者爲小。溝旁亦爲廣大之海埔地，有插竹式養蚵及血蛤之養殖。

鹽水溪在布袋內陸，溪寬約30公尺，退潮水深平均1.5公尺。此溪之水源爲嘉南大圳，漲潮時海水溯流而上。沿着該溪，有老百姓之垂下式養殖蚵。試驗養蚵架離開海口約5公里。

材料與方法

1967年5月，於布袋港航道設6個站，網寮溝設2個站，1968年3月於鹽水溪新設一站。每站搭設試驗蚵架一臺，該蚵架規格爲15公尺×7.5公尺，縱長方向與航道方向平行，其格式如圖2所示。

蚵串長度隨各站水深而略有差異，約在 1.4—1.8 公尺之間。蚵串是由塑膠線穿母殼5—11個，每個間隔20公分，中間隔以塑膠管。又每蚵串間隔30公分，故一臺蚵架可吊蚵串約800串。

1967年5月養殖之蚵苗來自高雄新打港。1968年1月開始試驗之蚵苗爲布袋港、網寮溝當地採集者。採苗方法是將蚵串放於養蚵架下，在海水中浮游的幼生便會附着於母殼成爲幼貝，開始生長。

有關各項調查方法分述於下。

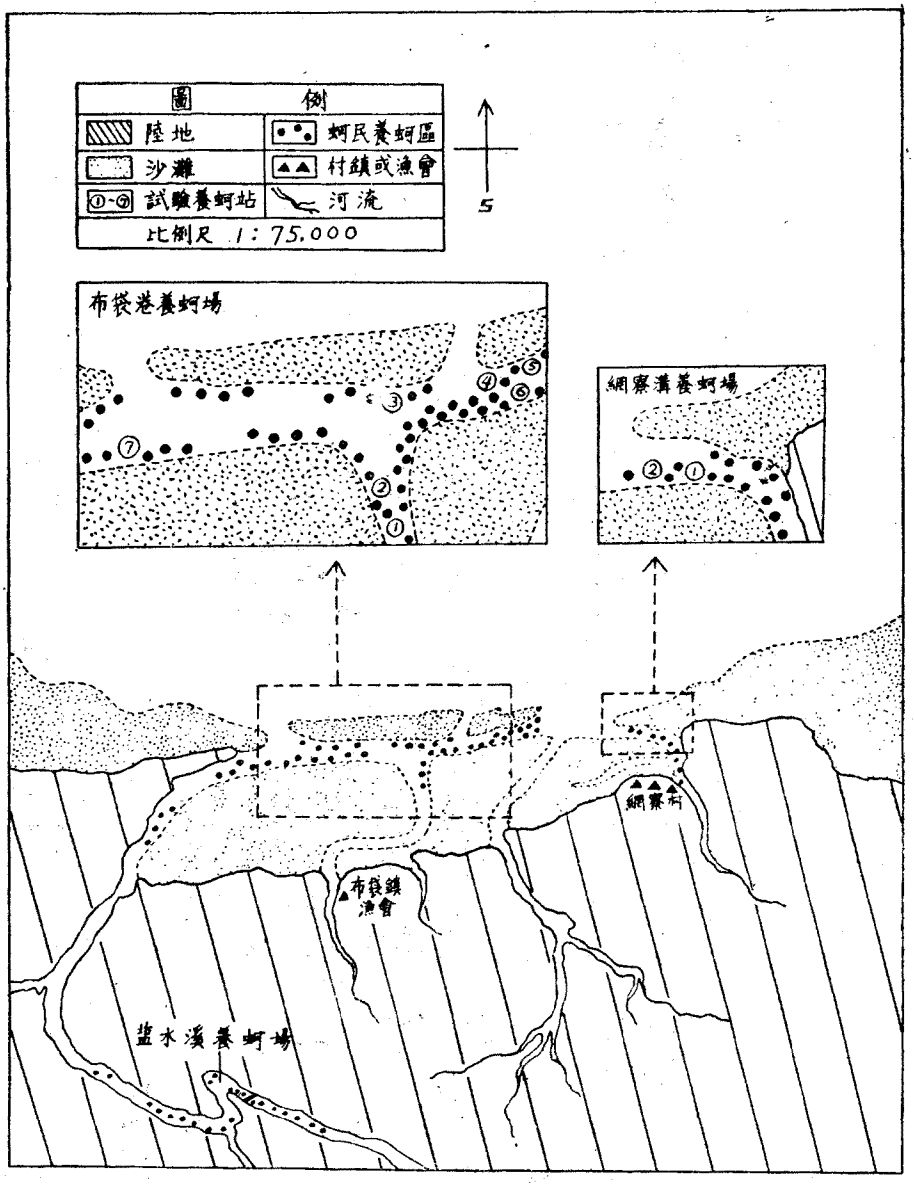

圖例
陸地
沙灘
①-⑦ 試驗養蚵站
蚵民養蚵區
村鎮或漁會
河流
比例尺 1：75,000
S
布袋港養蚵場
網寮溝養蚵場
布袋鎮漁會
網寮村
鹽水溪養蚵場

圖 1. 嘉義養蚵場地形圖

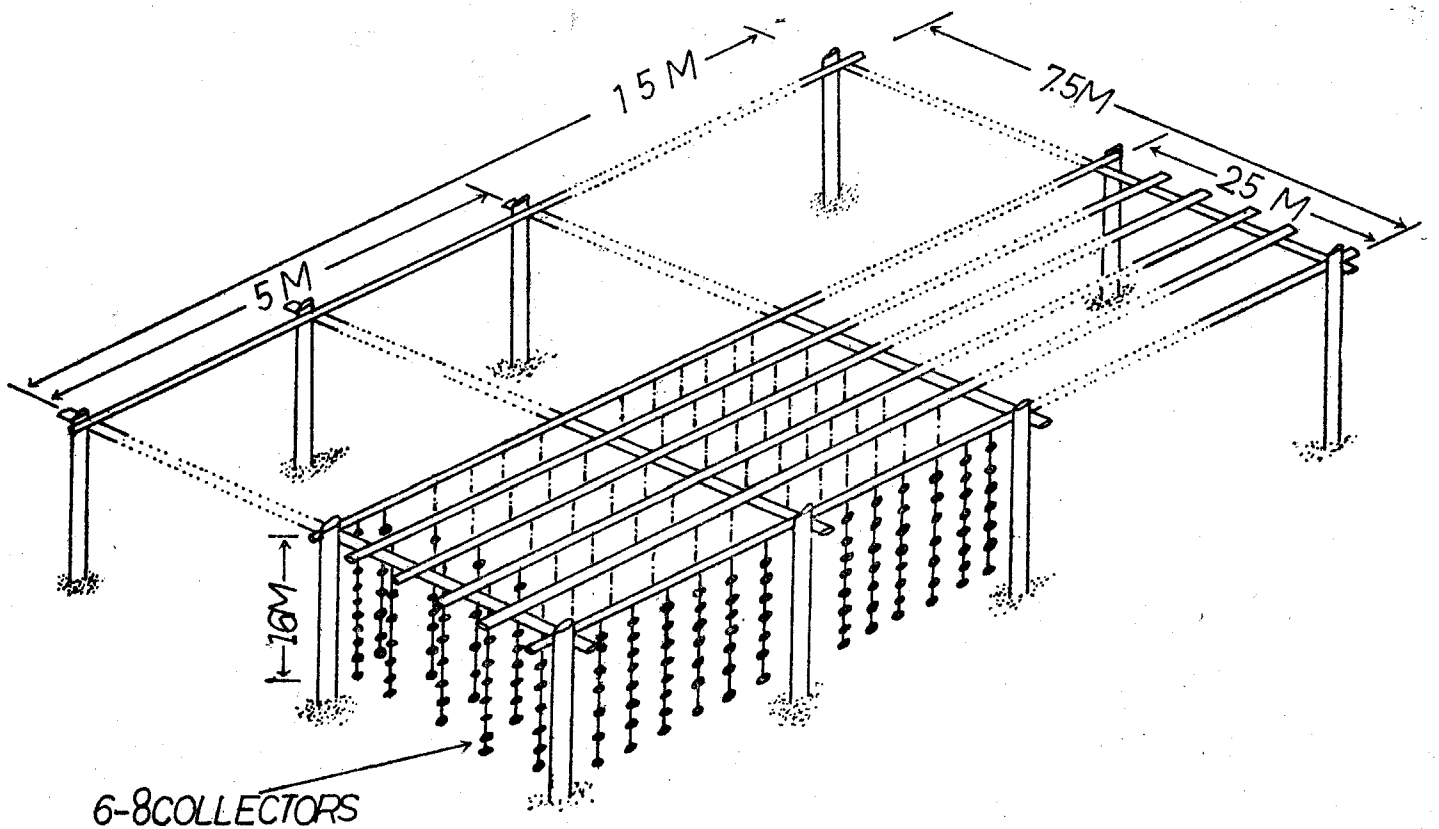


圖 2. 養蚵架模式圖

1. 氣象與水質

自1968年4月至1969年4月於布袋逐日記錄當地的氣溫、風力及下雨狀況。又於布袋港內、網寮溝及鹽水溪每星期一次調查養蚵架下表層之水溫、鹽度、pH, 氧氣含量、比重及鈣含量。

2. 卵巢觀察

1967年4月開始於布袋港、網寮溝及鹽水溪調查卵巢飽滿情形，每次剝蚵50個，將卵巢依其發育狀況分成下列4種標準：

（A）蚵剛排卵，外套膜透明，消化盲囊清晰可見。

（B）蚵的軟體部份具有生殖巢，消化盲囊大部可見。

（C）蚵的軟體部大部具生殖巢，消化盲囊部份可見。

（D）消化盲囊全部爲生殖巢覆蓋，軟體部成白濁或帶金黃色，體呈肥滿狀態。

3. 肥滿度調查

每次取蚵15個，分成3組，每組5個，各組測定其全蚵體積、蚵殼體積、濕肉重。前二者之相差爲殼內容積。依 Galtsoff (1964) 肥滿度指數=濕肉重 (g)×100/殼內容積。求三組之指數平均數變化。

4. 着苗調查

於布袋港第4站及網寮第二站，從事着苗試驗。每次出海放採苗串三串，每串有6個母殼，其間隔爲30公分，蚵串下懸重物使其垂直。於第二次垂下新採苗串時，取回前一次放之蚵串，連續調查其附着生存之蚵苗數。

5. 殘存率與死亡率調查法

每個月測定生長度之同時，計算其生存個數及死亡個數。

6. 生長度測定

（A）普通蚵苗　自1968年1月於布袋港及網寮溝各站開始採苗，並於原處繼續養殖至收成爲止。另於3月將布袋港採到之蚵苗移於鹽水溪養殖。以上三地之養殖蚵，均稱爲普通蚵苗之養殖。

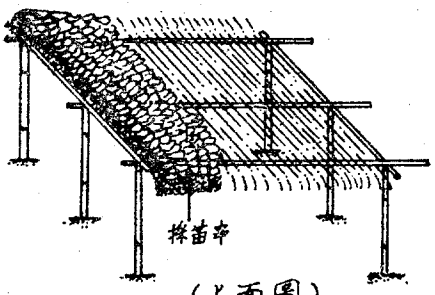
（B）抑制蚵苗　於1968年1月於布袋港另搭設採苗架，其方式如圖3所示。至4月便移往布袋港內溝之抑制苗架，其搭設方式與採苗架相同，唯其露出水面時間遠較採苗架者爲長。本次試驗之抑制苗架共分三種，每種之露日時間各不相同。

各養蚵架每月逢機取二串，分上、中、下三層測定生長度，包括殼高 (SH)、殼寬 (SL) 與殼厚 (SW)，其測定方式如圖4所示。

結　　果

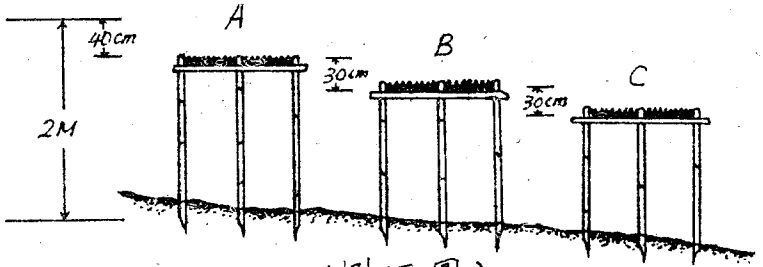
1. 氣象與水質

布袋港的年氣溫，風力如圖5所示。上午 9：00 之年氣溫在 9.6～30.9°C 之間，下午 3：00 之年氣溫在 12.4～35.4°C 之間。全年最冷季節爲2月，最熱爲8月。布袋主要落雨之季節爲 5～7



(上面圖)

抑制蚵苗	A	B	C
離最低潮線高度(M)	1.6	1.3	1.0
露出水面時間(小時)	18	16	14



(側面圖)

圖 3. 採苗架與抑制苗架模式圖

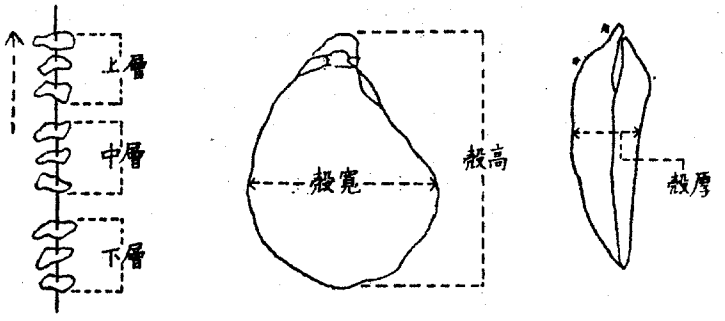


圖 4. 生長度測定標準圖

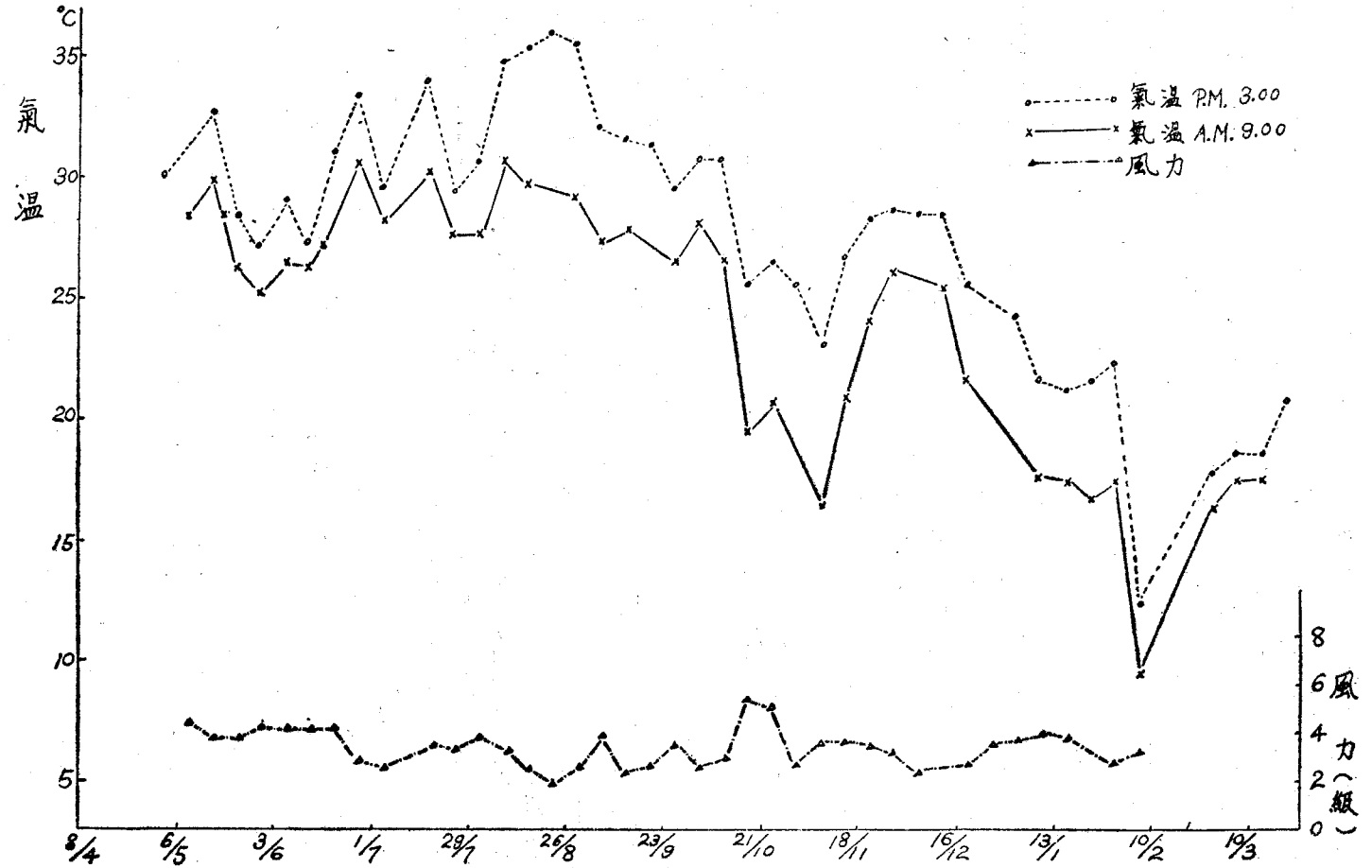


圖 5. 布袋港年氣溫及風力調查

月，9月底～10初。

各養蚵試驗區之水質測定如圖 6、7、8 所示。茲分述於下：

水溫：3個試驗場相距不遠，受同一氣溫之影響，故水溫之年變化一致。每週平均水溫在16.5～30.5°C 之間。5～10 月之水溫變化不大，10～4 月水溫變化呈不規則狀。

鹽度與比重：布袋港的鹽度爲 20.5～37‰。比重爲 1.011～1.028。網寮溝鹽度爲 13～36‰，比重爲 1.011～1.027。鹽水溪鹽度爲 3～35.5‰，比重爲 1.000～1.0267。比較三地之差異可發現，布袋港純爲海水，故鹽度與比重較高，網寮溝之鹽度比重次之，鹽水溪因受淡水影響較大，鹽度與比重較低，在雨季海水往往無法溯流而上。

氧氣含量：3個地區水質之全年含氧量都在 4.8～7.5 ppm 之間，3 個地區變化不一致，且無規律可言。

氧含量：3個地區之鈣含量爲布袋 0.62～1.6 g/l，網寮 0.68～1.62 g/l，鹽水溪 0.3～1.61 g/l。

pH：3個地區水之 pH 值在 7.0～8.2 之間。其中以鹽水溪之變化較大。

此外布袋港1966年5月至12月之水溫、氣溫及比重調查，如表1所示。水溫 15.5～31°C，比重 1.016～1.024。夏季水溫高時比重較低，冬季水溫低時比重較高。

2. 蚵之生育情形

2.1 卵巢發育：圖 9、10、11 爲 3 個地區養殖蚵之卵巢觀察結果。自卵巢肥滿至消瘦之階級，可推論蚵已排過卵。自以上九個月的調查中，可推測蚵曾發生排卵的時間如表2所示。每一地區的蚵都經過多次排卵，且排卵期無季節的限制。圖 12、13 爲各種養殖蚵卵巢觀察結果，抑制蚵苗放養時間不同，其卵巢發育便有遲速之別。

2.2 着苗：布袋港與網寮溝兩地着苗情形圖如 14、15 所示。除夏天外，周年均有蚵苗附着。布袋港主要着苗季節在 10～4 月，與蚵民採苗之季節 11～3 月一致。比較布袋港與網寮溝兩地着苗，可發現前者比後者附着要多。在鹽水溪的蚵，亦曾排卵，唯因該地比重低，不適幼生之發育，故沒有蚵苗之附着。

2.3 肥滿度：圖 16、17、18 爲 3 個地區蚵之肥滿度調查結果。自圖中可知蚵肥滿與消瘦之肉重相差甚大，蚵主要的肉重便爲卵巢部份，依此亦可推知蚵之排卵狀況。3 個地區以布袋港之蚵變化最大，網寮溝者次之，鹽水溪者最小。

2.4 殘存率與死亡率

表 3 爲布袋港、網寮溝 1967 年試驗蚵之每母殼生存數調查。表 4 爲 1968 年三地區各批養殖蚵之生存數調查。表 5 爲布袋港 1967 及 1968 年老百姓養殖蚵死亡率分佈調查表。表 6 爲死亡率與蚵養殖深度之關係。表 7 爲布袋港、網寮溝兩地區 1968 年蚵死亡率之月變化。

由上表可發現，1967 年布袋港之試驗蚵至 10 月 23 日，每母殼之生存數平均只有 2.8 個，已無養殖之價值。老百姓之養殖蚵死亡率爲 32.7～48.2％，而 1968 年爲 0.83～3.55％，兩年之死亡率有極顯著之差異，且可發現其死亡率與蚵所在之深度無關，而與離外海之遠近有關，亦便是自第一站至第六站，死亡率有增加之趨勢。

1968 年鹽水溪的蚵於 6 月初之每母殼平均之生存蚵數爲 47.8 個，而於 6 月下旬之調查只剩 28.8 個，死亡率達 37.6％，且死亡者多屬大蚵，體形小者死亡率低，此與當時之雨季有關。

2.5 生長度

1967 年 4 月 19 日自高雄新打港一批蚵苗至布袋港，在第 3 、6 站養殖者之生長度如圖

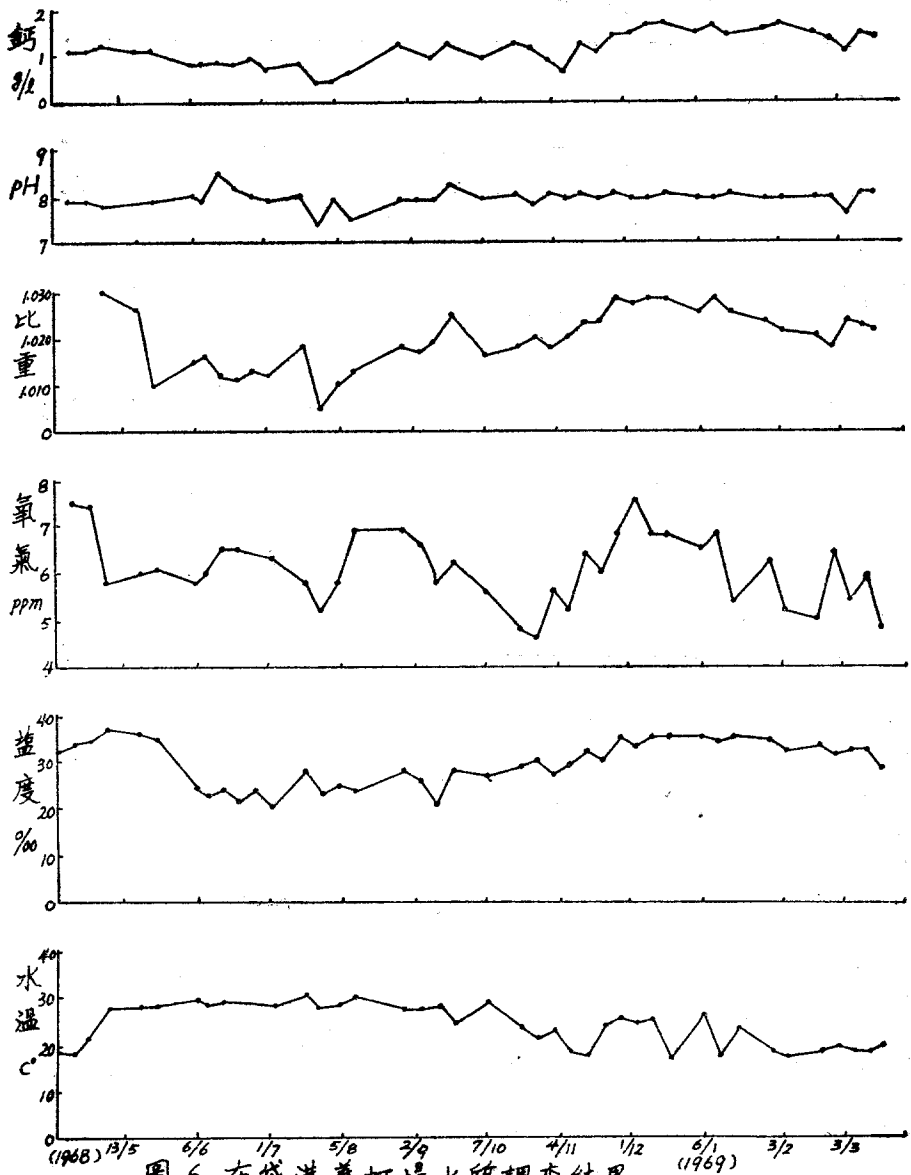


圖 6. 布袋港養蚵場水質調查結果

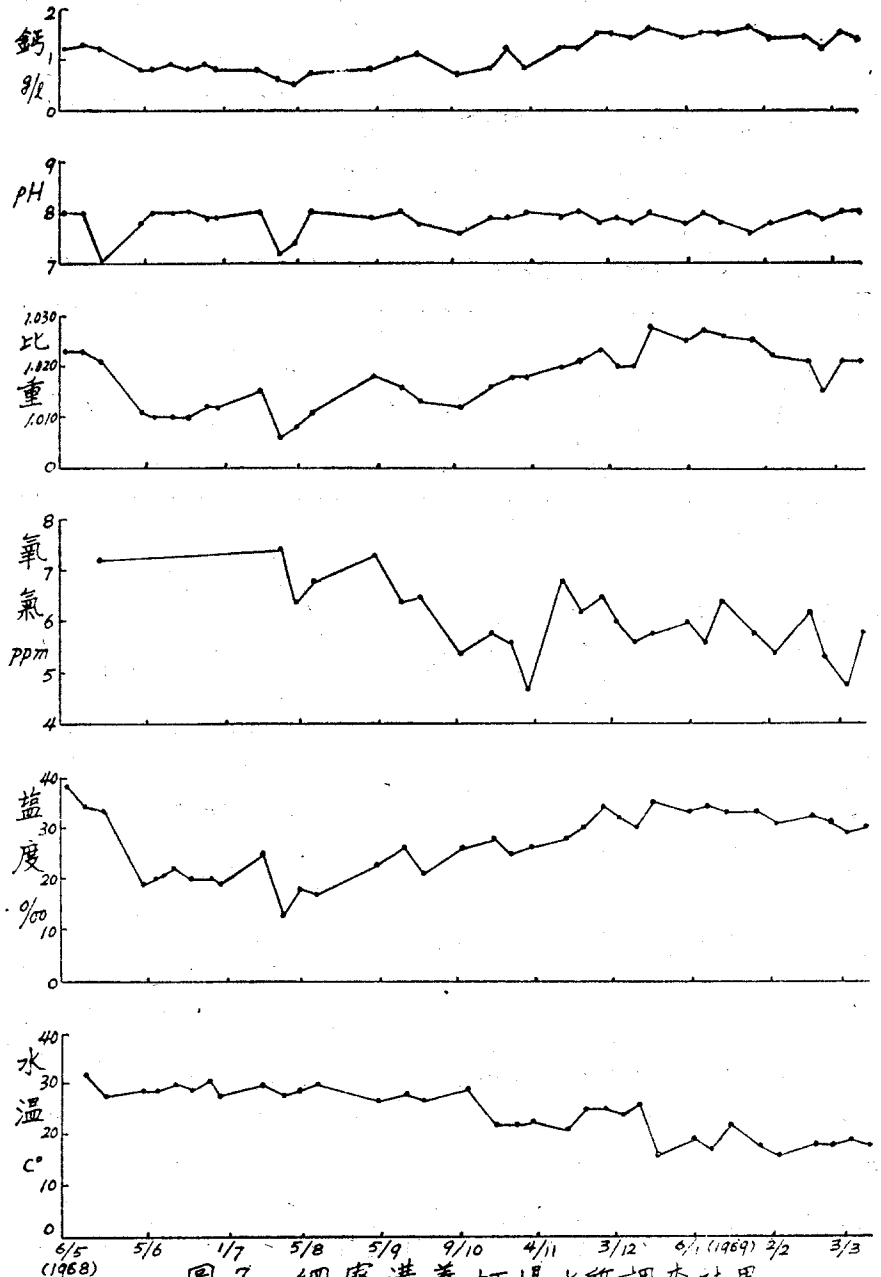


圖 7. 網寮溝養蚵場水質調查結果

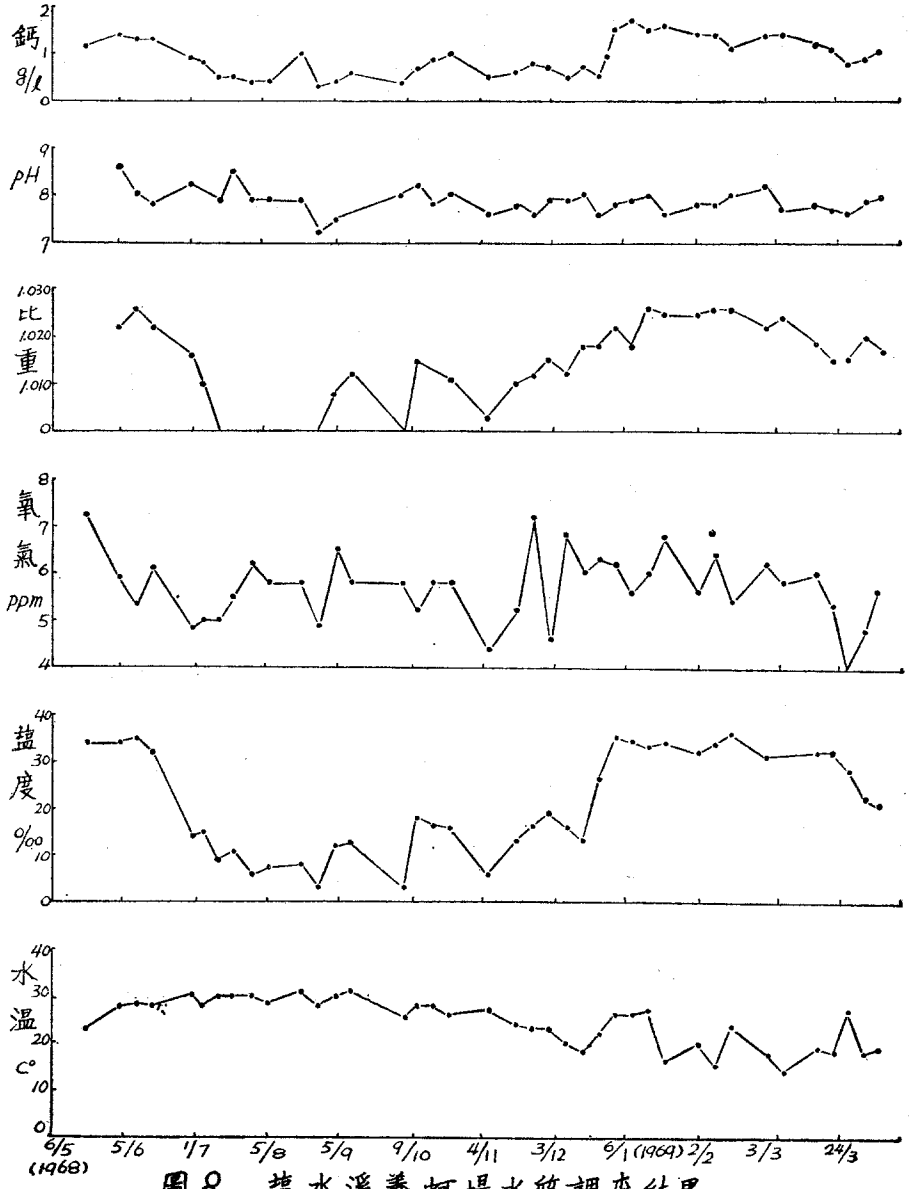


圖 8. 鹽水溪養蚵場水質調查結果

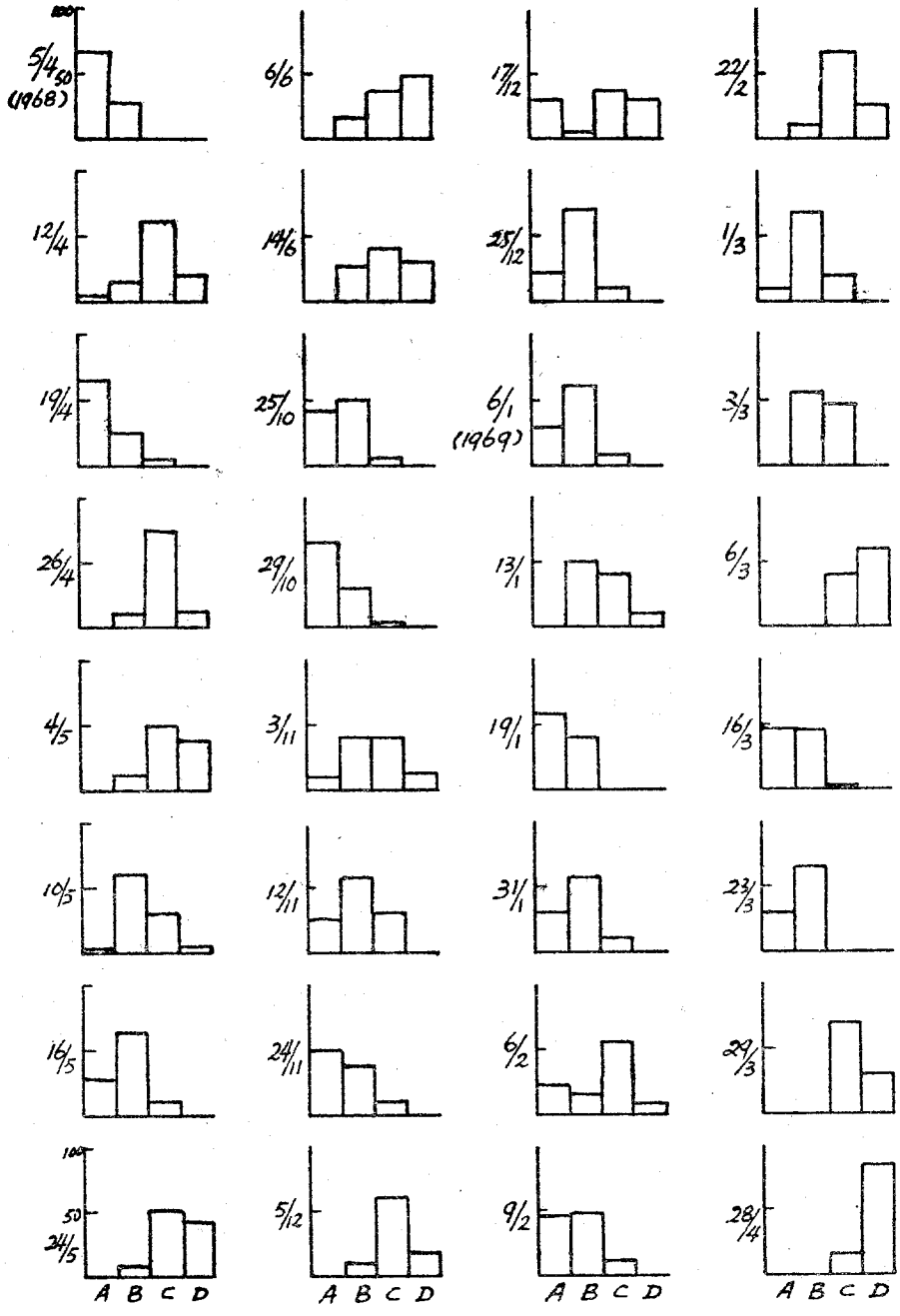


圖 9. 布袋港養殖蚵卵巢觀察 (%)

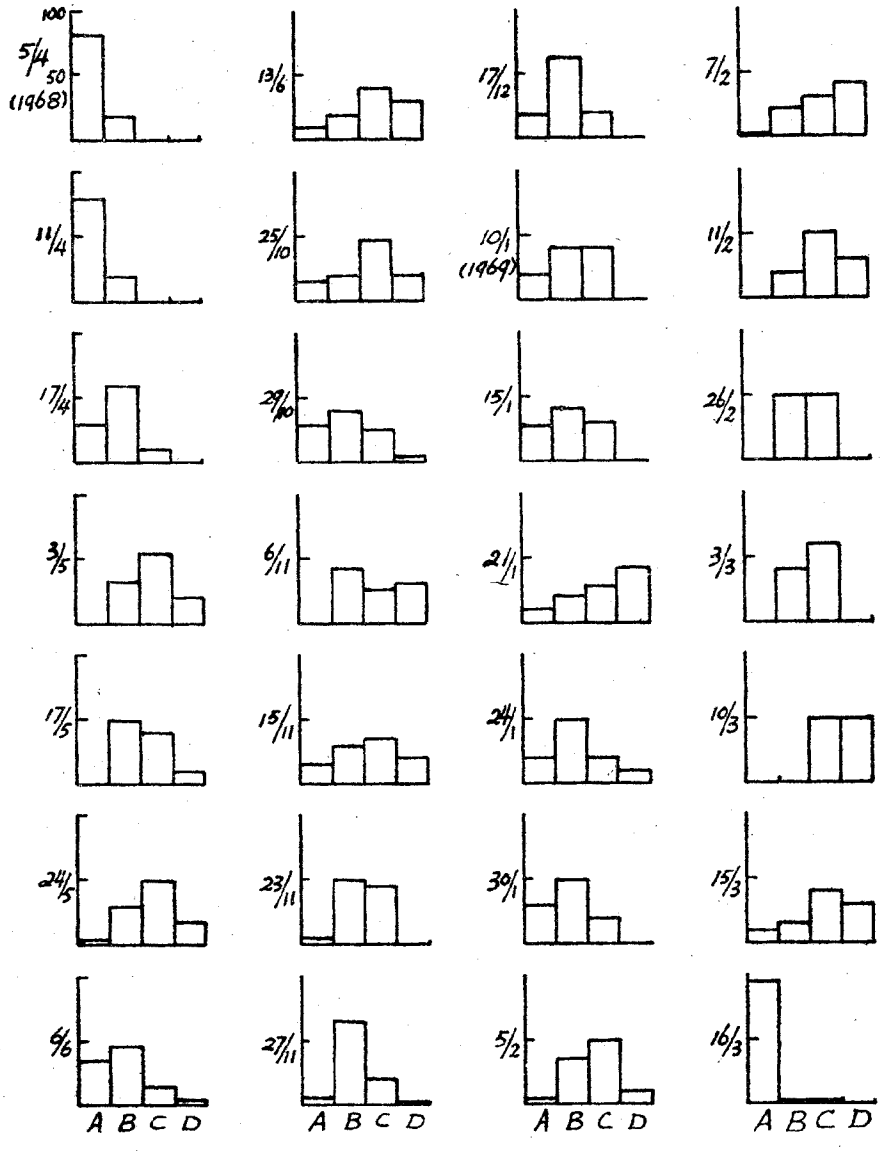


圖 10. 網寮溝養殖蚵卵巢觀察(%)

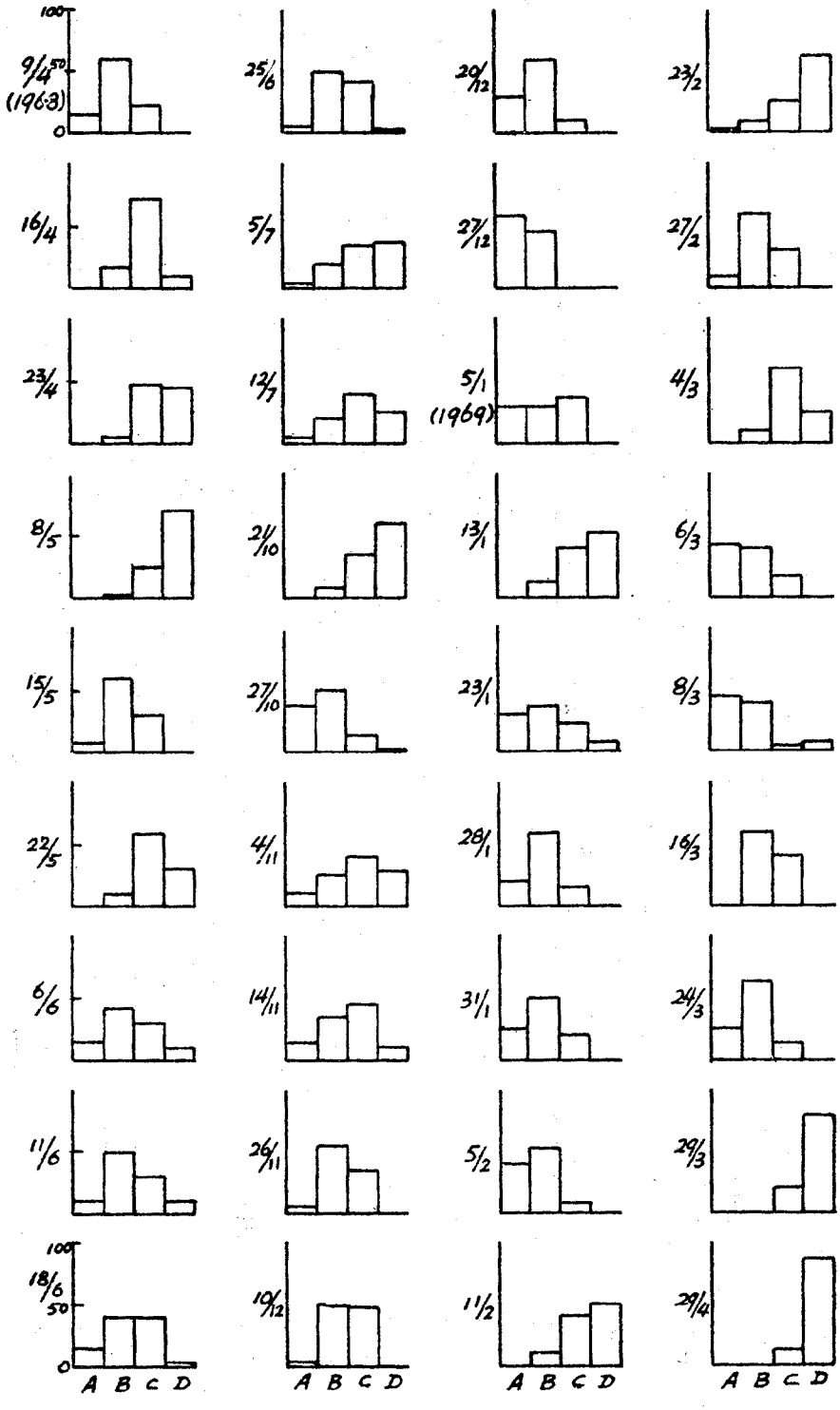


圖 11. 鹽水溪養殖蚵卵巢觀察 (%)

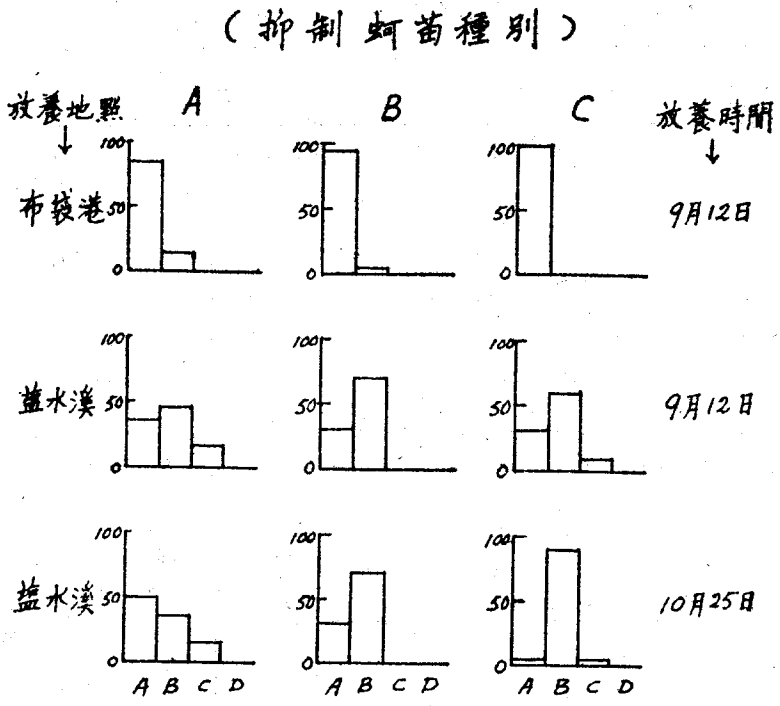


圖 12. 抑制種苗卵巢觀察比較圖 (%)

表 1　1966 年布袋港水溫、比重、氣溫調查

日　　期	比　　重	水　溫 °C	氣　溫 °C
1967. 5. 19	1.022	29.1	33.1
8. 4	1.016	30.6	30.5
15	1.019	30.5	31.0
9. 12	1.017	31.0	32.0
30	1.020	28.0	29.0
10. 5	1.020	26.8	27.3
24	1.023	18.8	18.0
11. 22	1.023	18.0	19.1
12. 06	1.023	17.0	16.2
12. 22	1.024	15.5	17.0

表 2　養蚵試驗區蚵排卵時間調查

排卵次序 ＼ 地點	布袋港 月 日～月 日	網寮溝 月 日～月 日	鹽水溪 月 日～月 日
1	4. 12— 4. 19	5. 3— 5. 17	5. 8— 5. 15
2	5. 4— 5. 10	5. 24— 6. 6	5. 22— 6. 6
3	5. 24— 6. 14	10. 25—10. 29	10. 21—10. 27
4	11. 3—11. 24	1. 21— 1. 24	11. 14—11. 26
5	12. 17—12. 25	2. 11— 2. 26	12. 10—12. 20
6	1. 13— 1. 19	3. 10— 3. 15	1. 13— 1. 23
7	2. 6— 2. 9		2. 23— 2. 27
8	2. 22— 3. 1		3. 4— 3. 6
9	3. 6— 3. 16		3. 16— 3. 24

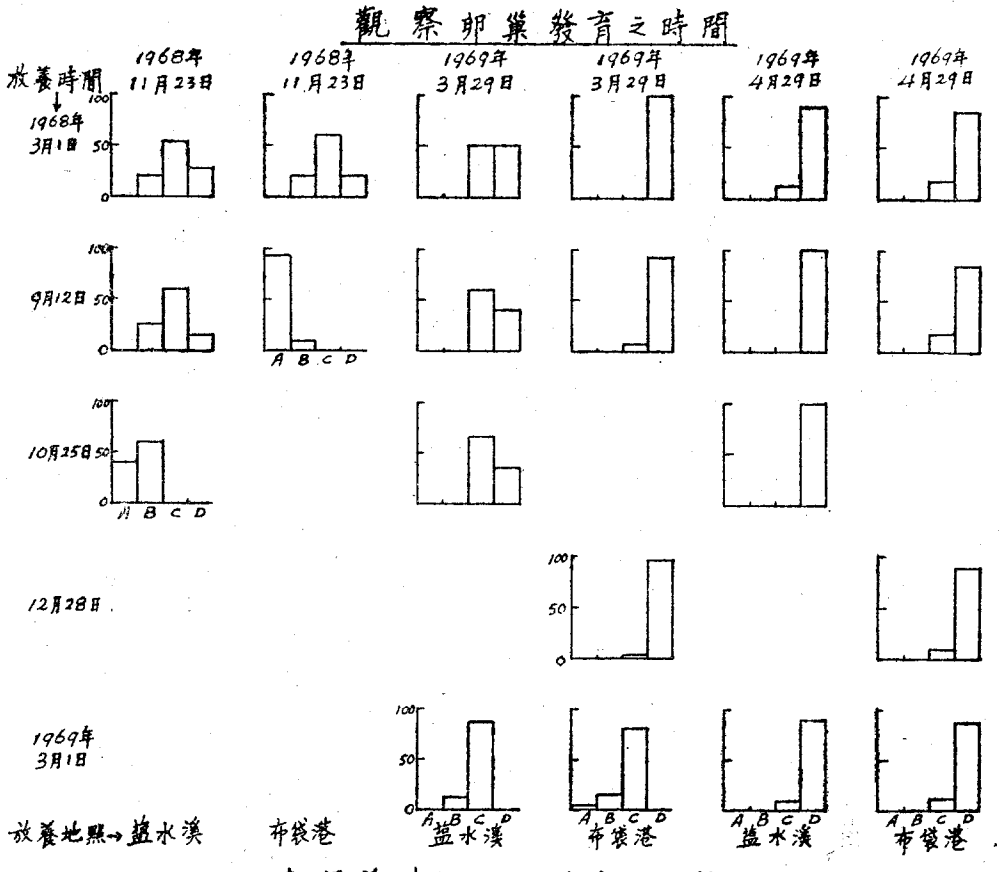


圖 13. 各種養殖蚵卵巢發育之比較(%)

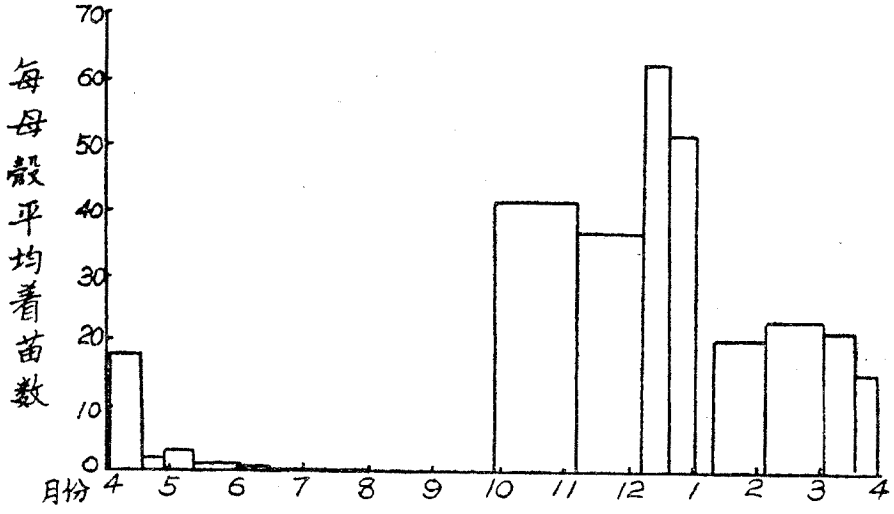


圖 14. 布袋港第4養蚵站着苗数之年変化

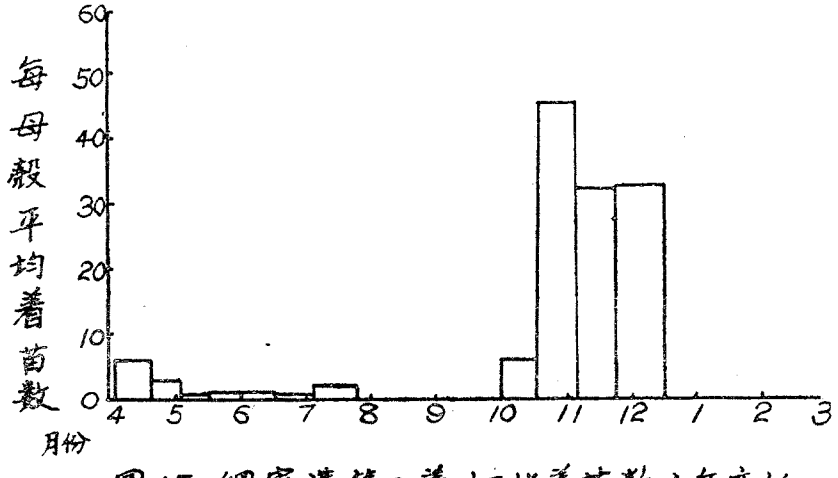


圖 15. 網寮溝第2養蚵站着苗数之年変化

圖 16. 布袋港養殖蚵肥滿度指數調查

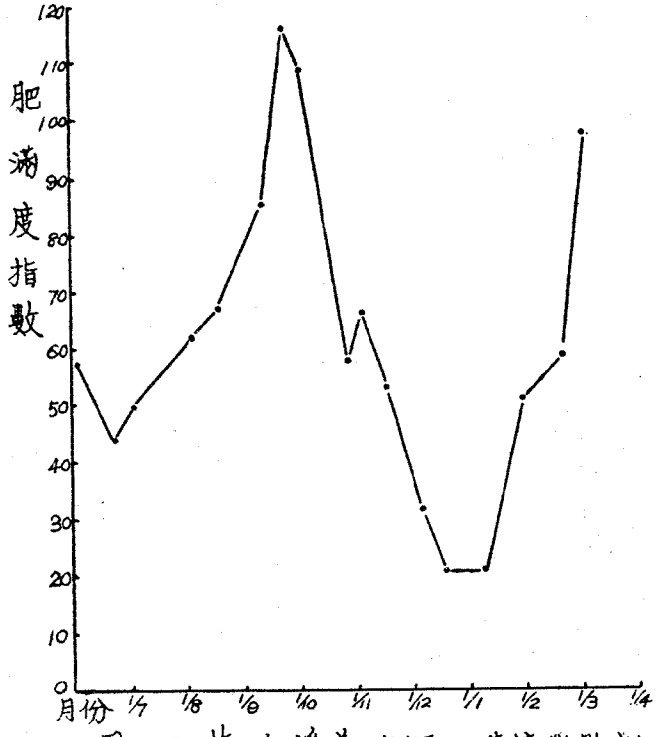


圖 17. 盬水溪養殖蚵肥滿度指數調查

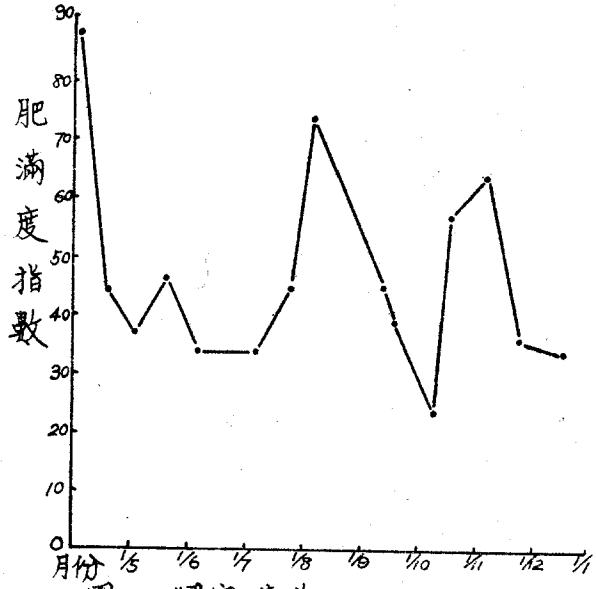


圖 18. 網寮溝養殖蚵肥滿度指數調查

表 3　1967 年布袋港、網寮溝蚵每母殼平均生存個數調查

調查日期	站分層	地點號	布袋港 1	2	3	4	5	6	7	8	網寮溝 1	2	3
23/8	上	層			5	9	13	6	23	22	17	13	15
	中	層			4	9	10	10	32	26	17	10	15
	下	層			3	8	8	9	41	33	8	14	22
	平	均			4	9	10	8	32	27	12	12	17
23/10	上	層	7	2	1	5	3	2					17
	中	層	7	1	2	2	4	2					10
	下	層	5	2	1	3	3	1					18
	平	均	6	2	1	3	3	2					15
23/11	上	層	7	2	2	4	4	3	17	15	18	18	14
	中	層	1	0	2	3	4	6	11	10	19	15	13
	下	層	9	2	4	2	7	2	18	11	24	15	19
	平	均	8	1	3	3	3	4	15	12	19	16	15

註：布袋港 1—6 站，網寮溝 1—3 站之蚵爲新打港之蚵苗。
布袋港 7. 8. 站爲當地採苗之養殖蚵。

表 4　1968～1969 年各批蚵之每母殼平均生存數月變化調查

種別＼月份	1968年 5	6	7	8	9	10	11	12	1969年 1	2	3	4	備考
1	83.0	61.6	54.3	38.5	33.5	—	—	39.6	35.0				布袋港普通蚵苗
2	28.6	—	17.0	—	19.4	19.2							A種抑制蚵苗
3	32.8	—	19.8	—	19.7	15.2	—	14.6					B種抑制蚵苗
4	33.8	—	23.0	—	20.0	17.4	—	16.8					C種抑制蚵苗
5					19.4	—	15.3	12.0	14.0	15.5	10		A種抑制蚵苗
6					19.7	—	21.5	17.0	15.5	17.5	13.5		B種抑制蚵苗
7					20.0	—	21.0	12.0	15.3	17.5	13.5		C種抑制蚵苗
8						17.2	17.0	—	—	17.3	21.3		A種抑制蚵苗
9						15.2	20.3	—	—	18.6	11.7		B種抑制蚵苗
10						17.4	22.7	—	—	20.0	16.7		C種抑制蚵苗
11					19.4	15.3	—	—	17.2	10.7	7.3		A種抑制蚵苗
12					19.7	13.8	—	—	19.7	8.8	9.5		B種抑制蚵苗
13					20.0	—	—	—	21.2	14.0	12.0		C種抑制蚵苗
14								14.6	—	11.5	8.7		B種抑制蚵苗
15								16.8	—	11.5	14.8		C種抑制蚵苗
16											14.4	7.0	鹽水溪之抑制者
17											8.6	7.2	鹽水溪之抑制者
18	61	—	—	35.0	—	31.7	—	—	20.3	—	24	16.5	網寮溝之普通蚵苗

2. 3. 4. 爲抑制苗於抑制期間之生存數
5. 6. 7. 爲9月12日移往鹽水溪之抑苗
8. 9. 10. 爲10月25日移往鹽水溪之抑苗
11. 12. 13. 爲9月12日移往布袋港之抑苗
14. 15. 爲12月28日移往布袋港之抑苗
16. 爲鹽水溪之抑制苗於當地養殖者
17. 爲鹽水溪之抑制苗移往布袋港養殖

表 5　布袋港百姓養殖蚵死亡率水平分布　(%)

站號 / 日期	1	2	3	4	5	6
1967 年 12月	29.8%	34.3		48.2		41.8
1968 年 12月	0.83%	20.8	1.25	1.68	2.91	3.56

表 6　1967 百姓養殖蚵之死亡率與深度之關係　(%)

深度 / 地點	上層 1	2	3	中層 4	5	6	下層 7	8
布袋港	42.6%	40.2	39.3	44.1	43.6	39.6	43.0	56
網寮溝	32.1%	39.4	25.5	24.0	25.7	32.3	27.5	38.1

表 7　1968 年百姓養殖蚵死亡率之月變化

月日 / 地點	5/6	6/7	6/8	12/9	8/10	7/11
布袋港	5.33%	7.78	4.70	14.19	7.74	9.31
網寮溝	8.40%	9.94	5.30	13.82	10.03	12.73

19、20 所示。養殖至 11 月 19 日各層之平均殼高爲 2.39-3.22 cm，生長極爲緩慢，又比較第 1、2、4、6 站蚵之生長度如表 8，至 10 月23日各層蚵之平均殼高在 2.20-3.26 cm 之間，顯示此4站蚵之生長度相近。而同年1月於布袋當地採苗養殖的蚵，其生長度至9月12日（第6站旁）爲5.58±1.00 cm，可見當地蚵苗遠較新打港之蚵苗生長要佳。

1967年12月於布袋港採苗並於當地養殖蚵之生長度如圖 21、22 所示。至次年8月4日各層蚵之平均殼高在 5.30～6.67 cm 之間，8月以後生長度便見緩慢，至1969年1月爲 6.00～6.30 cm，則幾至停滯。其後成長情形又漸顯著。至 4 月 1 日各層蚵之平均殼高爲 7.26～7.84 cm，殼寬爲 4.78～4.97 cm，殼厚爲 1.82～1.96 cm。

布袋港第 1、2、4、6 站蚵在 1968 年養殖生長度之比較如表9所示。其生長較 1967 年之試驗蚵爲佳，養殖9個月，各層蚵之平均殼高第1站 4.63 cm、第2站 5.52 cm、第4站 6.01 cm、第6站 6.83 cm，其生長情形以偏居外海者較佳。上、中、下三層之比較一般說來則以下層較佳。

1967年 12 月於網寮溝採苗並於當地養殖之蚵生長度，如圖 23、24 所示。至 9 月 2 日各層蚵平均殼高第 1 站爲 4.75～5.66 cm、第 2 站 5.03～6.61 cm，其生長情形與布袋港第 3、4 站相近，而比第 6 站爲差。至 1969 年 1 月第 1 站之平均殼高爲 5.55～6.01 cm，第 2 站爲 5.32～5.77 cm，可見 1968 年 9 月至 1969 年 1 月生長幾乎停頓。

1967 年 12 月網寮溝採苗，1968 年 3 月移往鹽水溪養殖之蚵生長度如圖 25 所示。養殖一年，各層蚵之平均殼高僅 5.45～5.88 cm，其中 4—7 月生長較速，7—10 月幾乎停頓，而 9 月特

表 8　1967 年布袋港第 1, 2, 4, 6 各養蚵站蚵之生長度比較（cm）

站號		第 1 站			第 2 站			第 4 站			第 6 站		
日期	層次	$\bar{X}$	SD	C	$\bar{X}$	SD	C	$\bar{X}$	SD	C	$\bar{X}$	SD	C
4/8	殼高 上	2.10	0.53	26.90	2.56	0.47	19.03	2.38	0.30	12.80	3.03	0.44	44.49
	中	2.17	0.53	22.51	2.30	0.60	27.56	2.64	0.45	17.47	3.16	0.44	14.22
	下	2.24	0.54	24.06	2.48	0.65	22.17	2.64	0.44	16.98			
	殼寬 上	1.55	0.53	34.89	1.85	0.47	26.37	1.76	0.25	14.16	1.97	0.58	30.07
	中	1.54	0.78	52.01	1.90	0.40	21.85	1.91	0.32	16.88	2.12	0.51	24.81
	下	1.54	0.20	13.00	1.91	1.04	55.89	1.89	0.45	24.88			
	殼厚 上	0.85	0.22	26.51	0.84	0.37	46.02	0.94	0.22	23.91	1.12	0.33	30.10
	中	0.92	0.27	30.55	0.97	0.32	33.97	1.01	0.22	22.52	1.16	0.24	21.04
	下	0.69	0.19	23.34	0.98	0.54	56.35	0.90	0.30	34.27			
23/10	殼高 上	2.20	0.49	23.00	2.75	0.67	25.37	2.95	1.12	39.14	2.81	0.78	28.32
	中	2.51	0.47	19.38	2.91	0.45	17.55	2.87	0.65	23.87	3.11	0.58	18.96
	下	3.19	0.96	31.38	3.25	0.63	21.13	3.26	0.61	19.18	2.96	0.83	28.91
	殼寬 上	1.51	0.34	23.10	1.85	0.49	27.65	2.02	0.75	38.48	1.99	0.65	35.42
	中	1.78	0.32	18.66	2.07	0.44	24.46	2.02	0.74	38.56	2.21	0.45	20.29
	下	1.98	0.69	35.12	2.40	0.64	28.96	2.25	0.39	17.92	2.05	0.49	24.98
	殼厚 上	1.02	0.33	32.90	1.04	0.20	20.27	1.19	0.32	28.03	1.07	0.37	39.14
	中	1.12	0.22	20.25	1.11	0.21	21.28	1.04	0.35	35.08	1.16	0.21	18.44
	下	1.16	0.28	24.33	1.30	0.42	34.96	1.19	0.26	22.65	1.16	0.29	25.55

表 9　1968 年布袋港第 1, 2, 4, 6 各養蚵站之生長度比較（cm）

站號		第 1 站			第 2 站			第 4 站			第 6 站		
日期	層次	$\bar{X}$	SD	C	$\bar{X}$	SD	C	$\bar{X}$	SD	C	$\bar{X}$	SD	C
22/6	殼高 上	2.74	0.29	11.01	3.62	0.47	13.12	3.61	0.61	16.33	4.75	0.67	14.39
	中	3.08	0.49	16.03	3.77	0.63	17.20	3.99	0.70	17.70	5.10	1.17	23.25
	下	3.88	0.59	15.58	3.61	0.64	17.81	3.82	0.81	21.39	5.17	0.19	18.53
	殼寬 上	1.83	0.27	15.15	2.45	0.57	23.46	2.56	0.50	19.86	3.09	0.56	18.29
	中	2.51	0.36	14.59	2.68	0.56	21.42	2.56	0.59	23.56	3.24	0.31	9.70
	下	2.50	0.34	13.18	2.24	0.15	20.45	2.80	0.53	19.10	3.25	0.45	13.96
	殼厚 上	1.07	0.22	21.19	1.15	0.16	14.34	1.24	0.35	28.48	1.53	0.29	18.97
	中	1.23	0.18	14.77	1.32	0.22	17.27	1.34	0.48	35.89	1.13	0.29	17.09
	下	1.16	0.23	20.18	1.08	0.21	20.01	1.29	0.28	21.90	1.61	0.31	18.99
12/9	殼高 上	4.63	0.89	19.69	5.52	0.75	13.88	6.01	1.52	30.17	6.83	1.02	15.18
	中	4.79	0.79	16.87	5.42	0.70	13.19	5.91	1.62	28.04	6.83	1.06	15.85
	下	4.25	0.52	12.69	5.83	1.17	20.52	6.20	1.03	16.91	7.29	0.81	22.74
	殼寬 上	3.61	0.57	11.01	4.15	0.59	14.67	5.07	1.01	20.19	5.41	1.09	20.49
	中	3.16	0.57	16.21	4.34	0.64	15.06	4.93	0.99	20.49	5.43	1.00	18.85
	下	3.25	0.81	25.71	4.61	1.05	22.97	4.69	0.99	21.59	5.83	0.76	13.20
	殼厚 上	1.49	0.19	13.49	1.73	0.41	4.05	3.43	0.78	22.97	1.88	0.47	25.37
	中	1.49	0.18	12.49	1.58	0.31	20.10	2.91	0.60	20.05	2.00	0.20	10.41
	下	1.48	0.29	20.60	1.83	0.40	22.48	2.91	0.59	20.15	1.79	0.50	28.44

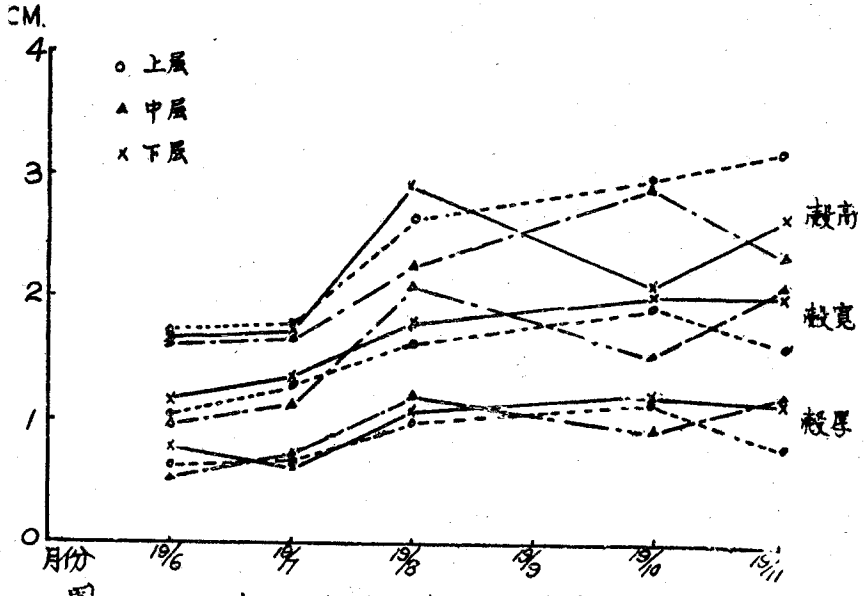


圖 19. 1967年4月自新打港移往布袋港第3站養殖蚵之生長度

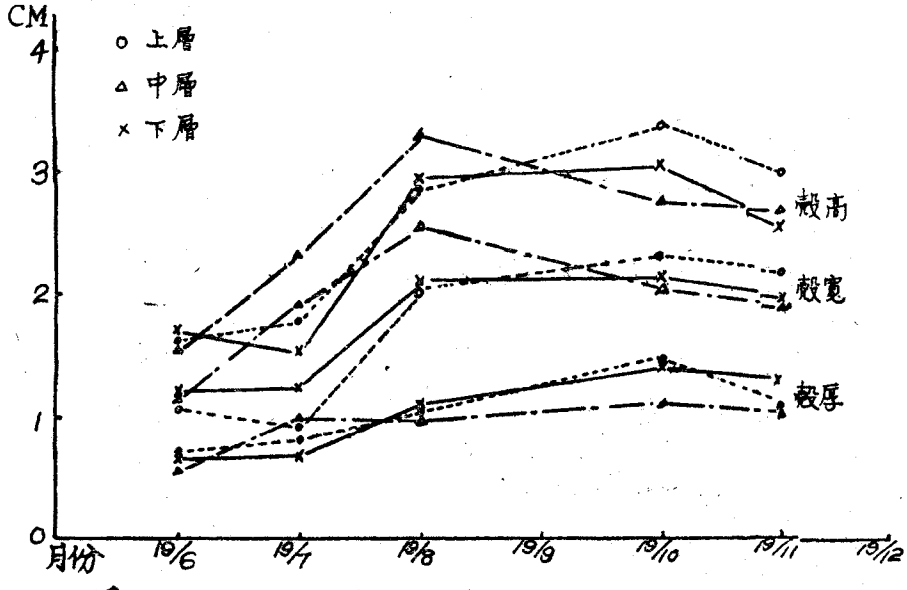


圖 20. 1967年4月自新打港移往布袋港第6站養殖蚵之生長度

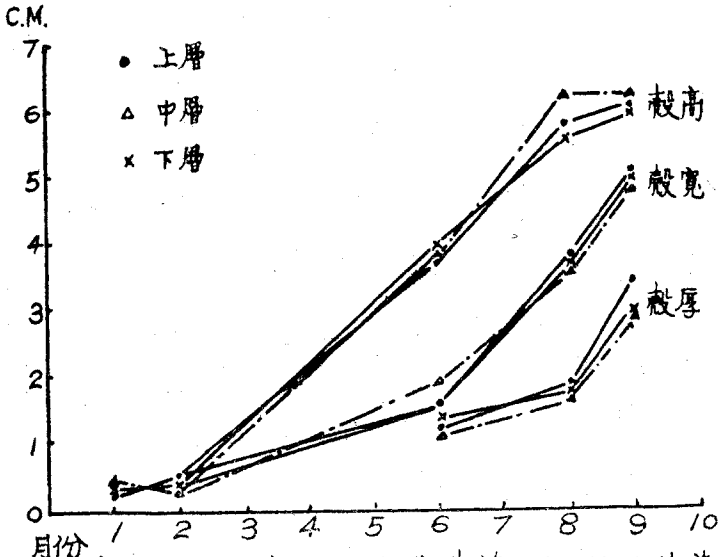


圖 21. 1967年12月布袋港第四站採苗並養殖蚵之生長度

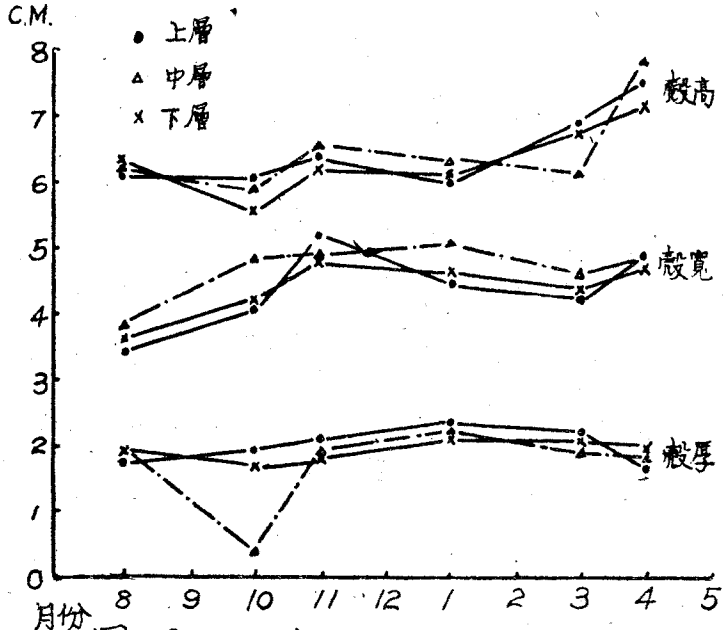


圖 22. 1968年8月將第四站之蚵移往第七站繼續養殖之生長度

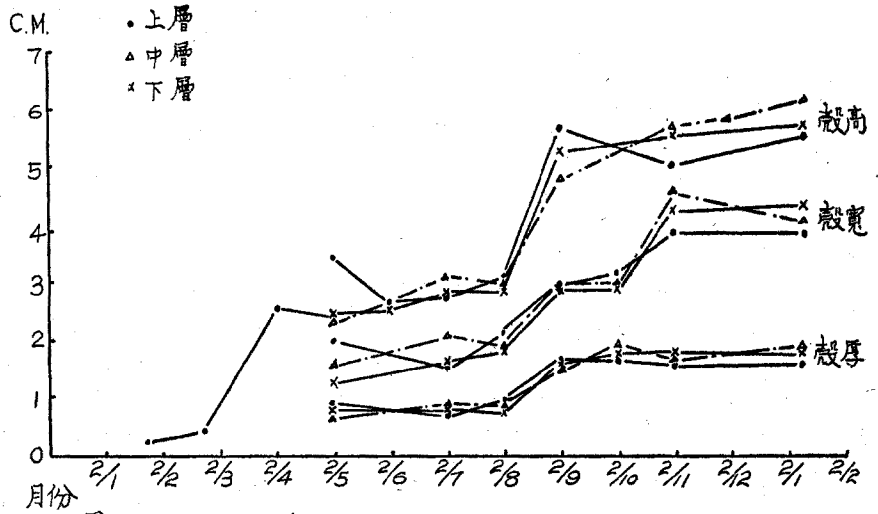


圖 23. 1967年網寮溝第一站採苗並於當地養殖蚵之生長度

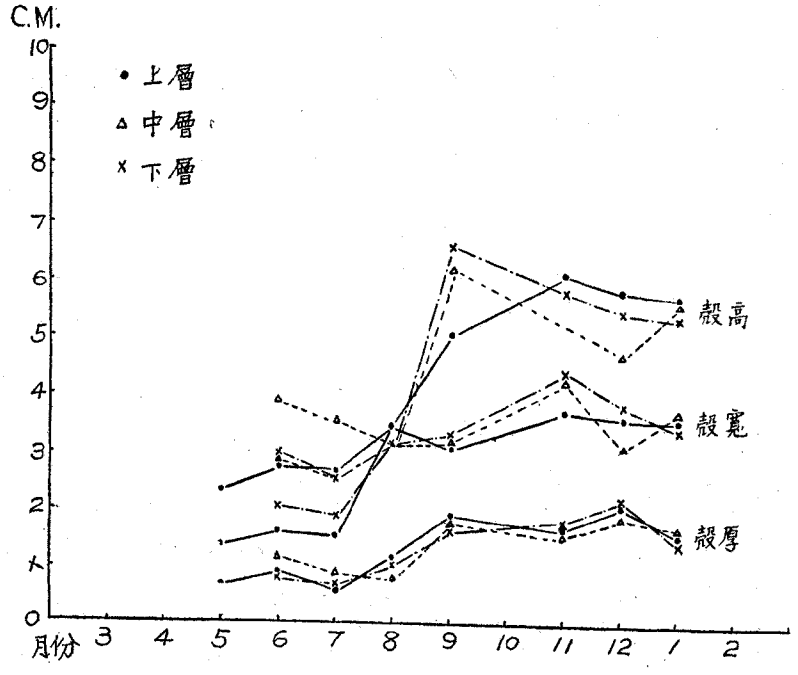


圖 24. 1968年網寮溝第二站
養殖蚵之生長度

別因雨季的緣故淡水過多，大蚵大量死亡，小蚵則忍受淡水能力較强，死亡甚少。此所以10月實施測定時，蚵之平均生長度有變小之現象。10月以後生長情形轉良好，次年1月至3月又形停頓，3月平均殼高爲 5.37～5.88 cm。

以下所述均爲抑制蚵苗的生長度調查：

抑制蚵苗於抑制期間之生長度如圖 26 所示，生長極爲緩慢。所調查之三種抑制蚵苗至，9月12日，平均殼高 A 種爲 2.49 cm、B 種爲 3.01 cm、C 種爲 3.32 cm，但殼增厚並變堅硬。

布袋抑制苗架上之蚵於9月移於鹽水溪養殖其生長度之調查如圖 27、28a 28b 所示。9—11月蚵之平均生長度經測定顯示有轉小現象，其原因乃雨季之來臨鹽度突然降低，大蚵大量死亡。11月至12月則生長迅速，以後又見緩慢，至次年4月中A種抑制苗各層平均殼高爲 4.85～5.36 cm，B種抑制苗 5.32～6.14 cm，C 種抑制苗 5.10～5.37 cm，其中以 B 種抑制苗生長較佳。

10月25日移往鹽水溪養殖之抑制蚵生長度如圖 29、30、31所示。養殖至第二個月（11月25日至12月25日）時，其生長速度最快，A 種抑制苗增大 2.5 cm、B 種 3.01 cm、C 種 2.85 cm，但自12月以後因大蚵死亡，測定之平均生長度反而變小。

1968年9月 A、B、C 三種抑制苗移往布袋港養殖之生長度如圖 32、33、34 所示，成長情形甚差，在 10 至 11 月期間，大蚵死亡，故平均生長度測定亦是變小。除 B 種抑制苗 11 月至12月之間，各層平均殼高增大 1.5 cm，其餘在養殖半年之期間，蚵殼之每月增長平均都在 1 cm 以下，成長甚爲緩慢。

1968年12月28日 B、C 二種抑制苗移往布袋港養殖其生長度如圖 35、36 所示。每月平均殼高增長 1 cm 左右，生長度亦是緩慢。

1968年12月於網寮溝採苗，次年3月移往鹽水溪抑制其生長，該種抑制苗，每日露出時間17小時，其後復於1969年3月1日部份移往布袋港，部份留於本地養殖，其成長情形如圖 37、38 所示。該抑制於移殖時，平均殼高爲 2.26 cm、殼寬 1.81 cm、殼厚 0.93 cm。至6月1日其鹽水溪養殖者，各層平均殼高爲 5.33 cm、殼寬 4.19 cm、殼厚 1.63 cm。而同一批移至布袋港者至6月1日平均殼高 4.20 cm、殼寬 3.06 cm、殼厚 1.41 cm。由上比較可知抑制苗於本地養殖者較移往布袋港者爲佳。

討　　論

1. 生殖腺的發育與排卵

在以上三個試驗區的蚵生殖巢觀察中，可發現當地蚵的排卵時間，不受季節的限制。一年之中，蚵反覆進行生殖腺的發育，成熟與產卵的過程。渡邊（1929～30），松井（1934）亦發現本省蚵是經常處於產卵的階段。筆者 1966 年8月～1967年7月於鹿港及本篇的採苗試驗中，發現本省的蚵苗除夏季外，全年均可附着，此亦可佐證以上的現象。在緯度較高的地區—如日本、美國的養殖蚵，蚵卵巢的肥滿，由春至夏漸行發育，而非反覆進行生殖腺發育。此種現象與水溫有密切之關係。Loosanoff (1937)，發現生殖腺開始發育的最低溫度爲 10°C，且其發育程度與其發育期間的水溫有關。緯度高的地區，蚵在冬季低水溫期蓄積營養的物質，以肝醣方式貯存於消化管周圍的結締組織內。在由春至夏，水溫漸行昇高之同時，肝醣漸轉化而供給生殖細胞的發育，至 6—7 月，生殖巢發育達於高峯。Ogasawara (1967) 認爲本省蚵因經年處於 15°C 之水溫之上，全年均適於生殖腺之發育。蚵於排卵後，吸收之養份直接供養生殖細胞，及後生殖腺肥厚被

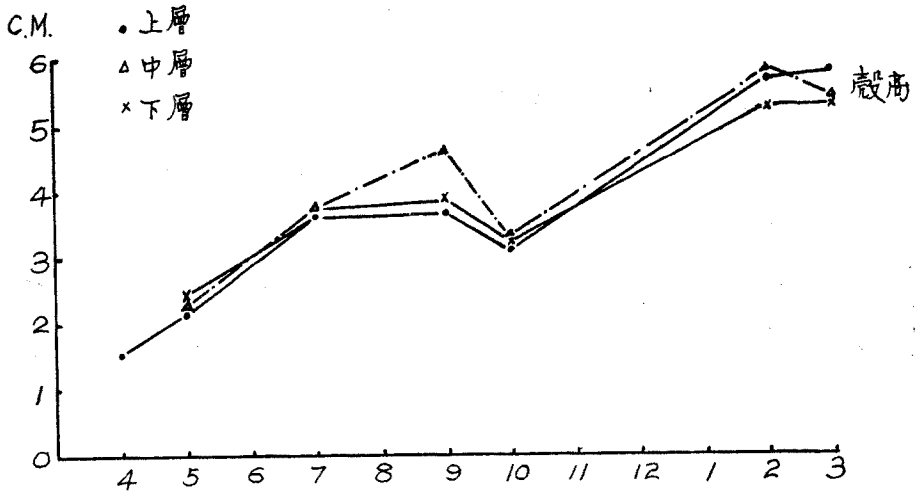


圖 25. 1968年3月網寮溝之普通蚵苗移至鹽水溪養殖之生長度

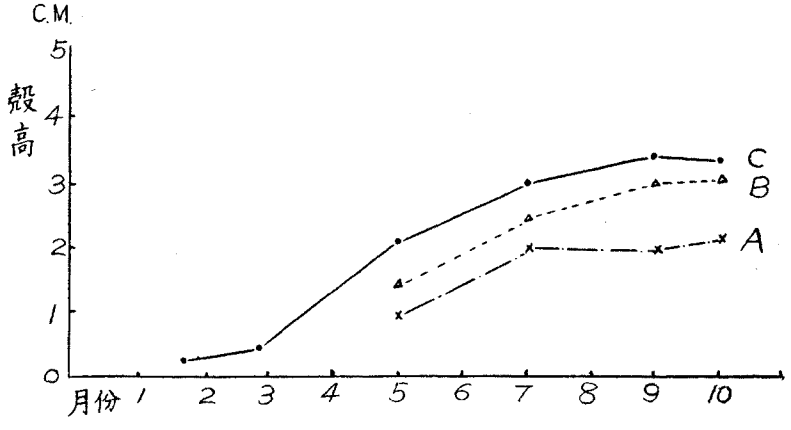


圖 26. A.B.C 三種抑制蚵苗於抑制期間之生長度

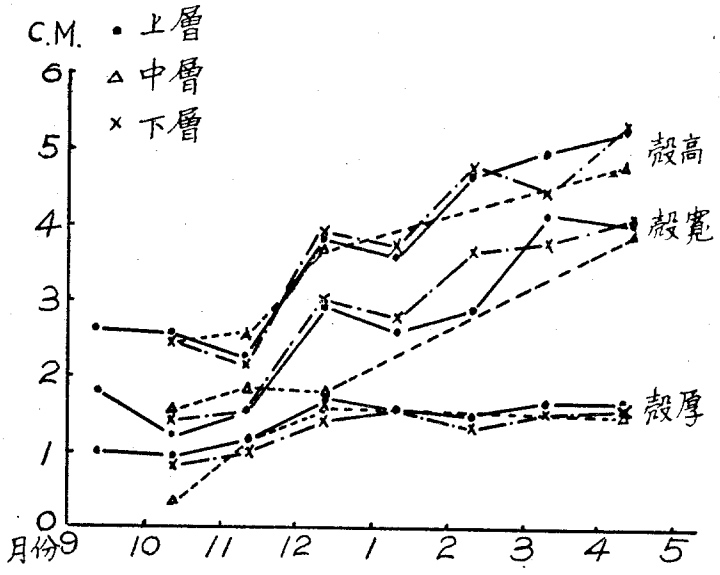


圖 27. 1968年9月A種抑制蚵苗移往鹽水溪養殖蚵之生長度

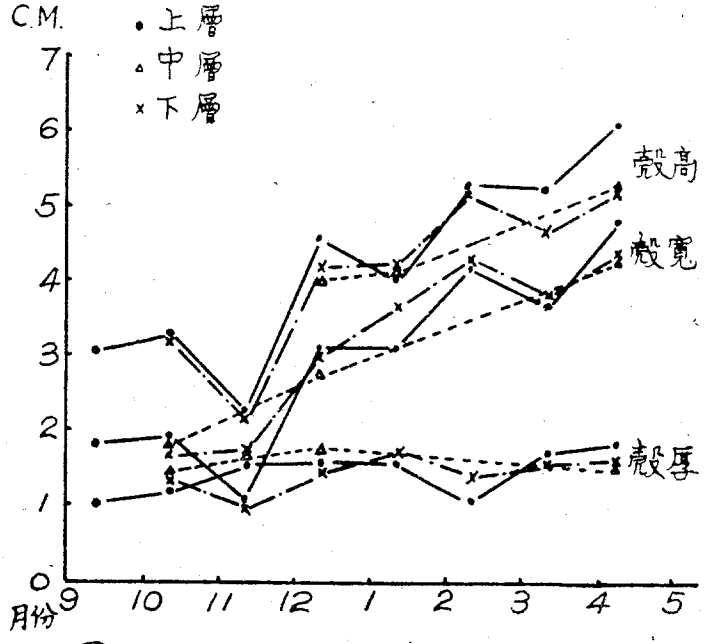


圖 28.a. 1968年9月B種抑制蚵苗移往鹽水溪養殖蚵之生長度

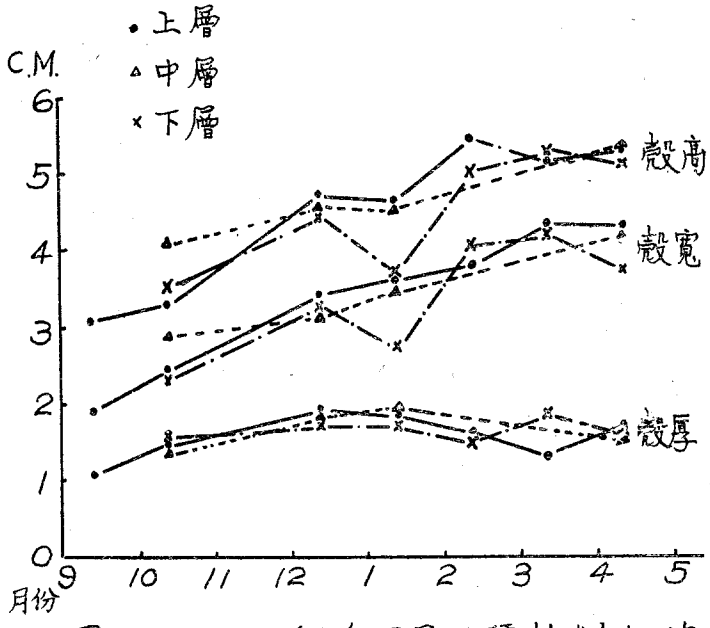


圖 28 b. 1968年9月C種抑制蚵苗移往鹽水溪養殖蚵之生長度

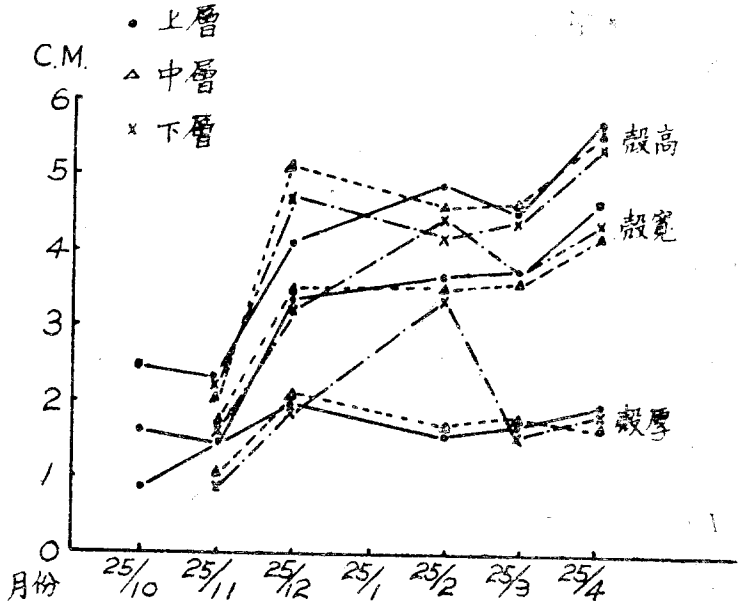


圖 29. 1968年10月25日A種抑制蚵苗移往鹽水溪養殖蚵之生長度

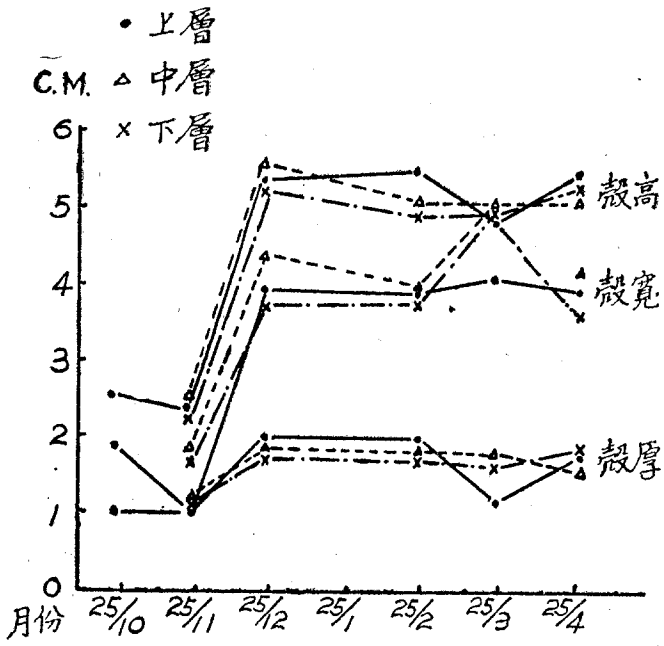


圖30. 1968年10月25日B種抑制蚵苗移往鹽水溪養殖蚵之生長度

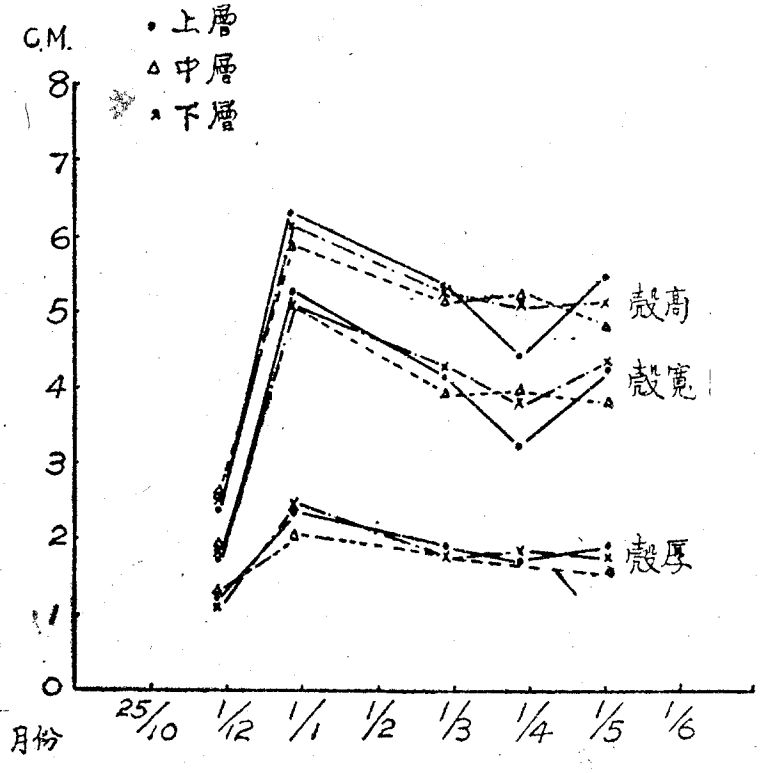


圖31. 1968年10月25日C種抑制蚵苗移往鹽水溪養殖蚵之生長度

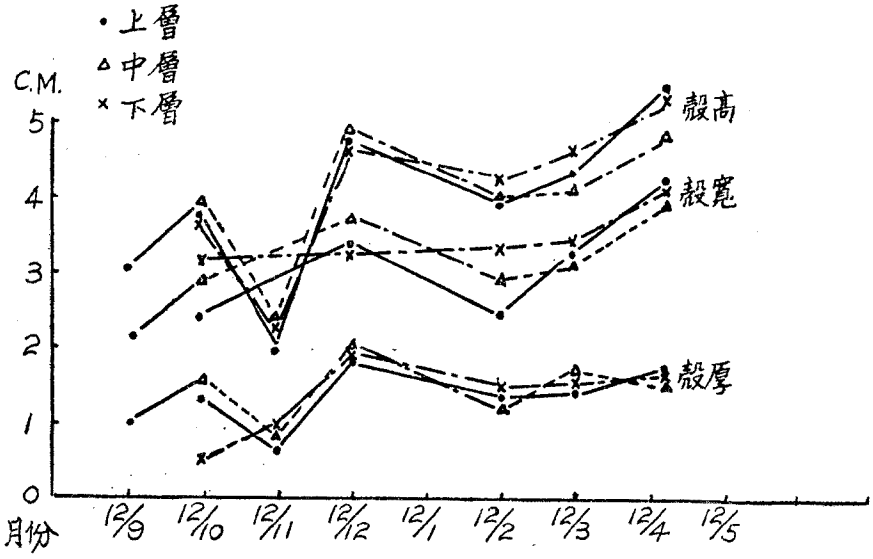


圖32. 1968年9月A種抑制蚵苗移往布袋港養殖蚵之生長度

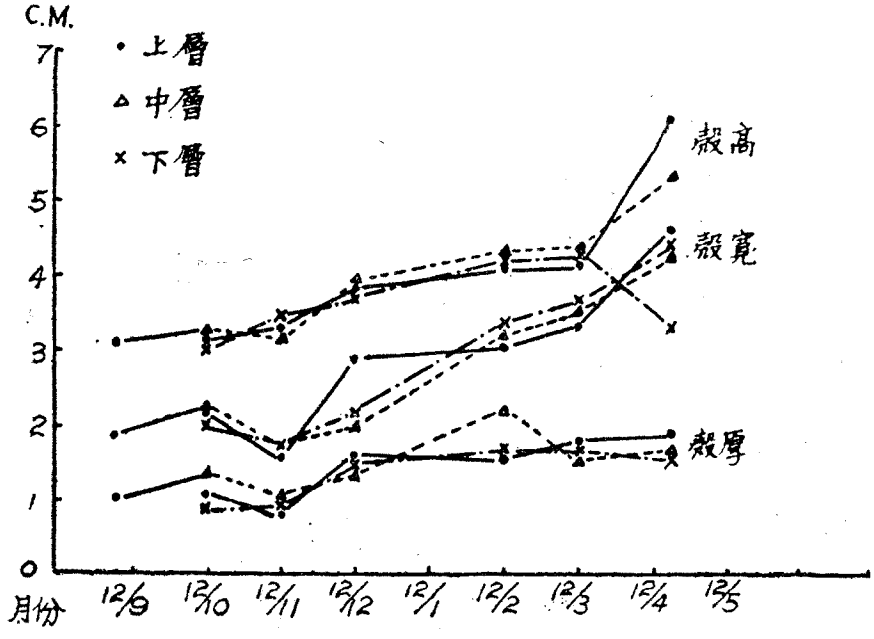


圖33. 1968年9月B種抑制蚵苗移往布袋港養殖蚵之生長度

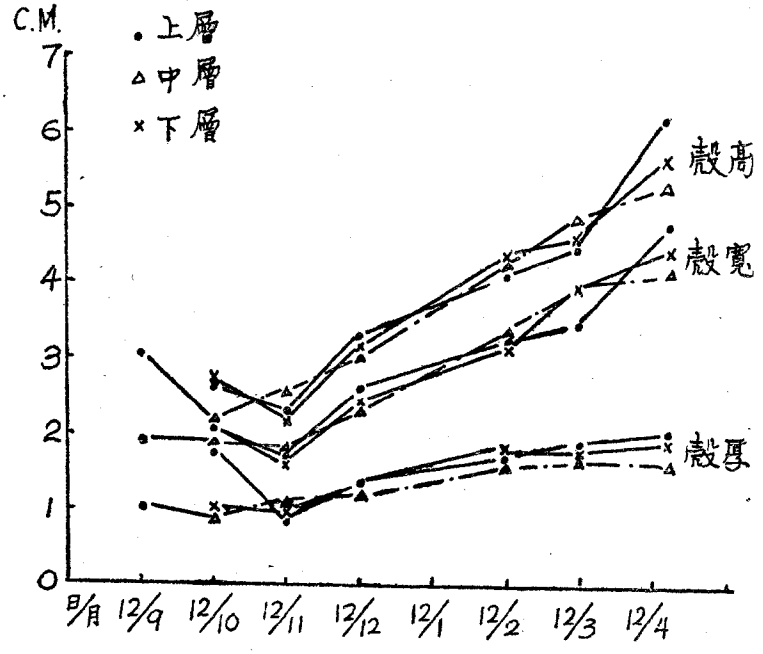


圖34: 1968年9月C種抑制蚵苗移往布袋港第4站養殖蚵之生長度

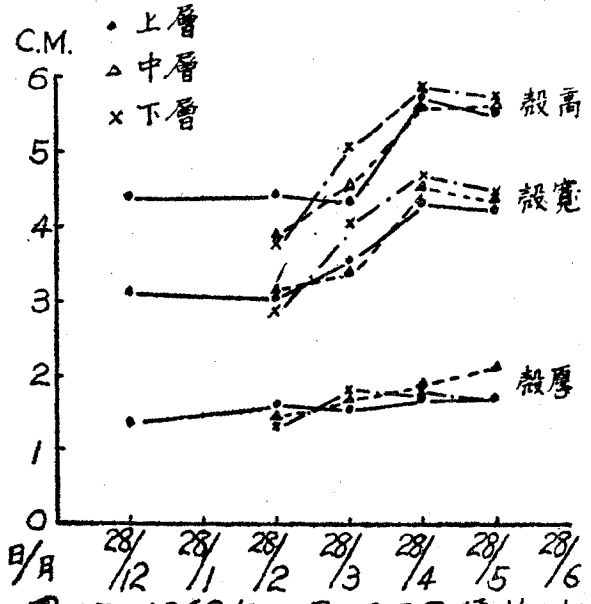


圖35. 1968年12月28日B種抑制苗移往布袋港養殖蚵之生長度

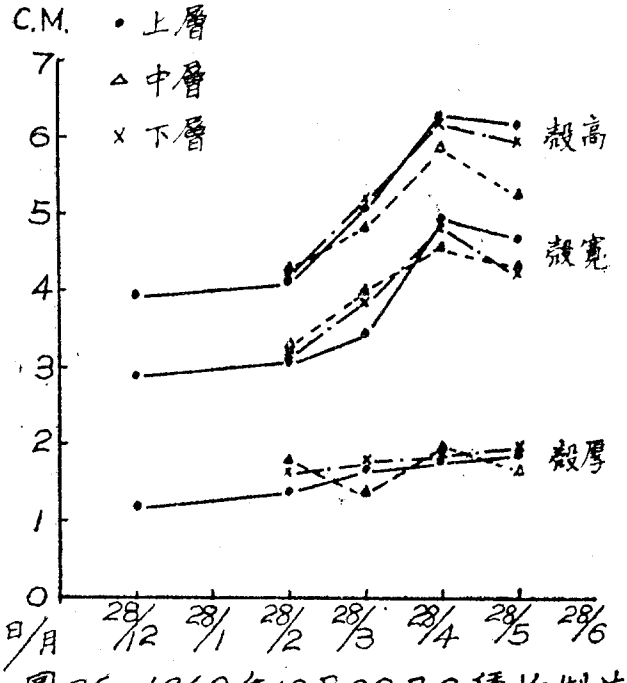


圖36. 1968年12月28日C種抑制苗移往布袋港養殖蚵之生長度

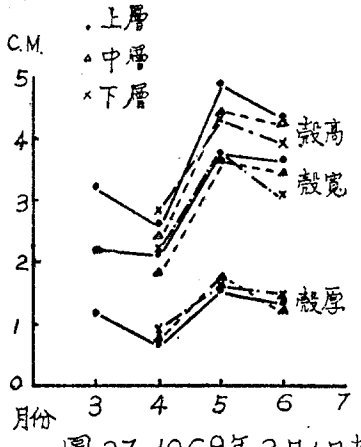


圖37. 1969年3月1日蓬水溪之抑制蚵苗移於當地養蚵架養殖之生長度

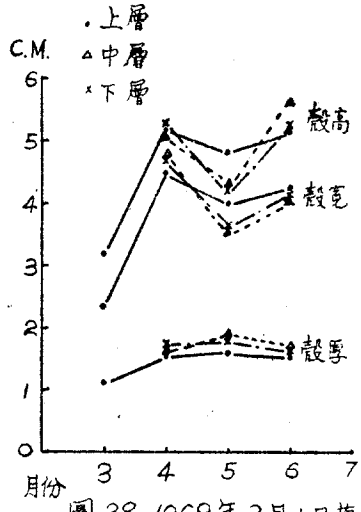


圖38. 1969年3月1日蓬水溪之抑制蚵苗移往布袋港養殖蚵之生長度

覆於體表，俟水溫上昇便可排卵，因此本省蚵之排卵次數比日本或美國地區者爲多。

本省蚵反覆進行排卵的作用，另一原因仍是本省的水溫變化多端。自以上三個試驗區蚵的排卵之時刻與水溫之年變化圖相對照，我們可發現蚵的排卵時刻，絕大部份均在水溫上昇線上。Galtsoff (1940) 於實驗室發現水溫之突然昇高可激發蚵的排卵。Ogasawara (1966) 亦認爲在養蚵場，若當天氣晴朗，尤其是雨後天晴，水溫突然昇高了2～3°C，則蚵必定產卵。但以上的產卵水溫是有限制的。Galtsoff (1930a) 在實驗室中發現 C. gigas 之最低產卵溫度爲 25°C, Elsey (1933) 發現爲 20°C，雨宮 (1933)，籐森 (1929)，Sato (1948) 發現日本的 C. gigas 在日本之產卵最低溫爲 20°C。宮崎一老 (1958) 以本省之 C. gigas 在冬季之實驗室中，水溫 20°C 便可誘使其產卵。本省寒冷期的水溫在 15°C-20°C 之間時，亦有排卵及着苗之現象，故本省養殖蚵在天然狀態下，產卵最低水溫並不以 20°C 爲其臨界水溫。且 Hopkins (1936) 亦曾發現雄性的 C. gigas 在 8°C 便有排精者。

布袋三種抑制種苗於9月12日，10月25日分別移往布袋港、鹽水溪養殖。而於 11 月 24 日調查以上三種蚵苗的卵巢發育狀況，其結果如圖12所示。A、B、C 三種抑制蚵苗在卵巢發育上無甚區別。抑制苗在布袋港養殖一個半月，卵巢發育仍未見發達，而早期移至者其卵巢已甚爲發達。而同一時期移往鹽水溪者，其卵巢則較發達。9 月 12 日與 10 月 25 日移往鹽水溪者，卵巢狀況相近，但其不會達到如普通蚵苗的肥滿。圖 13 爲各批移殖的蚵苗於三個不同時間，調查其卵巢發育之結果。在 11 月 23 的的觀察中，發現 9 月 12 日移殖到布袋港的蚵卵巢發育比 3 月 1 日移殖者要消瘦。但鹽水溪的蚵，3 月與 9 月移殖者無差別，而 10 月 25 日移殖者比 9 月 12 日移殖者要消瘦。

1969 年 3 月29日的觀察中，1968 年3月、9月、10月、12月，移殖的蚵其卵巢之間無差別。但 1969 年 3 月的蚵比前面 4 批蚵的卵巢發育要消瘦。4 月 29 日的觀察中，發現各批蚵苗之間均無差異。由以上可發現一共同現象——便是抑制蚵苗在初養的 1—2 個月內，其卵巢發育要比早期養殖者較消瘦，而此種消瘦時間的長短與養殖地區的水質有關。在 3 月 29 日的觀察便可發現同是 9 月12日移殖的，在布袋港的比鹽水溪者消瘦。

Ogasawara (1962) 的抑制蚵苗試驗中，便發現抑制蚵的卵巢橫切面厚度只有普通蚵的二分之一。由此可見抑制蚵苗生長的作用，是會阻礙卵巢正常的發育。

2. 着　　苗

布袋港與網寮溝，5 至 7 月着苗較少，8 月沒有蚵苗附着，其餘各月着苗均多，此與蚵之排卵多少及當時之水溫，比重等有關。Seno (1926) 發現 C. gigas 之發育適水溫爲 23-26°C 而 29.7°C 及 15.3°C 時只有極少數能够發育至稚貝。雨宮 (1921) 發現 C. gigas 發育可能之比重爲 1.010—1.025 之間，而以 1.014—1.021 發育最爲良好。以上兩地區之夏季水溫在 30°C 左右，比重 1.015 以下不適於蚵幼生之發育，故此段期間蚵縱使大量排卵，亦不一定有蚵苗發生。

自蚵苗附着量來推斷，9 月至次年 4 月均可作爲採苗期，但 9 至 10 月水溫尙高，藤壺附着甚多，影響蚵之生長。3 至 4 月做爲採苗期，又嫌其養殖期間過短，故當地蚵民大都選在 11 月至次年 2 月間採苗。

美國太平洋岸及北歐諸國的海岸水溫全年均低，不適於蚵之排卵，沒有蚵苗發生，故每年均需由他處移殖種苗前往養殖。掘重藏 (1939) 宮崎一老 (1938) 日本只有夏季水溫適於蚵苗之發生，且其蚵苗附着之大發生期甚短，蚵民必須時時注意蚵苗發生期而放下採苗母殼。本省就採苗

而言，天然環境得天獨厚，蚵民祇要在採苗期放下母殼，便不虞沒有蚵苗之附着 。但往往是附苗過多，影響蚵之生長，且至蚵收成期，大蚵易於脫落而得不償失。

3. 肥 滿 度

由於本省蚵之生殖巢發育是由蚵吸收之養分直接供養生殖細胞 ，此與日本蚵在秋冬貯存養分於結締組織 ， 春夏方供養生殖細胞之方式不同 ， 故兩地區蚵之肥滿意義亦復相異 (Ogasawara 1966)。後者之肥滿期是在 12～1 月，蚵養分最充實而且味最佳 。本省蚵由於卵巢肥滿期與產卵期混在一起，因此要生產肥滿度佳而美味可口之蚵，實屬困難（今井 1966）。

蚵之生殖巢重量在產卵前可達肉重之三分之二以上 (Ogasawara 1966)。Imai (1966) 亦發現蚵產卵前 (8 月) 其軟體部肉重爲其 5 月未開始試驗前之 180 %而產卵後則祇有5月時之 54%。

三個試驗區的蚵肥滿指數，其最大值與最小值之比，在布袋港爲 3.37；網寮溝 3.01；鹽水溪 5.53。此說明蚵之肥滿情形變化甚大，故養蚵除考慮到其外殼成長之大小 ，於收成前必須講求蚵之肥滿與否，方能達到最高之經濟利益。故養蚵之原則乃是於高鹽度區，使殼充分長大；而於收成前移往餌料豐富地區養殖，使其飽滿。在排卵前收成，則可達到最高之經濟價值。自肥滿指數調查，亦可知蚵之產卵期；布袋港在 7～10 月期間有 2 次排卵，網寮溝 8 月至 10 月亦有一次排卵，其餘排卵的時間與由卵巢觀察者相一致。

4. 殘存率與死亡率

有關蚵之大量死亡現象，自本世紀以來，世界各大養蚵區便時有發生。廣島養蚵之死亡率在 1946 年爲 70 %， 1948年爲 70—80 % (Ogasawara 1962)， 松島灣 1961—1964 年之死亡率爲 41.6—62.5% (Imai 1965)。死亡期爲 6—10 月上旬，8—9 月爲盛期 (管野 1965)，此與 1967 年布袋港、網寮溝發生死亡之時期相近。在日本發生死亡的原因主要與水質有關。日下部 (1931) 發現水溫 28-30°C，比重 1.023—1.024 蚵便有死亡之危險，比重達 1.0245 則必定受害。但本省蚵在上述情況則不會死亡。 (Seno 1935) 發現低水溫、高比重，或高水溫低比重均不致於引起蚵之死亡。而本試驗區的夏季水溫在 30°C 左右，比重都在 1.020 以下，故 1967 年試驗蚵之死亡殊難歸因於高水溫，高比重之作用。

角皆 (1953) ，Imai (1965) 均發現蚵之死亡率高的地區與蚵成育良好有一致的現象。此點亦與布袋港蚵死亡率之分佈相似。其原因乃是由於成育良好之蚵，勤於排卵，體質變弱，環境一激變，便易引起死亡。

Kanno (1965) 發現蚵死亡率達 60 %以上的地區其底部都顯示出有相當高之有機物，含硫化物，COD。在布袋港筆者於 1968 年 12 月曾測定各養蚵架底質，發現未養蚵區的底質土爲沙質，養蚵架年齡 8 個月者，其底質含 90 cm 的沙泥質。20 個月者，其底層泥質層深 205 cm。32 個月者，底層泥質爲 235 cm。且泥質隨養蚵架愈老而愈細，腐質成分亦較高。蚵之成長情形，以新蚵架者好，死亡率亦以新蚵區較低。Imai (1955～1966) 亦發現養蚵場連年使用，底層腐殖質增加，減低養蚵場之生產力，易引起斃亡發生。1967 年嘉義蚵死亡之原因或與此有關。

1967 年布袋港的試驗蚵，附着有甚多之外界生物，軟體類者有多毛蟲、海鞘、渦蟲。其中渦蟲危害較烈。1965 年自鹿港移往琉球養殖者便因渦蟲與海鞘類之着生 ，養殖 4 個月便大部份死亡 (瀨底正武 1966)。外界生物之附着量依筆者之調查 6 臺養蚵架 ，在布袋港者，其附着重佔全蚵重的 5.4 %，在網寮溝者爲 1.8 %。在 1968 年便甚少渦蟲與海鞘類之發生，當年蚵亦無大

量死亡現象發生。因此渴蟲、海鞘亦可能是造成 1967 年蚵大量死亡原因之一。

鹽水溪於 1968 年 6 月 10 日至 15 日連綿大雨，使海水無法逆流而上，比重降至與淡水同，以後數日比重又行上昇。此種急激之變化使當地蚵致死 37.6%，且死亡的蚵體形較未死者要大，此乃是小蚵的抵抗環境激變的能力較大之故（Ogasawara 1962）。以上這種現象於日本濱名湖的天然灣亦發生過（事業報告 1951、1952）。

依 Ogasawara (1962) 的抑制種苗研究，發現抑制蚵苗的生存率比普通蚵苗要高。且生長速度較大。此種抑制種苗的養殖在日本實施已有十年以上，成果良好。（木村知博 1959）。本省蚵爲避免 1967 年蚵之大量死亡之再發生，抑制種苗之應用，倒不失爲一良策。

5. 生 長 度

C. gigas 的生長情形在 10°C 以下不明顯，其體形增長部份的 75 %是在 15°C 以上 (Shaw 1962) 而各試驗區年水溫均在 15°C 以上，所以全年皆適於蚵之生長。

蚵對鹽度及海水比重適應性皆廣。鹽度在 11～32 ‰，海水比重低至 1.005或高至 1.025，蚵之生長情形均無甚差異（鴨脚 1921）。布袋港之海水比重在 1.011～1.028 之間，鹽度 23～36‰；網寮溝海水比重爲 1.006～1.028，鹽度 13～35 ‰。以上二地區之鹽度及海水比重皆適於蚵之生長。但在鹽水溪因爲雨季來臨時受河川淡水影響，溪水比重降至 1.000 蚵因而停止生長，有時甚至造成大量死亡。鹽度高的海水，鈣含量交稍高。布袋港鈣含量全年平均爲 1.10 g/l；網寮溝 1.11 g/l；鹽水溪 0.94 g/l 以三地區之蚵生長情形亦以鹽水溪最差。Ogasawara (1962) 認爲鹽度高的地區適於蚵殼的生長，此說法與上述之養殖情形相一致。

在布袋港六個養蚵站，以偏居外海的蚵生長較快，此與當地的水流速較大及餌料豐富有關，又蚵成長度以偏居下層最好，其原因仍上層蚵於退潮時會露出水面。普通蚵在 4～7 月生長最速，8 月平均殼高長至 6 cm，自 9～12 月期間生長近乎停頓，其原因可能與當時之高水溫及排卵盛期有關，至次年 1 月便又行增長，4 月時平均殼高達 7.55 cm。日本 *C. gigas* 依 Imai (1961) 之 *C. gigas* 品種試驗，發現廣島灣的 *C. gigas* 在日本各地區養殖9個月其平均殼高在 5～7 cm 之間，且自 9 月至次年 4 月由於水溫低未見長大。Hokkaido 地區 *C. gigas*，在日本各地區養殖 9個月其平均殼高可達 7～9 cm 左右。在 Massachusetts (Shaw 1962) 的 *C. gigas* 養殖 2 年始達 7 cm。故本省蚵之生長速度與日本廣島灣的蚵相近，而比 Massachusetts 的蚵生長要快，但比 Hokkaido 者要慢。而蚵體形之大小依 Imai (1961) 的調查發現眞牡蠣自北而南體形漸變小，其原因與當地之水溫有關。本省偏於亞熱帶，*C. gigas* 終年排卵，吸收之養分大部消耗於卵巢發育，故蚵不易長成大之體形。

因抑制蚵苗之卵巢發育比普通蚵要遲緩及消瘦，故其成長比普通蚵要快 (Ogasawara 1962)。未廣 (1951) 之鯉魚試驗亦發現，當抑制其生長一段時間後，當回復正常環境下時，其生長速度突增。而於本次試驗發現抑制苗 9 月移殖的一批，適逢雨季成長甚差，10 月移殖的一批其第二個月成長特別迅速，但其殼高長至 5～6 cm 後，成長速度便行緩慢。12 月及 3 月移殖者、當體形長至 5～6 cm 以後生長亦開始緩慢。

Ogasawara (1962)發現抑制苗雖具有促進生長迅速之功能，但並不能改善其原有蚵之生長體形大小，在日本抑制蚵長至 8～9 cm 以後，促進生長速度之功能便行消失，此後生長速度便與普通蚵苗相同。本省蚵之體形比日本的要小，故抑制蚵長至 5～6 cm，以後便行停止了。

摘　　要

1. 本省嘉義蚵場，水溫在 16.5-30.5°C 之間，故終年適於蚵卵巢的發育以及排卵。
2. 日本與美國的 Crassostrea gigas 之產卵臨界水溫爲 20°C，但在嘉義養蚵場的蚵，其產卵臨界水溫可能要低些，而在 16-20°C 之間。又每當水溫昇高 2-3°C 時，蚵便會產卵。
3. 抑制蚵苗的卵巢，初期發育比普通蚵苗遲緩。普通蚵苗由消瘦長至肥滿的變化異常迅速，而抑制蚵苗則否。但養殖 2 個月後，其卵巢發育情形與普通蚵苗則完全相同。
4. 布袋港除最熱的季節 8 月外，全年均可有蚵苗附着。每年 9 月至翌年 4 月可作爲本省之採苗季節。
5. 蚵於排卵前後，肥滿度相差甚大，爲達到最高之經濟價值，必須於排卵前收成。
6. 普通蚵於 4～8 月生長最速，9 月至翌年 1 月間生長則近乎停頓。養殖 9 個月殼高可達 6～7 cm，與日本廣島灣蚵之生長速度相近。
7. 抑制蚵苗的成長在抑制期間極爲緩慢，而在養殖初期比普通蚵苗迅速。此種情形僅能維持 2 個月之久。殼高長至 5～6 cm 後，生長速度又見緩慢與普通蚵苗則相同。但由於其可於短期間達到收成之體形，故較具有經濟價值。
8. 1967 年布袋港的蚵有大量死亡現象，至當年 12 月大蚵之死亡率更達 36.8 %。其原因可能與蚵苗的品質，渦蟲之附着，腐殖土中 H_2S 的產生等有關。
9. 1968 年布袋港，網寮溝的蚵未有大量死亡現象發生。但鹽水溪蚵在 5 月時死亡 37.6 %，其原因與水之比重降低至 1.000 有關。
10. 凡蚵生長愈佳之地區，其死亡率愈高，此與其卵巢較發達，及排卵較勤而使蚵之體質變弱有關。

誌　　謝

本文承蒙 繆端生教授、林書顏教授殷切指導策勵，動物系研究所所長 梁潤生教授，水產試驗所所長 鄧火土教授，及日本 小笠原 義光教授之惠賜良多，並承農復會 陳組長同白之推薦，得獲農復會之補助，使本試驗工作，得以順利進行，又於工作期間獲嘉義縣政府水產課陳鴻達先生等之協助，特此深致衷心之謝意。

參 考 文 獻

1. 今井丈夫，伊藤進、中村捷、小野寺弘 • 1957 • 氣仙沼灣蚵養殖場的生態學的研究；環境條件與蚵的生產，氣仙沼灣開發研究會。pp. 1-39。
2. 小島直一、角皆英明 • 1952 • 牡蠣採苗試驗。靜岡縣水產試驗場，事業報告。pp. 135-138。
3. 小島直一 • 1933 • 一年牡蠣養成試驗。靜岡縣水產試驗場，事業報告。pp. 165-168。
4. 妹尾秀實 • 1934 • 三崎灣眞牡蠣斃死的原因及預防方法，動物學雜誌，Vol. 46, No. 545 pp. 76-77。
5. 妹尾秀實 • 1935 • 昭和 9 年度三崎諸磯灣牡蠣的斃死調查，動物學雜誌。Vol. 47, No. 555 p. 111。
6. 瀨底正武 • 1966 • 羽地內海臺灣產牡蠣養殖試驗 (*Ostrea gigas*)，琉球水產研究所，事業報告。pp. 81-93。

7. 瀨底正武 • 1967 • 屋我地村前垣入江臺灣產眞牡蠣（*Ostrea gigas*）養殖試驗，琉球水產研究所，事業報告。pp. 129-137。
8. 田村正 • 1960 • 淺海增殖學，水產學全集 2，恒星社。pp. 182-206。
9. 高槻俊一 • 1949 • 牡蠣，技報堂。pp. 1-262。
10. 角皆英明、阿井敬雄 • 1952 • 蚵種苗比較試驗，靜岡縣水產試驗場。事業報告。pp. 105-111。
11. 掘重藏 • 1938 • 北歐的養牡蠣事業。養殖會誌。Vol. 8, No. 6, 7. p. 70。
12. 野口博、龜井秀雄、角皆英明 • 1950～1951 • 養殖蚵的斃死調查，靜岡水產試驗場，事業報告。pp. 328-336。
13. 野口博、龜井秀雄、角皆英明 • 1950～1951 • 牡蠣採苗試驗，靜岡縣水產試驗場，事業報告。pp. 337-341。
14. 松井魁 • 1933 • 臺灣養蠣業的現況，養殖會誌。Vol. 3. No. 3. pp. 52-55。
15. 松原考之、木村知博、竹本義照 • 1960 • 廣島灣牡蠣養殖調查，廣島縣水產試驗場。事業報告。Vol. 21. No. 1。
16. 宮崎一老 • 1932～33 • 金澤灣牡蠣的斃死。養殖會誌。Vol. 4. No. 22. pp. 17-25。
17. 矢野瀧雄 • 1932 • 眞牡蠣的生殖，養殖會誌。Vol. 2 No. 1. pp. 7-11。
18. 横田瀧雄 • 1936 • 牡蠣幼蟲的附着，養殖會誌。Vol. 5. No. 9-10, pp. 147-154。
19. 横田瀧雄 • 1936 • 牡蠣幼生的附着（補遺）。養殖會誌。Vol. 6. No. 11, pp. 203-206。
20. 渡邊宗童 • 1955 • 臺灣牡蠣養殖之初步研究。中國水產31期。pp. 8-15。
21. 林曜松 • 1968 • 鹿港牡蠣着苗初步調查，臺灣省水產試驗所試驗報告。No. 14. pp. 109-112。
22. Galtsoff, P. S. 1964. The American Oyster *Crassostrea virginica* Gmelin. U.S. Fish. Bull. Fish and wildlife service. Vol. 64. pp. 1 - 480.
23. Hopkins, A. E. 1937. Experimental observations on spawning, larval development, and setting in the Olympia oyster (*Ostrea lurida*). U.S. Bur. Fish. Bull. No. 23. pp. 439 - 503.
24. Ito, S. and Imai, T. 1955. Ecology of oyster bed. 1. On the decline of productivity due to repeated cultures. Tohoku. Jour. Agri. Res. Vol. 5. No. 4. pp. 251 - 266.
25. Imai, T. and Sakai, S. 1961. Study of breeding of Japanese oyster. *Crassostrea gigas*. Tohoku. Jour. Agri. Res. Vol. 12. No. 2. pp. 125 - 171.
26. Imai, T., Numachi, K., Oizumi, J. and Sato, S. 1965. Studies on the mass mortality of the oyster in Matsushima Bay. II. Search for the cause of mass mortality and the possibility to prevent it by transplatation experiment. 1965. Bull Tohoku Region. Fish. Res. Lab. No. 25. pp. 27 - 38.
27. Kan-no, H., Sasaki, M., Sakurai, Y., Watanabe and Suzuki K. 1965. Studies on the mass mortality of the oyster in Matsushima Bay 1. General aspects of the mass mortality of the oyster in Matsushima Bay and its enviroment conditions. Bull. Tohoku Region. Fish. Res. Lab. No. 25. pp. 1 - 26.
28. Loosanoff, V. L. and Engle, J. B. 1940. Spawning and setting of oyster in Long Island Sound in 1937, and discussion of the method for predicting the intensity and time of oyster setting. Bull. Bur. Fish. Vol. 49. No. 33. pp. 217 - 255.

29. Medcof, J. C. 1961., Oyster farming in the Maritimes. Fish. Res. Board. Ottawa. Canada. pp. 1-158.

30. Mori, K., Imai, T., Toyoshima and Usuki, 1. Studies on the mass mortality and the glycogen content of the oyster during the stages of sexual maturation and spawning. 1965. Bull. Tohoku Region. Fish. Res. Lab. No. 25. pp. 65-88.

31. Ogasawara, Y. and Furukawa, A. 1953. Fundamental studies of technique in oyster culture. (1) On size and some observations of the larvae settling. Bull. Naikai Reg. Fish. Res. Lab. No. 5. pp. 21 - 24.

32. Ogasawara, Y., Kobayasashi, Okamoto, R., Furukawa, A., Hiraoko, M. and Nogami, K. 1962. The use of the hardened seed oyster in the culture of the food oyster and its significance to the oyster culture industry. Bull. Naikai Reg. Fish. Research. Lab. No. 19. pp. 1 - 153.

33. Prytherch, H. F. 1929. Investigation of the physical conditions controlling spawning of oysters and the occurrence, distribution, and setting of oyster larvae in harbor. Connecticut. Bull. Bur. Fish. Vol. 44. No. 1054. pp. 429 - 503

34. Seno, H., Hori, J. and Kusakabe, D. 1926. Effects of temperature and salinity on the development of the eggs of the common Japanese oyster, *Ostrea gigas*, Thumberg. Jour. Imp. Fish. Inst. Vol. 22. No. 3. pp. 169-176.

35. Seno, H. and Hori, J. 1927. A new method for the fattening of oyster. Jour. Imp. Fish. Inst. Vol. 22. No. 4. pp. 211 - 261.

36. Sato, S., Kanno, H. and Kikuchi, S. 1960. On the low-salinity, green water and oyster larvae during the seed-oyster-collecting season in Matsushima Bay. Tohoku. Region. Fish. Res. Lab. pp. 87 - 103.

37. Shaw, W. A. 1962. Raft culture of oysters in Massachusetts. Fish. Bull. Fish and wildlife service. Vol. 61. No. 197. pp. 481 - 495.

38. Tanita, S. and Kikuchi, S. 1957. On the density effect of the raft culture oysters. 1. The density effect within one plate. Bull. Tohoku. Region. Fish. Res. Lab. No. 9. pp. 133 - 142.

Notes on Hybridization of Tilapia

By H. Kuo

Director of Lukang Fish Culture Station

In four concrete ponds of 2m × 4.5m with water 30cm in depth, the following combinations of mature *Tilapia mossambica* and *T. nilotica* were placed for normal reproduction and hybridization during the period from April to July 1968. The purpose of this spawning arrangement was to obtain normal offsprings and hybrids at the same time for comparison in pond culture.

Combination 1 — *nilotica* ♀ × *mossambica* ♂
Combination 2 — *mossambica* ♀ × *mossambica* ♂
Combination 3 — *nilotica* ♀ × *nilotica* ♂
Combination 4 — *mossambica* ♀ × *nilotica* ♂

Soon after the above stocking, reproduction occurred and the F_1 offsprings of each crossing were used to stock separate ponds of 600 m^2 with water about 80 cm in depth. The stocking rates and other conditions were as follows:

Pond No.	Type of F_1	Mean wt (g)	Stocking rate fish/m^2	Total wt (g)
1	*n* ♀ × *m* ♂	1.25	1	825
2	*m* ♀ × *m* ♂	1.67	1	1102
3	*n* ♀ × *m* ♂	0.55	1	363
4	*m* ♀ × *n* ♂	0.55	1	363

The following table shows that the F_1 offsprings of *mossambica* ♀ × *nilotica* ♂ have the fastest growth rate and are very promising for use in commercial pond stocking.

Pond No.	1	2	3	4
F_1 (normal or hybrid)	*n* ♀ × *m* ♂	*m* ♀ × *m* ♂	*n* ♀ × *n* ♂	*m* ♀ × *n* ♂
Culture period (days)	122	122	122	122
Total harvest (kg)	59.5	43.5	52.0	90.3
Mean wt (g)	104	72	91	142
Survival rate (%)	87	93	86	97
♀ : ♂ ratio	44:56	49:51	69:31	85:15
Daily growth rate (g)	0.85	0.59	0.74	1.16
Total feedstuff supplied:				
Rice bran (kg)	78	78	78	78
Peanut cake (kg)	114	114	114	114

This hybrid of *m* ♀ × *n* ♂ appears to be more resistant to low temperature than *T. mossambica,* although specific tests remain to be made at different low temperatures.

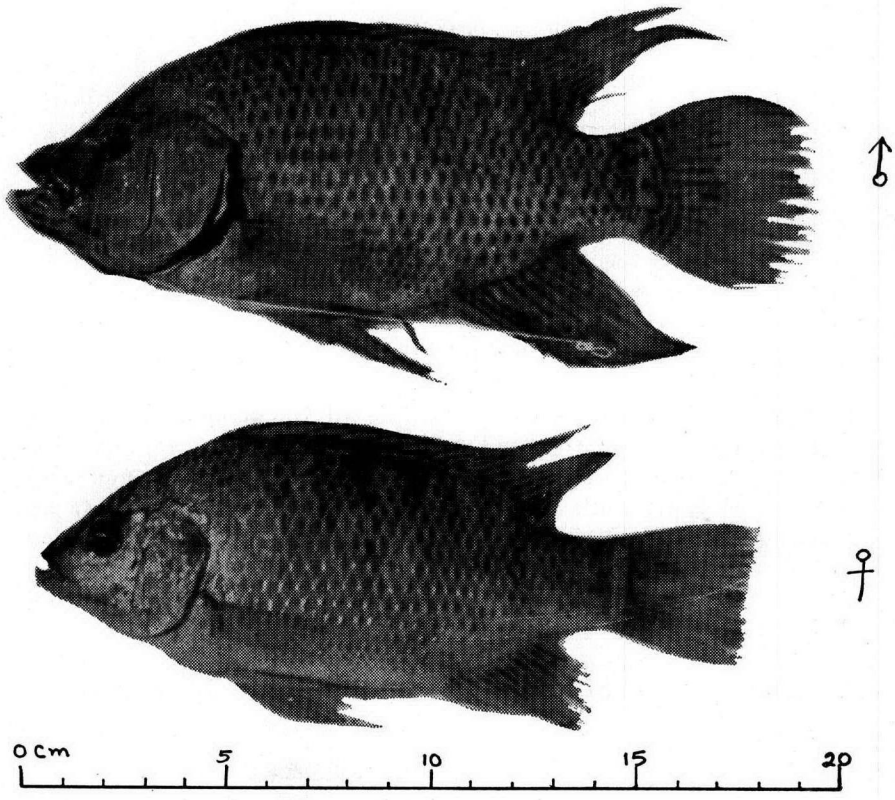


Figure 1. Hybrid of *T. mossambica* ♀ × *T. nilotica* ♂

好必定50%乳劑 (Abate 50% E.C.) 防治虱目魚塭紅筋蟲試驗

Control of Chironomid Larvae in Milkfish Ponds with Abate 50% E.C.

蔡 山 慶 • 黃 丁 郎

By S. C. Tsai

Research Fellow, Rockefeller Foundation

Fish Culture Research Program

and

T. L. Huang

Taiwan Fisheries Research Institute

Abstract

Abate 50% E.C. when diluted 2,000 times with water and then applied to milkfish ponds in quantity that would make up a concentration of 0.05 ppm was found effective for killing all Chironomid larvae at the swath of 10 meters, while the milkfish and bottom algae were safe. Abate 50% E.C. is therefore considered as the most efficient for Chironomid larval control as compared with many others such as Sumithion and Lebaycid which used to be the popular pesticides for application in milkfish ponds.

一、緒　　言

臺灣約 16,000 公頃虱目魚塭，佔世界全部虱目魚塭的 2.5 %，可是由於有獨特的方法，來培養底藻，供給虱目魚生長所須的食料和氧氣，單位面積年產量高達 2.000 公斤／公頃，居世界第一位。不巧的是，在虱目魚的生長季節，每年都發生大量的紅筋蟲〔*Chironomus longilobus* (Kieffer)〕，殘食底藻，使虱目魚產量大幅降低。由於虱目魚塭劇烈的鹽度波動，紅筋蟲的天敵不易養成，加以紅筋蟲深居地下，不易爲魚蝦所掠食，生物防治效果極微。因此，化學藥劑的防治成爲增產所必須的手段，將 50 多種殺蟲劑對紅筋蟲作生物試驗的結果，證明 Sumithion (LC_{50}: 0.027 ppm), Lebaycid (LC_{50}: 0.0085 ppm) 和 Abate (LC_{50}: 0.0025 ppm)，都能有效控制紅筋蟲。尤其是 Abate 是效力最高的殺紅筋蟲劑，實有進一步做田間試驗，以推薦給養殖業者使用的必要。

二、材　　料

好必定 50 %乳劑 (Abate 50% E. C., 0, 0, 0′, 0′—tetramethyl 0,0′-thiodi-p-phenylene phosphorothioate) 及好必定 1 %粒劑 (Abate 1% granule) 及速滅松〔Accothion 1,000E,

0,0-dimethyl 0-(3-methyl 4-nitrophenyl) phosphorothioate〕由美國氰胺公司（American Cyanamid Co.)提供。力拔山〔Lebaycid 50%E. C.0,0-dimethyl 0-(4-methylmercapto-3-methyl-phenyl) thiophosphate〕則由德國拜耳公司（Bayer）提供。供試虱目魚苗係由海濱撈獲之三點花（體長 1.3cm-1.5cm，體重 7.0-11.0mg）經臺南分所蓄養一個月者（體長 6.0cm-6.5cm，體重 2.8gr-3.2gr)。供試紅筋蟲則由魚塭底藻中採選體長在 0.5cm-0.6cm 者供室內試驗之用。

方法：

(1) 好必定 50%乳劑對虱目魚苗之毒性：

在一系列容積 40 公升之玻璃水槽中放置海水 20 公升虱目魚苗 10 隻靜置一天後加入不同濃度之殺蟲劑，放置 72 小時計算死亡率，於 log Concentration-Probit mortality 紙上劃回歸線求 LC_0 及 LC_{50} 試驗中，水溫保持 27°C-28°C。

(2) 好必定 50%乳劑對紅筋蟲之毒性：

在一系列容積 15 公升之玻璃水槽中，置底泥 1.0 公升海水 10 公升體長 0.5-0.6 公分之紅筋蟲 50 隻靜置一天後，加入不同濃度之殺蟲劑，於 72 小時後，計算其死亡率。求 LC_{50} 及 LC_{100}

(3) 好必定 50%乳劑對底藻之毒性：

在一系列3公升燒杯中，各加入 2公升培養液，並接種 0.05cc（濕體積）之藍綠藻（*Lyngbya* sp.）並加入不同濃度之殺蟲劑，培養 5 天後測定各濃度下藻體之乾重。如用 Abate 1% 粒劑則測定其溶氧（D.O.）量及葉綠素量。

(4) 好必定防除紅筋蟲之田間試驗：

將適量好必定 50%乳劑用池水稀釋 2,000 倍後以動力噴霧機或杓子散佈在水面上。經 48 小時後計算死亡率。

三、結　　果

好必定 50%乳劑及粒劑對虱目魚及紅筋蟲之毒性列於表一，目前常用之殺紅筋蟲劑力拔山（Lebaycid）和速滅松（Sumithion）之毒性亦列於表上以資比較。

表一　殺紅筋蟲劑對虱目魚及紅筋蟲之毒性

Table 1: Toxicity of some Chironomid larvicides to milkfish and Chironomid larvae

殺蟲劑 Insecticides	形態 Formulation	虱目魚苗 Milkfish fingerlings		紅筋蟲 Chironomid larvae		安全率 Value of safety factor
		最底致死濃度 LC_0 (ppm)	中央致死濃度 LC_{50}(ppm)	中央致死濃度 LC_{50}(ppm)	最低有效濃度 LC_{100}(ppm)	
Abate	50% E.C.	1.0	2.0	0.0025	0.020	50
Abate	1% granule	70	103	0.013	0.025	2,800
Lebaycid	50% E.C.	0.75	1.7	0.0085	0.020	38
Sumithion	50% E.C.	7.0	11	0.027	0.25	26

上表顯示好必定50%乳劑殺蟲力優於其他三種藥劑，而好必定粒劑對虱目魚苗極安全。

好必定對底藻藥害甚輕，其 50%乳劑對底藻之藥害列於表二

表二　好必定 50%乳劑對底藻之藥害

Table 2: The phytotoxicity of Abate 50% E.C. to a benthic alga

濃　　度 Conc. (ppm)	0	0.20	0.50	1.0	2.5	5.0	10	20	35
底　藻　乾　重 Dry wt. of algae (gr.)	0.38	0.45	0.47	0.35	0.34	0.32	0.31	0.29	0.24

表三　好必定 1%粒劑對底藻之藥害

Table 3: The effects of Abate 1% granule on the growth of a benthic algae

濃　　度 Conc. (ppm)	0	0.1	0.2	0.5	1.0	2.5	5.0	10	20	40	80
溶　　氧 D. O. (ppm)	12.2	11.6	11.0	10.8	10.5	9.6	9.4	8.6	8.4	7.7	6.8
葉綠素之吸光度 OD of chlorophyll solu.	0.32	0.31	0.30	0.29	0.30	0.28	0.24	0.24	0.21	0.05	0.09

好必定 1%粒劑之濃度達 40 ppm 時，底藻完全死亡，但在一般田間用量（0.05-0.06 ppm）時，並無藥害。

田間試驗在安平及臺南五處魚塭舉行。其結果列於表四。用在這個試驗的魚池共有 22 個，總面積75公頃，分爲 A，B，C，D，E 五個系統，A 系統爲安平渡口張老山塭，B 系統係試驗所試驗池，C系統爲臺南協安塭，D系統屬臺南道東塭，E系統爲安平周阿三塭，其面積列於表五。

表五　供試魚塭之面積

Table: 5: The area of the ponds used for the field test

面　　積 Area (ha)	0.35	0.75	1.0–1.9	2.0–2.9	3.0–3.9	4.0–4.9	5.0–5.9	6.0–6.9
池　　號 Pond No.	B_3, B_4	B_1, B_2	D_2, D_3	A_3, A_4 C_4, E_1	A_1, A_2 C_3, C_5 C_7	C_1, C_6 C_8	D_5	C_2, D_1 D_4

好必定 50%乳劑之田間試驗結果列於表四，以 0.050 ppm 之濃度使用，Abate 50% E. C. 可安全殺死池中紅筋蟲，劑型對 Abate 之殺蟲力影響，可由 6 月20日在 B_1，B_2 二池之比較試驗看出。粒劑之效力遠遜於乳劑，此結果與預期粒劑優於乳劑之假定相反。使用動力噴霧器散佈藥液，其效果和使用杓子相差不多，此點可由 6 月 3 日在 B-4 池和 6 月 20 日在 B-2 池之結果顯示出來。7 月 5 日在 D_3，D_4 和 D_5 池的試驗中，顯示 Abate 50% E.C. 在 0.050 ppm 即可殺死池中全部紅筋蟲，而 Sumithion 即使在 0.30 ppm 亦不能全部殺死紅筋蟲。

檢查 A-1，A-2 池，在 6 月22日及 7 月11日之結果，知在 0.05 ppm 以上再加重劑量不能增長有效防治期間。A-1 池於 6 月22日用了 0.070 ppm 之高劑量，但是到 7 月11日，其紅筋蟲密度並不比 A-2 池低。

表四　好必定50%乳劑防治虱目魚塭紅筋蟲之田間試驗結果

Table 4: The results of field tests of Abate 50% E.C. against Chironomid larvae in milkfish ponds

日期 Date day/mon.	池號 Pond No.	濃度 Conc (ppm)	撒佈方法 Application Method	水塭 Water Temp. (°C)	鹽度 Salinity (‰)	水深 Water Depth (cm)	藥量 Dosage (cc/ha)	紅筋蟲密度 Population Density (larvae/m²) Pre-treatment	Post-treatment	防除率 % of Control	備註 Remark
7/5	A-1	0.080	Sprayer	34	54	20	330	4,400	0	100	
8/5	A-2	0.10	〃	35	53	20	400	4,700	0	100	
11/5	A-3	0.060	〃	33	55	20	240	3,300	0	100	
11/5	A-4	0.050	〃	34	50	20	200	2,400	0	100	
31/5	B-1	0.060	〃	31	36	40	480	4,900	0	100	
31/5	B-2	0.040	〃	31	36	40	320	3,800	0	100	
3/6	B-3	0.030	〃	27	34	42	250	14,400	0	100	
3/6	B-4	0.020	〃	27	34	42	168	8,200	300	96	
5/6	A-1	0.040	Scoop	28	32	40	320	5,500	400	93	
6/6	A-2	0.045	〃	28	25	45	405	2,600	0	100	
8/6	A-3	0.050	〃	28	30	42	420	3,500	0	100	
8/6	A-4	0.057	〃	28	28	42	480	4,500	0	100	
11/6	C-1	0.050	〃	32	33	42	420	3,200	50	99	(1)
11/6	C-2	0.050	〃	32	33	40	400	2,650	50	98	(1)
11/6	C-3	0.060	〃	32	33	42	500	1,550	128	92	(1)
20/6	B-1	0.020	Hand	27	24	40	8,000*	4,200	1,500	64	(2)
20/6	B-2	0.020	Scoop	27	25	40	160	6,400	200	97	
22/6	A-1	0.070	〃	26	22	40	560	12,500	0	100	
22/6	A-2	0.050	〃	26	21	40	400	11,000	0	100	
24/6	D-1	0.050	〃	33	26	40	400	4,500	0	100	
25/6	D-2	0.040	〃	35	24	40	320	16,300	200	99	
25/6	A-3	0.050	〃	33	20	40	400	2,800	100	96	
25/6	A-4	0.040	〃	33	21	40	320	3,700	150	96	
24/6	B-3	0.16	〃	34	35	40	1,280	5,200	0	100	(3)
24/6	B-4	0.12	〃	34	33	40	960	6,500	0	100	(3)
24/6	B-1	0.050	〃	36	40	40	400	1,600	0	100	
24/6	B-2	0.070	〃	36	35	40	560	240	0	100	(4)
28/6	C1-8	0.050	〃	32	35	40	400	2,700	0	100	(4)
5/7	D-3	0.30*	〃	30	36	33	990	22,300	1,700	92	(5)
5/7	D-4	0.040	〃	30	36	33	264	4,400	200	96	
5/7	D-5	0.050	〃	31	38	33	330	100	0	100	
10/7	B-3	0.040	〃	34	23	24	193	1,500	0	100	(6)
10/7	B-4	0.030	〃	34	23	25	146	1,900	0	100	(7)
11/7	A-1	0.040	〃	32	31	29	230	92,000	5,700	94	(8)
11/7	A-2	0.030	〃	32	33	29	171	5,700	1,600	72	(8)
12/7	A-3	0.035	〃	31	22	33	264	11,800	1,400	88	(8)
12/7	A-4	0.030	〃	32	32	36	216	19,100	2,700	86	(8)
14/7	E-1	0.050	〃	32	47	30	300	5,800	0	100	
15/7	B-1	0.050	〃	36	34	36	360	1,500	0	100	
15/7	B-2	0.050	〃	36	33	36	360	100	0	100	

*: 8,000 grams of Abate 1% granule is used instead of Abate 50% E.C.

Remarks:

(1) In these ponds, Abate 50% E. C. was diluted to only 600 times rather than the ordinary 2,000 times, and the swath width is 30 meters instead of 10 meters.

(2) Abate 1% granule was used in this pond.

(3) All the sand-shrimps in the screen cages in the ponds were killed.

(4) The density of the Chironomid larvae in these ponds ranged from 1,300 to 4,800 larvae/m²

(5) Accothion 1,000 E. was used instead of Abate 50% E. C.

(6) At this concentration, Abate 50% E. C. was harmless to the sand-shrimps in a screen cage.

(7) 12% of the sand-shrimps in a screen cage died in three days.

(8) These ponds are also stocked with sand-shrimps at the rate of 40,000 fry per hectare. There was no shrimp found dead in the ponds.

表六　好必定 50%乳劑對虱目魚塭中其他魚類及無脊椎動物之毒性

Table 6: The toxicity of Abate 50% E. C. to certain fish and invertebrates in milkfish ponds

學名 Scientific Name	中央致死濃度 LC_{50} (ppm)	學名 Scientific Name	中央致死濃度 LC_{50} (ppm)
Tilapia mossambica	3.5	*Nereis glandicincta*	1.5
Anguilla japonica	7.5	*Berosus afairmaiyi*	0.0080
Mugil cephalus	0.60	Copepoda	0.13
Mugil carinatus	0.023	*Argulus sp.*	0.024
Penaeus monodon	0.045	*Metapenaeus monoceras*	0.32
Neocaridina denticulata	0.045	*Penaeus japonicus*	0.001
Cerithidea cingulata	58		

表六顯示，好必定 50%乳劑可能對防除魚虱（*Argulus* sp），有試驗價值。它對鯔華鯔 (*Mugil carinatus*) 及 *Berosus* sp 毒性相當高，"好必定" 以 0.05 ppm 防除田間紅筋蟲時，該二種動物多被殺死。

Abate 對白鰻 (*Anguilla japonica*) 之毒性甚低，用於養鰻池防治寄生蟲亦值得試驗。

四、結　　論

好必定 50%乳劑經稀釋 2.000 倍後，以池水量之 0.050 ppm 施佈於虱目魚塭，如施布行之幅寬不大於 10 公尺，則可殺死池中全部紅筋蟲。依上用法，虱目魚及底藻不受損害。每年由5月開始至11月爲止，每 15-31 天施用一次。

五、參考文獻

BOWMAN, J. S. and E. J. ORLOSKI, 1966. Abate insecticide residues in streams and ponds treated for control of mosquito larvae. Mosquito News 26(4): 557-561.

BROOKS, G. D., H. F. SCHOOF and E. A. SMITH, 1966. Evaluation of five formulations of Abate against *Aedes aegypti*, Savannah, Georgia, 1965. Mosquito News 26 (4): 580-582.

DOUDOROFF, P. et al, 1951. Bioassay method for the evaluation of acute toxicity of industrial wastes to fish. Sewage and industrial wastes, 23: 1380-1397.

MULLA, M. S., 1966. Toxicity of new organic insecticides to mosquito fish and some other aquatic organisms. Mosquito News 26(1): 87-91.

PATTERSON, R. S. and F. L. WILSON, 1966. Fogging and granule applications are teamed to control Chironomid midges on Florida lakefronts. Pest Control 34(6): 26, 29-30, 32.

TANG, Y. A. and T. P. CHEN, 1959. Control of Chironomid larvae in milkfish ponds. Chinese-American Joint Commission on Rural Reconstruction, Fisheries Series, No. 4, 1-36.

UKELES, R., 1962. Growth of pure cultures of marine phytoplankton in the presence of toxicants. Appl. Microbiol, 10: 532-537.

The Disease Organisms of *Tilapia mossambica*

By Wilson S. Y. Wu

I. Introduction

In the brackish and fresh-water ponds used for fish culture in Taiwan, three types of bacteria are usually found: (1) the naturally occurrng aquatic bacteria, (2) soil dwelling organisms and (3) organisms that normally inhabit the intestines of man and animals. Some of them are beneficial to human beings, but some are pathogens. Some cause the spoilage of fish and food products.

Organisms which cause diseases in fish include: viruses, bacteria, sporozoans and parasites. *Tilapia mossambica* cultivated in south Taiwan often suffers some kind of diseases that cause great loss to fish farmers. The symptoms of the diseased fish are, first of all, the lack of appetite even though the intestine is empty; the fish then begin to swim in an erratic manner with their heads pointing upward toward the surface of water, as if there is a deficiency of oxygen, and finally die. Externally the sick fish shows no special abnormality, but when it is dissected, the liver is found to be abnormal and surrounded by bubbles. Some parts of the intestines are swollen and the intestinal wall tends to become very thin and transparent. The color of the intestine turns pale yellow, somewhat fawn.

II. Method of Collection

1. Water samples were collected from different localities of Tainan and Kao-hsiung counties in 500 ml Erlenmeyer flasks about two feet from the margin of pond. Collections were made once a month from June 1968 to January 1969. The water samples were brought into the laboratory for study.
2. Diseased and healthy samples of the fish *Tilapia mossambica*, were collected and put into plastic bags which were then put into separate vaccum bottles with ice. These samples were dissected as soon as possible, and swabs were taken of their intestinal contents and cultured on agar.

III. Isolation of Organisms

A. Water sample

1. The Miles and Misra surface method was employed, (Miles and Misra, 1938). This method consists of placing very small drops of serial dilutions on the surface of poured agar plates, and the isolated colonies which develop upon the plates are used for study.

2. Pour-plate method

(a) Sterile water blanks were made up to 1/10, 1/100, 1/1,000, 1/10,000 and 1/100,000 dilutions.

(b) A sterile pipette was used for transferring 1 ml aliquots of the diluted pond water to sterile Petri dishes, e.g. 1 ml of the 10^{-5} was mixed in the pipette by sucking up and down to the 1 ml mark 10 times and then discharged into a Petri dish.

(c) With the same pipette 1 ml of the 10^{-4} dilution was transferred to a sterile Petri dish.

(d) In the same way, 1 ml of the 10^{-3}, 10^{-2}, 10^{-1} dilutions and of the original water sample were transferred into sterile Petri dishes.

(e) 15 ml of melted agar at 45°C was added to each plate, and immediately mixed with the medium and inoculum by a combination of circular movements and up and down shaking process lasting for a few seconds. Care was taken to avoid getting the agar on the lid of the Petri dish.

(f) The agar plates were incubated at 30°C for 24-48 hours. Then selected colonies were grown in pure culture on agar slants.

B. Fish sample

Both healthy and diseased fish were dissected in an aseptic cabinet and with the use of a sterilized cotton swab the bacteria were removed from the intestine and liver onto agar plates. Then isolated colonies were obtained by the streak plate method.

IV. Identification

The identification and classification of the bacteria were made according to the Standard Descriptive Chart prepared by the Committee on Bacteriological Technique of the Society of American Bacteriologists.

All culture media used for growing organisms isolated from brackish pond water were prepared by adding 4% sodium chloride. The culture media used for growing organisms isolated from fish and fresh water pond contained 0.5% sodium chloride

V. Inoculation Tests

Three tests were performed on the fish. The first time the fish were transferred to water collected from a pool supplied with water by a fountain and to this water a broth culture of *Streptococcus pyogenes* was added. The second time the fish were transferred to tap water. The third time the fish were placed in the same kind of water as the first, only fish food was prepared by mixing it with

Culture Number	Form of cell	Size of cell (Micron)	Broth	Agar slant
PS 081Y	short rod	0.3×1.2	turbid, highly	abundant white yellow
FS 087	coccus	0.8	turbid	grayish white
FH 090	bacillus	0.5×1.3	turbid	light yellow
PS 093	bacillus	05.×1.9	turbid	white smooth
FS 097	short rod	0.5×1.5	turbid	white yellow
FH 099	bacillus	0.8×3.0	turbid	abundant white rough
FH 101Y	short rod	0.7×1.3	turbid pellicle	gray smooth
FS 106	streptococcus	0.6	sediment	small colony punctiform
FH 113	rod	0.7×1.9	turbid pellicle, sed.	yellow smooth
FS 122	tetracoccus	1.3	slightly turbid	abundant yellow smooth
FS 128	streptococcus	0.6	sediment	small colony clear
FS 130	streptococcus	0.6	sediment	small colony clear
PS 142	short rod	0.8×1.5	highly turbid	abundant moist opaque
PS 144A	short rod	0.7×1.2	highly turbid pellicle	abundant moist opaque
PS 149	short rod	0.8×1.4	turbid pellicle	light yellow
PS 156	staphylococcus	0.9	turbid	abundant light yellow
PS 157	short rod	0.8×1.3	slightly turbid	abundant yellow brown
PS 159	short rod	0.7×1.1	turbid	spread cream yellow
PS 160A	〃	〃	〃	〃
PS 161	rod	0.8×1.2	slightly turbid	moist opaque
PS 163	staphylococcus	0.8	turbid	light yellow
PS 165	bacillus	0.8×2.0	sediment	light orange

Culture Number	Gram Stain	Spores	Motility	Indol	Gelatin Stab	
					Growth	Lique.
PS 081Y	−	−	+	−	+	+
PS 087	+	−	−	−	+	−
FH 090	−	−	−	+	+	+
PS 093	+	+	+	−	−	−
FS 097	−	−	+	−	+	+
FH 099	+	+	+	−	+	+
FH 101Y	−	−	+	+	+	+
FS 106	+	−	−	−	−	−
FH 113	−	−	+	−	+	+
FS 122	+	−	−	−	+	−
FS 128	+	−	−	−	−	−
FS 130	+	−	−	−	−	−
PS 142	−	−	+	−	+	−
PS 144A	−	−	+	+	+	+
PS 149	−	−	+	−	+	+
PS 156	+	−	−	−	+	+
PS 157	−	−	+	−	+	+
PS 159	−	−	+	+	+	+
PS 160A	−	−	+	+	+	+
PS 161	−	−	+	−	−	−
PS 163	+	−	−	−	−	−
PS 165	+	+	+	−	+	+

Culture Number	M—R test	V—P test	Citrate broth	Catalase	Hydrolysis of starch
PS 081Y	−	−	+	+	+
PS 087	+	+	−	+	−
FH 090	+	−	−	−	−
PS 093	+	−	+	+	−
FS 097	−	+	+	+	+
FH 099	+	+	−	+	+
FH 101Y	−		+		
FS 106	−	−			−
FH 113	−	−	+		−
FS 122	−	−	+	−	−
FS 128	−	−			−
FS 130	−	−			−
PS 142	+	−	+	+	−
PS 144A	+	−	+	+	+
PS 149	−	−	+	+	+
PS 156	+	−	+	+	−
PS 157	−	−	−	+	−
PS 159	−	−	−	+	+
PS 160A	−	−	−	−	+
PS 161	−	−	+	+	−
PS 163	−	−	−	+	−
PS 165	−	−	+	+	+

Culture Number	Litmus Milk					
	Acid	Curd	Alkaline	Peptonization	Red	No visible change
PS 081Y			+	+		
PS 087					+	
FH 090				+		
PS 093				+	+	
FS 097				+		
FH 099				+		
FH 101Y	+	+		+		
FS 106	sl.+					+
FH 113	+	+		+		
FS 122						+
FS 128	sl.+					+
FS 130	sl.+					+
PS 142	+			+	+	
PS 144A						+
PS 149	sl.+			+		
PS 156	+			+	+	
PS 157				+	+	
PS 159		+		+		
PS 160A		+		+		
PS 161						+
PS 163						+
PS 165						+

Culture Number	H_2S production	Nitrate		Blood agar
		Nitrite	NH_3	
PS 081Y	−	−	−	
PS 087	+	−	−	
FH 090	+	+	−	
PS 093	+			
FS 097	+	+	−	
FH 099	+	+	−	
FH 101Y	+			
FS 106	−			β type hemolysis
FH 113	−	+	−	
FS 122	−	−	−	
FS 128	−			β type hemolysis
FS 130	−			β type hemolysis
PS 142	−	−	−	
PS 144A	+	+	+	
PS 149	+	+	−	
PS 156	−	+	−	
PS 157	+	+	+	
PS 159	+	+	+	
PS 160A	+	+	+	
PS 161	−	−	−	
PS 163	−	+	−	
PS 165	−	−	−	

Culture Number	Glucose		Lactose		Sucrose		Maltose		Mannitol		Sorbitol	
	Acid	Gas	Acid	Gas	Acid	Gas	Acid	Gas	Acid	Gas	Acid	Gas
PS 081Y	+	−	−	−	+	−	+	−	+	−	+	−
PS 087	+	−	+	−	+	−	+	−	+	−	+	+
FH 090	+	+	−	−	+	+	+	+	−	−	+	−
PS 093	+	−	−	−	+	−	+	−	+	−	−	−
FS 097	+	+	+	+	+	−	+	−	+	−	+	−
FH 099	+	−	−	−	+	−	+	−	−	−	+	−
FH 101Y	+	+	−	−	−	−	+	−				
FS 106	+	−	+	−	+	−	+	−				
FH 113	+	−	−	−	+	−	+	−				
FS 122	−	−	−	−	−	−	−	−				
FS 128	+	−	+	−	+	−	+	−				
FS 130	+	−	+	−	+	−	+	−				
PS 142	+	−	−	−	+	−	+	−	−	−	+	−
PS 144A	+	−	−	−	+	−	+	−	+	−	+	−
PS 149	+	−	−	−	+	−	+	−	+	−	+	−
PS 156	+	−	+	−	+	−	+	−	−	−	+	−
PS 157	−	−	−	−	−	−	−	−	−	−	−	−
PS 159	+	−	−	−	+	−	+	−	+	−	+	−
PS 160A	+	−	−	−	+	−	+	−	+	−	+	−
PS 161	+	−	−	−	+	−	+	−	+	−	+	−
PS 163	−	−	−	−	−	−	−	−	−	−	−	−
PS 165	+	−	−	−	+	−	+	−	+	−	+	−

Culture Number	
PS 081Y	*Flavobacterium marinum*
PS 087	*Micrococcus ureae*
FH 090	*Paracolobactrum coliforme*
PS 093	*Bacillus pumilus*
FS 097	*Aerobacter cloacae*
FH 099	*Bacillus ceteus*
FH 101Y	*Aeromonas punctata*
FS 106	*Streptococcus pyogenes*
FH 113	*Flavobacterium rhenanum*
FS 122	*Sarcina barkeri*
FS 128	*Streptococcus pyogenes*
FS 130	*Streptococcus pyogenes*
PS 142	*Achromobacter superficialis*
PS 144A	*Achromobacter iophagus*
PS 149	*Achromobacter delicatulus*
PS 156	*Micrococcus conglomeratus*
PS 157	*Flavobacterium okeanokoites*
PS 159	*Flavobacterium suaveolens*
PS 160A	*Flavobacterium suaveolens*
PS 161	*Achromobacter guttatus*
PS 163	*Micrococcus colpogenes*
PS 165	*Bacillus subtilis*

the broth culture of *S. pyogenes* rather than mixing it with tap water as we usually do.

On the first trial 8 out of the 13 fish died after 4 to 7 days. On the second trial none of the fish died. The third time 6 out of 7 died after 2 or 3 days. An 18 to 20 hours broth culture of *S. pyogenes* which had been isolated from sick fish was used each time.

Cultures FS 106 and FS 128 came from fish collected in ponds in Tainan city owned by Chao Shau-Lung, and culture FS 130 was from a pond in Kao-hsiung county owned by Mr. Chuang Ho which is located at Hai Shang, Hu Nuei.

VI. Results

The results of all the tests and observations are recorded on the following sheets. Depending on the result of each test and the characteristics of the bacteria, we were able to identify the bacteria by the use of Bergey's Manual of Determinative Bacteriology. The genus and species name of each bacterium is recorded on page 131.

VII. Discussion

The results of the infection tests showed that some fish remained alive each time. This fits well into C. van Duijn's (1966) opinion that some fish possess greater resistance to bacterial infection. This is due to the presence of larger amounts of bactericidal substances in their blood which helps them to overcome infection. But if they are wounded or their resistance is decreased by other causes, then bacterial infection may not be so easily resisted. Most of the bacteria that cause diseases of fish can only attack the fish if the fish have been previously injured or weakened but some bacteria may attack completely healthy fish. Scientists in Russia and Yugoslavia (Pjessov, Goncarov, Tomasec, Ljajman and Spoljaanskaja) have gathered evidence in favour of the opinion that a virus is the primary cause of certain diseases, and the bacteria come into play only as secondary invaders.

On the second test none of the fish showed signs of sickness. This might be because the water which was used to culture the fishes came directly from the faucet. Tap water contains at least 0.8-0.9 ppm of chlorine under which condition most bacteria can not live.

According to the results of our inoculation tests this disease of *Tilapia mossambica* was caused by *Streptococcus pyogenes.*

The probable sources of the contamination of the ponds with these bacteria may have been the application of night soil in the ponds or transmitted by other carriers.

When Mr. Chuang fed his ducks with the untreated diseased fish, after several hours, the ducks all died. Mr. Chao fed the pigs with the boiled diseased fish, and the pigs lived.

VIII. References

1. Ramadan, F. M. (1967). Studies on the growth of group D and other streptococci in different media. J. Appl. Bact. 31: 145-152.
2. Kenner, B. A., Clark, H. F. & Kabler, P. W. (1960). Fecal streptococci II. Quantification of streptococci in feces. Am. J. Publ. Hlth 30: 22
3. Kjellander, J. (1960). Enteric streptococci as indicators of fecal contamination of water. Acta. Path. Microbiol. Scand. Suppl. 138, 48, 111.
4. Ramadan, F. M. & Sabir, M. S. (1963). Differentiation studies of fecal streptococci from farm animals. Can. J. Microbiol. 9: 443.
5. Smith, P. A. & Sherman, J. M. (1938). The haemolytic streptococci of human faeces. J. Infect. Dis. 62: 186.
6. Ferguson Wood, E. J. (1958). The significance of marine microbiology. Bacteriological Reviews, Mar. Vol. 22.
7. Brown, A. D. (1960). Some properties of a Gram-negative heterotrophic marine bacterium. J. Gen. Microb. 23:471.
8. Kazanas, N. (1968). Proteolytic activity of microorganisms isolated from freshwater fish. Applied Microbiology Vol. 16, No. 1.
9. C. van Duijn, Jnr. (1966). Diseases of Fishes 131-178
10. Davis, H. S. (1953). Culture and Diseases of Game fishes.
11. Salle, A. J. (1954). Fundamental Principles of Bacteriology. McGraw-Hill Book Company, Inc.
12. 笠原正五郎：魚病研究 (2), 48 (1967) 。
13. 江草周三：化學と生物 (1967) 5: 406-401
14. 大島泰雄：化學と生物 2: 232, (1964)
15. 保科利一：養魚學第四冊魚病
16. 谷川英一：水產細菌學 584-612. (昭和24年)
17. 柳澤文德：魚介類食中毒と好鹽性細菌 61-131
18. 谷川英一，坂井稔：水產微生物學 (昭和38年)

Recent Publications of Taiwan Fish Culture Research (in English)

Chang, T.P., 1969. Algae of Tainan milkfish ponds. JCRR Fisheries Series No. 7, p. 91-135.

Chen, T.P., 1952. Milkfish culture in Taiwan. JCRR Fisheries Series No. 1, 17 pages.

Huang, T.L., Y.Y. Ting and S.C. Hsieh, 1969: Artificial propagation and culture experiments of *Penaeus japonicus*. JCRR Fisheries Series No. 7, p. 54-67.

Kuo, C.M., I.H. Tung, T.H. Tan and F.H. Liu, 1965. The physiology of some teleost fishes. Part I. Study on the sexual maturity of silver carp (*Hypophthalmichthys molitrix*). Rept. Inst. Fish. Biol., 2 (1):46-52

Liaw, W.K., 1969. Chemical and biological studies of fish ponds and reservoirs. JCRR Fisheries Series No. 7, p. 1-43.

Lin, C.N., 1969. Phosphorus dynamics and primary production in fertilized ponds. JCRR Fisheries Series No. 7, p. 44-53.

Lin, H.S., 1969. Some aspects of milkfish ecology. JCRR Fisheries Series No. 7, p. 68-90.

Lin, S.Y., 1965. Induced spawning of Chinese carps by pituitary injection in Taiwan (a survey of techniques and application). JCRR Fisheries Series No. 5, 31 pages.

Lin, S.Y., 1968. Pond fish culture and the economy of inorganic fertilizer application. JCRR Fisheries Series No. 6, 37 pages.

Lin, S.Y., 1968. Milkfish farming in Taiwan (a review of practice and problems). Taiwan Fisheries Research Institute, Fish Culture Report No. 3, 63 pages.

Lin, S.Y. and T.P. Chen, 1966. Increase of production in freshwater fish ponds by the use of inorganic fertilizers. FAO World Symposium on Warm-water Pond Fish Culture. FAO Fisheries Reports No. 44, 3 : 210-225.

Liu, F.H. and T.H. Tan, 1963. The physiology of reproduction of some teleost fishes. II. Study on the hypophysis of silver carp. Bull. Inst. Zool., Academia Sinica, 2:37-43.

Tang, Y.A., 1954. Effect of soil-fertilization and water fertilization on the production of plankton, bottom organisms and goldfish in ponds. Fish Culture Report No 2, p. 1-10. Taiwan Fish. Res. Inst.

Tang, Y.A., 1954. On the processes and ridges on the pectoral fin rays of the males of *Hypophthalmichthys molitrix* and *Aristichthys nobilis*. Fish Culture Report No. 1, p. 1-12, Taiwan Fish. Res. Inst.

Tang, Y.A., 1961. The use of saponin to control predaceous fishes in shrimp ponds. Prog. Fish-Culturist, 23 (1):43-45.

Tang, Y.A., 1964. Induced spawning of striped mullet by hormone injection. Jap. J. Ichthyol., 12 (1/2):23-8.

Tang, Y.A., 1965. Progress in the hormone spawning of pond fishes in Taiwan. Proc. Indo-Pacific Fish Coun. 11.

Tang, Y.A. and S.H. Chen, 1966. A survey of the algal pasture soils of milkfish ponds in Taiwan. FAO World Symposium on Warm-water Pond Fish Culture. FAO

Fisheries Reports No. 44, 3:198-209.

Tang, Y.A. and T.P. Chen, 1957. The use of chemical fertilizers in the milkfish ponds of Taiwan. JCRR Fisheries Series No. 3, 19 pages.

Tang Y.A. and T.P. Chen, 1959. Control of Chironomid larvae in milkfish ponds. JCRR Fisheries Series No. 4, 36 pages.

Tang, Y.A. and T.L. Huang, 1966. Evaluation of the relative suitability of various groups of algae as food of milkfish in brackish-water ponds. FAO World Symposium on Warm-water Pond Fish Culture. FAO Fisheries Reports No. 44, 3:365-372.

Tang, Y.A., Y.W. Hwang and C.K. Liu, 1963. Preliminary report on injection of pituitary hormone to induce spawning of Chinese carps. Occ. Pap. Indo-Pacific Fish Coun., (63/14):71.

Recent Publications of Taiwan Fish Culture Research (in Chinese)

An, K.L., 1967. Parasites of eel and their control. China Fisheries No. 180, p. 12-13.

An, K.L., 1967. Artificial mixed feed for eel culture. China Fisheries No. 187, p. 10-14.

An, K.L., 1969. Experiments on the control of red fin disease on eel. China Fisheries No. 194, p. 8-10.

Ann, Y., 1956. Effect of urea on *T. mossambica*. Jour. Nat. Sci. No. 7, p. 75-89.

Anonymous, 1964. Artificial propagation of grey mullet by hormone injection. China Fisheries No. 136, p. 2-9.

Anonymous, 1965. Artificial propagation of grey mullet (second report). China Fisheries No. 150, p. 2-4.

Anonymous, 1967. Artificial propagation of grey mullet (4th report). China Fisheries No. 173, p. 2-7.

Anonymous, 1969. Artificial propagation of grey mullet, China Fisheries No. 199, p. 3-9.

Chen, S.H. and Y.Y. Kuo, 1955. The cause of green oysters in Kaohsiung Harbor. Mon. Rep. Taiwan Fish. Res. Inst. 3(10):1-15.

Cheng, C.S., 1968. Artificial propagation of Ayu, *Plecoglossus altivelis*. China Fisheries No. 188, p. 9-17.

Cheng, C.S. and Y.W. Hou, 1965. Reaction of grey mullet fry to salinity and temperature. China Fisheries No. 147, p. 17-18.

Cheng, C.S. and C.S. Hsieh, 1965. Problems of culture, maturation and spawning control of fishes in ponds. China Fisheries No. 149, p. 2-4.

Chiang, Y.M., 1960. Marine algae of northern Taiwan. Taiwan Sci. Rept., Nat. Taiwan University, (7):51-76.

Chiang, Y.M., 1962. Marine algae of northern Taiwan. *ibid.* (8):143-165.

Chiang, Y.M., 1969. Commercial sea-weeds and their utilization. China Fisheries No. 200, p. 2-8.

Chow, T.C., 1956. The effect of temperature on *T. mossambica*. Jour. Nat. Sci. No. 7, p. 105-123.

Chow, Y.W., 1956. The effect of Indole on *T. mossambica*. Jour. Nat. Sci. No. 7, p. 90-104.

Chu, C.H. and C.C. Hsu, 1965. Feeding experiments with yeast and Aureomycin. China Fisheries No. 153, p. 4-7.

Fan, K.C., 1953. *Gracilaria* culture in Taiwan. China Fisheries No. 11, p. 19-21.

Hou, Y.W., 1963. Low temperature tolerance of the sperms of bighead. China Fisheries No. 131, p. 5.

Hou, C.H. and C.S. Chou, 1969. Experiments on hanging method of oyster culture. China Fisheries No. 194, p. 11.14.

Hsu, C.W., 1963. *Gracilaria* culture experiments. China Fisheries No. 121, p. 2-8.

Hsu, S.C., 1967. Some fish culture practices in Changhua county. China Fisheries No. 174, p. 20-22.

Hu, P.C., 1956. Relationship between color pigments and environment. Jour. Nat. Sci. No. 7, p. 124-132.

Huang, C.Y., 1957. Brackish-water pond construction. China Fisheries No. 60, p. 34-36.

Huang, T.L., 1965. Some essential steps in artificial propagation of Chinese carps. China Fisheries No. 156, p. 14-16.

Huang, T.L., 1967. Artificial propagation of crabs. China Fisheries No. 179, p. 2-8.

Huang, T.L., 1967. Artificial propagation of *Metapenaeus monoceros*. China Fisheries No. 180, p. 8-11.

Huang, T.L., 1967. *Tilapia* culture with domestic sewer water. China Fisheries No. 182, p. 12-14.

Huang, T.L. and C.S. Cheng, 1967. Artificial propagation and culture of *Penaeus japonicus*. China Fisheries No. 178, p. 7-20.

Huang, T.L. and C.P. Hung, 1964. Control of fish lice in milkfish wintering ponds. China Fisheries No. 139, p. 11-12.

Huang, Y. W., 1963. Relationship between D.O., pH and algal production in milkfish ponds. China Fisheries No. 130, p. 13-15.

Huang, Y.W., 1965. Factors influencing the growth of oysters. China Fisheries No. 145, p. 4-7.

Kuan, W.H., 1961. *Gracilaria* culture. China Fisheries No. 111, p. 3-9.

Kuo, H., 1964. Artificial spawning of pond silver carp. China Fisheries No. 138, p. 11-12.

Kuo, H. and Y.W. Huang, 1966. Distribution of oyster drill and oyster mortality. China Fisheries No. 164, p. 2.

Lai, Y.S., 1966. Protein digestibility of some milkfish feedstuffs. China Fisheries No. 168, p. 2-4.

Lai, Y.S. and Y.Y. Su, 1967. The efficiency of mixed feed for eel. China Fisheries No. 177, p. 14-17.

Lai, Y.S. and Y.Y. Su, 1967. Second report on mixed feedstuff for eel. China Fisheries No. 179, p. 13-15.

Lai, Y.S. and Y.Y. Su, 1967. Mixed feedstuff for eel experiments (3rd report). China Fisheries No. 182, p. 2-4.

Lai, Y.S. and Y.Y. Su, 1968. Artificial feedstuff for eel (4th report). China Fisheries No. 188, p. 18-21.

Liang, J.K., 1966. Monoculture of shrimp. China Fisheries No. 162, p. 2-5.

Liang, J.K., 1967. Experiments of milkfish stocking rates. China Fisheries No. 178, p. 2-6.

Liang, J.K. and T.L. Huang, 1966. Experiments on control of Chironomid larvae by Sumithion and Nankor. China Fisheries No. 160, p. 5-8.

Liang, J.K. and Y.Y. Ting, 1967. Artificial propagation of shrimps. China Fisheries No. 173, p. 8-10.

Liang, J. K. and Y.Y. Ting, 1967. Further notes on shrimp propagation. China Fisheries No. 174, p. 23.

Liao, I.C., 1969. Feeding of *Penaeus japonicus*. China Fisheries No. 197, p. 17-18.

Lin, C.H., 1956. Physiology of the blood of *Tilapia mossambica*. Jour. Nat. Sci. No. 7, p. 29-63.

Lin, L.T., 1964. Artificial propagation of mud carp. China Fisheries No. 139, p. 13-18.

Lin, M.C., C.S. Cheng and T. K. Ting, 1966. Experiments on seed collecting of *Porphyra*. China Fisheries No. 160, p. 8-12.

Lin, S.S., 1953. The effect of H_2S on aquatic insects. Jour. Nat. Sci. No. 4, p. 27-42.

Lin, S.Y., 1965. Additional notes on the problems of culture, maturation and spawning control of fishes in ponds. China Fisheries No. 149, p. 5-6.

Lin, S.Y., 1965. Freshwater fish pond fertilization. China Fisheries No. 151, p. 2-5.

Lin, S.Y., 1965. On the culture of spawners of grass carp and silver carp. China Fisheries No. 154, p. 2-4.

Lin, S.Y., 1966. Four important points in pond fertilization. China Fisheries No. 160, p. 2-4.

Lin, S.Y., 1966. The importance of phosphorus fertilizer in ponds. China Fisheries No. 161, p. 2-6.

Lin, S.Y., 1966. Sources and cycle of nitrogen in ponds. China Fisheries No. 165, p. 2-7.

Lin, S.Y., 1969. Special nature of Na and K as fertilizers. China Fisheries No. 195, p. 7-8.

Lin, Y.S., 1967. Hanging method of oyster culture. China Fisheries No. 179, p. 16-18.

Lin, Y.S., 1969. On the control and supply of oyster seeds in Taiwan. China Fisheries No. 195, p. 4-6.

Liu, C.K. and S.F. Wu, 1963. Experiments on freshwater pond fertilization. China Fisheries No. 130, p. 4-12.

Liu, C.K., S.F. Wu and S.L. Chiung, 1963. Induced spawning of silver carp and grass carp by Synahorin. China Fisheries No. 132, p. 1-4.

Liu, C.L., 1965. Digestive physiology of *T. mossambica*. Jour. Nat. Sci. No. 7, p. 64-74.

Liu, M.S., 1958. The influence of Folidal, cutting and inserting on the central nervous system of *Cyprinus carpio*. Taiwan Normal University Bull. No. 3, p. 1-32.

Miu, T.S., 1958. The ecological effects of hydrogen sulfide on the freshwater animals in Taiwan. Taiwan Normal University Bull. No. 3, p. 1-26.

Miu, T.S., 1961. On the mechanism of the reproductive habit of *Tilapia*. Bull. Taiwan Fish. Res. Inst. No. 7, p. 1-11.

Miu, T.S., 1966. Ecological studies on pisciculture in Taiwan. Taiwan Normal University Bull. No. 11, p. 1-20.

Miu, T.S. and C.H. Hsu, 1966. The relationship between feeding habit and protein synthesis in fishes. Biol. Bull. Taiwan Norm. Univ. No. 1, p. 12-14.

Miu, T.S. and L.L. Ling, 1966. The effects of ammonia on the growth of *Cobilis taenia* L. Bull. Taiwan Norm. Univ. No. 11, p. 1-10.

Ogasawara, Y., 1967. Present and future of oyster culture in Taiwan. China Fisheries No. 187, p. 2-8.

Tan, K.C., 1956. Physiology of the brain of *Tilapia mossambica.* Jour. Nat. Sci. No. 7, p. 24-48.

Tang, Y.A., 1960. Killing fish with saponin in shrimp ponds. China Fisheries No. 90, p. 2.

Tang, Y.A., 1960. Reproduction of Chinese carps in Ahkuntien Reservoir. China Fisheries No. 96, p. 9-14.

Tang, Y.A., 1961. Reproduction of Chinese carps in Ahkuntien Reservoir. China Fisheries No. 110, p. 2-7.

Tang, Y.A., 1963. Artificial spawning of silver carp, bighead and grass carp. China Fisheries No. 127, p. 3-6.

Tang, Y.A., 1963. Introduction of Channel catfish and *Tilapia zillii* to Taiwan. China Fisheries No. 131, p. 2-4.

Tang, Y.A. and T.L. Huang, 1961. Control of snails and *Nereis* in milkfish ponds. China Fisheries No. 107, p. 11-12.

Teng, H.T., 1963. The ecology of spiny lobster. China Fisheries No. 126, p. 2-3.

Ting, Y.Y. and J.K. Liang, 1967. Preliminary report on the life history of edible shrimps in Taiwan. China Fisheries No. 175, p. 2-7.

Tseng, C.T., 1955. Milkfish pond fertilization experiment. Mon. Rep. Taiwan Fish. Res. Inst. 3(7):1-19.

Tung, I.S., 1959. Migration and fishing seasons of grey mullet, *Mugil cephalus.* China Fisheries No. 84, p. 13-31.

Tung, I.S., 1960. Grey mullet migration and fishing season forecast. China Fisheries No. 95, p. 2-14.

Tung, I.S., 1960. Maturity of grey mullet in the coastal waters of Kaohsiung and Tungkang. China Fisheries No. 86, p. 2-6.

Wang, T.H., 1965. Economic survey of pond culture in Shichiao, Tainan. China Fisheries No. 150, p. 7-8.

Wang, T.H., 1967. Experiment on the fertilization of milkfish ponds with superphosphate and zeolite. China Fisheries No. 172, p. 2-6.

Wang, T.S., 1956. Reproduction of *Tilapia mossambica.* Jour. Nat. Sci. No. 7, p. 4-23.

Wang, Y.W. and T.P. Lin, 1964. Animals in milkfish ponds and their habits. China Fisheries No. 134, p. 24-28.

Wu, C.N., 1968. Anchor worm in ponds belonging to the Taoyuan irrigation system. China Fisheries No. 191, p. 2-9.

Wu, C.Y., 1961. Studies on the acclimatization of loaches in Taiwan. Medical Bulletin 1(1):29-41.

Wu, S.F., 1967. Zeolite application in freshwater ponds. China Fisheries No. 174, p. 18-19.

Ying, T.S., 1963. Soft-shell turtle culture in Taiwan. China Fisheries No. 122, p. 18-22.

Yu, T.C., 1965. Running water eel culture in Lotung. China Fisheries No. 149, p. 7-8.