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Preliminary Report on the Mass Propagation of Grey Mullet, *Mugil Cephalus* Linnaeus

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摘　　要

本省之烏魚人工繁殖試驗，已有八年歷史。1969/1970 年度（即1969年12月至1970年2月間)始告初步成功，共育成431尾魚苗，展示了此魚人工繁殖之可能性。

1970/1971 年度之試驗重點在於大量繁殖，結果共育成7,786尾魚苗，其最高活成率爲 2.23%，較1969/1970 年度之最佳成績提高三倍。1971/1972年度，又繼續是項試驗，進一步育成魚苗 23,695 尾，活存率提高至 3.40%。又1970/1971年度成功了魚塭養成烏魚之人工繁殖，提供解決種魚來源之方法，1971/1972 年度又成功了一次自然受精。至此，本省之烏魚人工繁殖可謂已初步確立了大量繁殖之技術。

Experiments on the artificial propagation of grey mullet have been carried out for eight years during the mullet spawning seasons in Taiwan. Success was first reported in 1969/1970 when a total of 431 fingerlings survived[1], proving the possibility of grey mullet artificial propagation.

In 1970/1971, emphasis of the experiment was placed on mass production. A total of 7,786 fingerlings survived. The same experiment was repeated in 1971/1972 with greater success, producing 23,695 surviving fingerlings, thereby establishing the primary technique for mass production. In addition, induced breeding of pond-reared mullet was done in 1970/1971[2], thus partially overcoming the difficulty of obtaining mature spawners by providing the pond-reared mullet as spawners in the future. In 1971/1972, natural fertilization in tank[3] was successful with the advantage of much saving in time and labor.

Work on the mass production of grey mullet fingerlings in the last two years is summarized in this report.

Material and Method

The spawners were obtained from the mullet that migrate each winter to the offshore waters of Tungkang for spawning. The technicians went to sea to

buy good spawners from the purse-seine fishermen. The spawners were put into plastic bags filled with oxygen and brought back to the stock tanks in the Laboratory.

Hormone treatment was given according to the best method used in past experiments[1), 4)]. The spawners received the first injection within the first hour after being brought back, and the second one 24 hours later. The total dosage of injections for each spawner was 2-6 pituitary glands of grey mullet combined with 10-90 Rabbit Units of Synahorin and 100-300 mg of Vitamin E. Some of the pituitary glands used were from the male and female mature mullets that had just been caught and the rest from the hormone-treated spawners that died after ovulation.

Seasoned sea water was used for hatching. Well-rinsed fertilized eggs were put into 0.5 and 1.0 ton round plastic tanks provided with sufficient aeration and frequent water renewal. Thirty hours after fertilization, the fertilized and the unfertilized eggs could be distinguished. Stirring the tank water by hand, one noticed the fertilized eggs with embryos distributed throughout the water, while most of the unfertilized eggs settled in the center bottom and could be siphoned out.

As for rearing mullet fingerlings, the fertilized eggs were immediately placed in the rearing tanks as soon as they were separated from the unfertilized ones, because the newly-hatched larvae should not be moved during early rearing period. Both plastic tanks of 0.5 ton and large cement tanks (5m × 7m × 1.5m) were used in 1970/1971 for rearing the fingerlings, but only large cement tanks were used in 1971/1972. Temporary warming equipment was used in 1970/1971, while a nursery house was used for this purpose in 1971/1972.

The rearing water used was seasoned sea water with green algae or diatoms added, and gradually freshened. Feeds were modified at different stages of development. Artificially fertilized oyster eggs and larvae were given initially; next rotifers and copepods from fish ponds were fed; then *Artemia* larvae were given; and rice bran was used as feed at the late stage. But egg albumin, fish meal, yeast and dregs from soy fermentation were used in some cases at the initial stage.

Results

In 1970/1971, 11 out of the 28 spawners used ovulated and 39.3% of the eggs hatched. In 1971/1972, 10 out of the 30 spawners produced larvae at the ratio of 33.3% (Table 1).

Table 1. Response of spawners to hormone treatment

Year		Ovulated and eggs hatched	Ovulated but eggs not hatched		No ovulation			Mistaken sex identification	Total
			Natural spawning	Eggs unfertilized	Responded but not ovulated	Died from injury	No response		
1970/1971	Number of treated spawners	11	1	7	4	3	1	1	28
	%	39.3	3.6	25	14.2	10.7	3.6	3.6	
1971/1972	Number of treated spawners	10	2	5	1	6	5	1	30
	%	33.3	6.7	16.7	3.3	20	16.7	3.3	

Three fish spawned naturally in tanks and the eggs obtained were artificially fertilized and hatched.

Tables 2 and 3 show the response of spawners to hormone treatment, ovulation, hatching and survival of fingerlings in 1970/1971 and 1971/1972. Data in Table 3 show that the time needed for response to hormone treatment in 1971/1972 was shorter than that in 1970/1971 (Table 2) and the previous years[1]. The survival rate of fingerlings in 1971/1972 was higher than that in 1970/1971. In the former, the survival rate was 15-20% on the 15th day while in the latter it was below 15%. The pituitary glands from hormone-treated spawners that died after stripping were used to inject other spawners with satisfactory effect on maturation and ovulation as shown by spawner No. 16 in Table 3.

Table 2 shows the results of the 1970/1971 experiment in which seven spawners (excluding one pond-reared mullet) produced fry. 585,480 fertilized eggs from spawners No. 4 and No. 5 were reared in a large cement tank and the survival rate of the fingerlings was 0.44%. 19,300 fertilized eggs from spawner No. 52 were reared in an indoor 0.5 ton plastic tank and the survival rate was 2.23%.

The survival rates in 1971/1972 are shown in Table 3. Three large cement tanks were used for mass production. A survival rate of 3.4% in tank No. 3 was the best record. 358,450 fertilized eggs from spawner No. 5 in tank No. 3 produced 12,181 fingerlings measuring on average 2.49 cm on the 45th day. Next was tank No. 6 in which 1,188,000 fertilized eggs from spawner No. 8 produced 7,056 fingerlings at a survival rate of 0.59%. The lowest survival rate was in tank No. 5 where 1,170,000 fertilized eggs from spawners No. 16, No. 34 and No. 39 produced only 3,243 fingerlings at a survival rate of 0.28%.

Table 2. Size of spawners and their response to hormone treatment, ovulation, fertilization, hatching and number of larvae that survived during rearing in containers of different capacity in 1970/1971

Individual number	Standard length (cm)	Injection				Ovulation		Eggs for hatching			Hatching		Remarks
		1st. injection		2nd. injection		Date	%	Total no. of eggs	No. of fertilized eggs	Fertilization %	Date	%	
		Date	Dosage	Date	Dosage								
3	47.0	19-12-70 12:05	2P+20RU + 150VE	20-12-70 13:12	2P+20RU	21-12-70 12:00 12:44	40 50	1,660,000	914,000	54.40	23-12-70 3:00	95	The belly became swollen at 6:00 on Dec. 21 after the second injection. 465,300 and 448,700 fertilized eggs were put into large cement tanks No. 5 and No. 6 respectively. A better survival rate of 2,025 fingerlings was obtained in tank No. 5 and the survival rate was 0.43%. Rearing water in both tanks was inoculated with *Skeletonema*.
4	38.0	20-12-70 15:08	2P+10RU + 150VE	21-12-70 13:22	2P+20RU	22-12-70 12:55	90	1,002,000	633,600	63.20	24-12-70 2:30	90	The belly became swollen in the morning on Dec. 22 and "water eggs" were released. 329,490 fertilized eggs and some from spawner No. 5 were transferred to large cement tank No. 3. Finally 2,577 larvae were produced at a survival rate of 0.44%. Water was inoculated with *Skeletonema*.
5	41.0	20-12-70 15:12	2P+10RU + 150VE	21-12-70 13:27	2P+20RU	22-12-70 15:18	80	1,068,000	660,000	61.70	24-12-70 2:30	90	The belly became swollen in the morning on Dec. 22. 255,990 fertilized eggs were transferred to large cement tank No. 3 and 267,990 in No. 4. Water in tank No. 4 was mixed with green water, Condition in tank No. 3 was mentioned above.
24	44.0	29-12-70 12:00	2P+10RU + 150VE			30-12-70 13:05	100	746,600	156,500	21.90	1-1-71 7:00	90	The spawner died after being stripped. The eggs in the ovaries were removed and fertilized. All fertilized eggs were transferred to large cement tank No. 6 and only 133 fingerlings were obtained on the 53rd day. The survival rate was 0.08%. Water was mixed with green water.
34	45.0	4-1-71 11:35	2P+10RU + 150VE	5-1-71 10:26	2P+20RU	6-1-71 11:45	95	961,500	500,000	52.00	8-1-71 8:00	95	350,000 fertilized eggs were transferred to Tainan Station and the rest were put into three 0.5 ton tanks. Among them, 241 fingerlings at a survival rate of 0.48% was the best result. Water was mixed with green water.
52	43.2	13-1-71 15:43	2P+20RU + 150VE	14-1-71 12:06	2P+20RU	15-1-71 9:20	90	685,000	230,000	33.50	17-1-71 8:00	90	115,500 fertilized eggs were in 0.5 ton tanks Nos. 1-6 and the rest in Nos. 7-11. Water in tanks Nos. 1, 2, 4, 5, 9, 10 and 11 was mixed with green water but not in the rest. Best record was 430 fingerlings and a survival rate of 2.23% in tank No. 4.
53	43.5	13-1-71 15:49	2P+20RU + 150VE	14-1-71 12:15	2P+20RU	15-1-71 13:50	90	859,500	146,500	16.90	17-1-71 9.00	90	The belly became swollen at 10:00 on Jan. 15 after the second injection. 54,000 fertilized eggs were transferred to large cement tank and the remaining 92,500 eggs were put in 0.5 ton tanks. 248 fingerlings and a survival rate of 0.81% in one tank was the best record. Water was mixed with green water.

Table 3. Size of spawners and their response to hormone treatment, ovulation, fertilization, hatching, and number of larvae survived during rearing in containers of different capacity in 1971/1972

Individual number	Standard length (cm)	Injection				Ovulation		Eggs for hatching			Hatching		Remarks
		1st. injection		2nd. injection		Date	%	Total no. of eggs	No. of fertilized eggs	Fertilization %	Date	%	
		Date	Dosage	Date	Dosage								
5	41.7	21-12-71 15:42	2P+10RU + 100VE	22-12-71 15:36	2P+20RU	23-12-71 12:17	95	1,273,500	358,450	28.15	25-12-71 8:30	95	The second injection made the belly distinctly swollen. Fertilized eggs were transferred to large cement tank No. 3. On the 45th day, 12,181 fingerlings were obtained and transferred to fish pond. Rearing water was inoculated with *Skeletonema* and green water. The survival rate of fingerlings was 3.4%.
8	45.2	25-12-71 11:57	3P+20RU + 200VE	26-12-71 12:12	3P+20RU + 100VE	26-12-71 21:10 23:05	10 80	1,888,110	1,188,000	62.90	28-12-71 19:50	90	The belly became swollen at 9:30 on Dec. 26. Another injection of 50 RU of Synahorin was added at 20:10 on Dec. 26. All the fertilized eggs were transferred to large cement tank No. 6 and 7,056 fingerlings survived 72 days after hatching. Green water was added. The survival rate of fingerlings was 0.59%
16	45.0	30-12-71 10:57	2P+10RU + 100VE	31-12-71 11:34	1P+30RU	31-12-71 14:35	96	1,544,000	869,500	56.30	2-1-72 17:15	90	Solid white discharged matter was found released in the morning on Dec. 31. The pituitary glands for injection were from hormone-treated spawner after being stripped. Fertilized eggs were transferred to large cement tank No. 5. The survival rate was very low. Green water was added to rearing water.
34	40.0	19-1-72 17:00	2P+10RU + 100VE	20-1-72 17:31	2P+20RU + 150VE	21-1-72 14:20	100	849,500	98,000	11.50	23-1-72 18:30	90	The belly became swollen after the second injection and white solid discharged matter was found released at 9:00 on Jan. 21. The fertilized eggs were transferred to large cement tank No. 5. Green water was added.
39	40.7	24-1-72 10:10	2P+10RU + 100VE	25-1-72 10:30	2P+20RU + 100VE	25-1-72 22:10	100	981,000	202,500	20.60	27-1-72 12:30	80	Response was noted after the second injection. All the fertilized eggs were transferred to large cement tank No. 5. Green water was added.

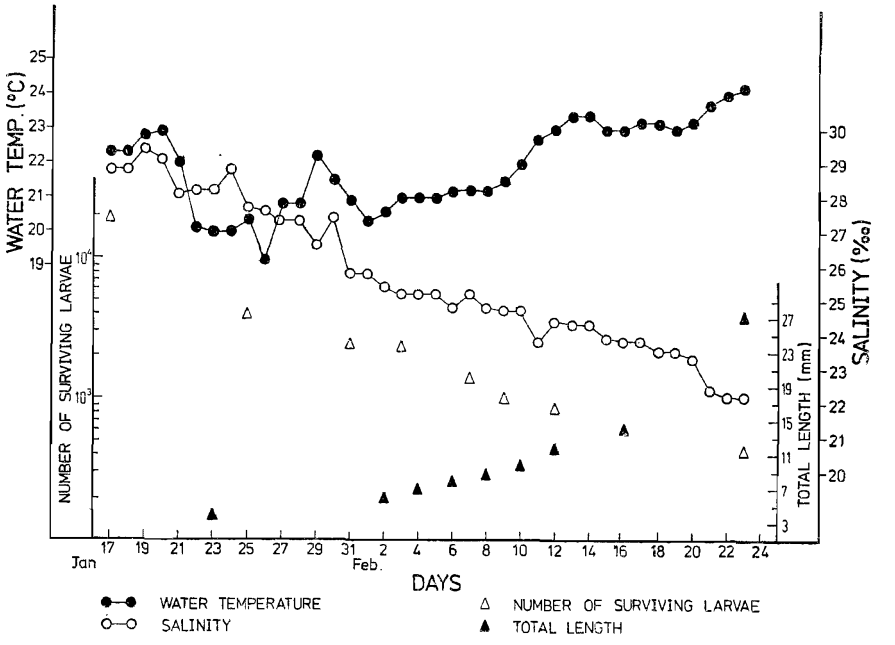

Fig. 1. Water temperature, salinity, number and total length of surviving larvae in 0.5 ton tank in 1970/1971.

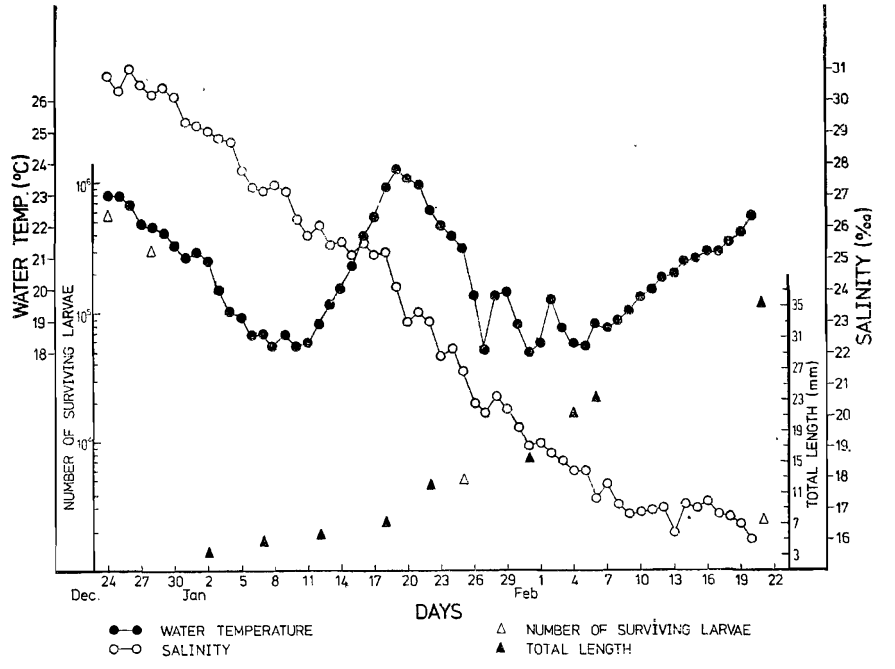

Fig. 2. Water temperature, salinity, number and total length of surviving larvae in large cement tank (5m×7m×1.5m) in 1970/1971.

Rearing of fingerlings in the indoor 0.5 ton plastic tanks and in the large cement tanks is shown in Figs. 1 and 2. The results clearly show that the water temperature in the indoor 0.5 ton plastic tanks was steadier than in the large cement tanks with temporary warming equipment. Water temperature in the large cement tanks in the nursery house built for the experiment in 1971/1972 was even steadier (Figs. 3 and 4). Gradual freshening of sea water did not vary much in the two years. The growth rate of fingerlings was about the same, with that in 1971/1972 slightly slower as shown in Fig. 4.

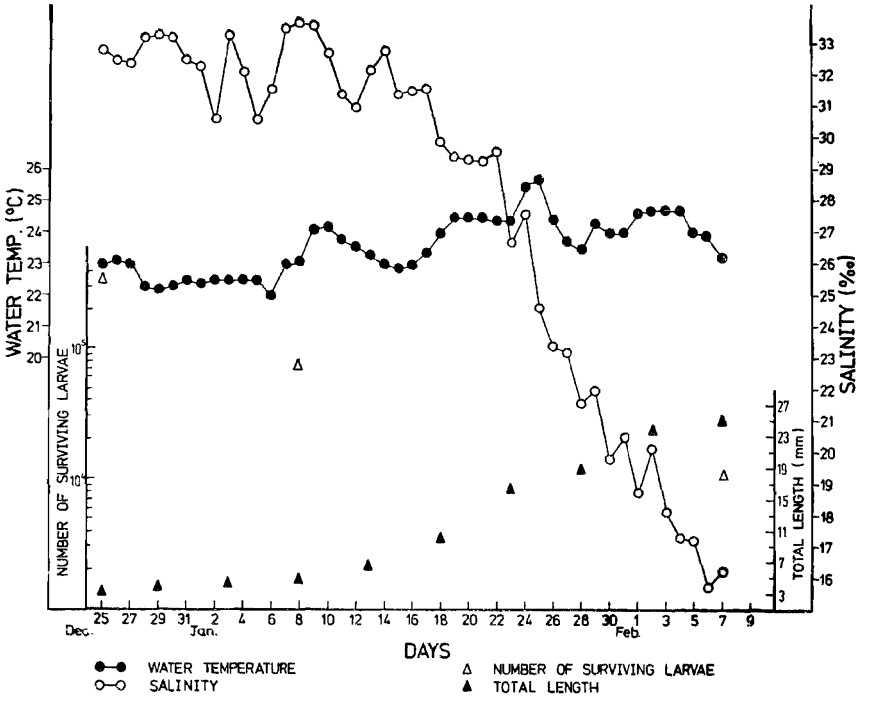

Fig. 3. Water temperature, salinity, number and total length of surviving larvae in large cement tank (5m×7m×1.5m) in 1971/1972.

With regard to feed, more adequate food was given in 1971/1972 than in 1970/1971. *Artemia*, in particular, was often inadequate in the large cement tanks in 1970/1971.

No conclusion was reached in this experiment regarding the effect of green algae or diatoms on the survival rate. All the water used for rearing fingerlings was inoculated with green algae or diatoms.

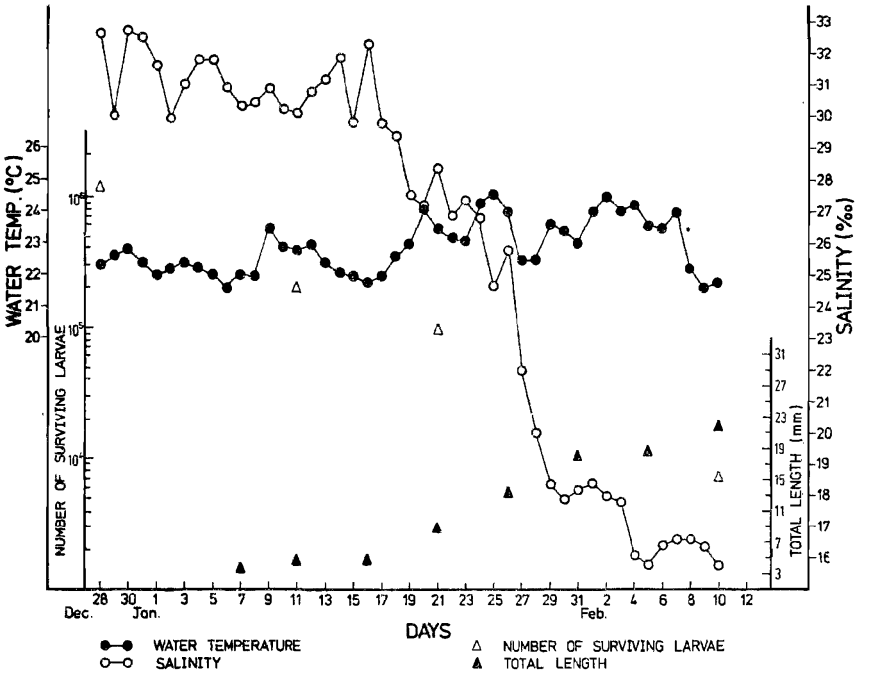

Fig. 4. Water temperature, salinity, number and total length of surviving larvae in large cement tank (5m×7m×1.5m) in 1971/1972.

On the whole, although the mass production experiments in 1970/1971 and 1971/1972, with the benefit of experience, showed progress from year to year, still greater effort is needed to strengthen research and provide millions of mullet fingerlings to fish farmers in Taiwan through artificial propagation.

Discussion

In 1970/1971, the first spawner used for experimentation was obtained on Dec. 18, 1970 and the last one, Jan. 15, 1971; and in 1971/1972, the first one was obtained on Dec. 20, 1971 and the last one, March 2, 1972. Actually, the mullet fishing season started before the acquisition of the first spawner and lasted for some time after the purchase of the last one.

The mullet spawning migration begins early December and lasts till late February or early March. The entire fishing season is about 80 - 90 days, and the time needed for the process of artificial propagation including the acquisition of spawner, hormone treatment and rearing of larvae is about 50 days. There-

fore, if the date of the experiment is advanced, the propagation work could be repeated in one spawning season and each tank could be utilized twice. Since the water temperature at the beginning and end of the spawning season is fairly high, it is advisable to start production early and repeat it later in the season. Besides, if the rearing period is shortened to 30 days to bring the fingerlings to 1.2–1.7 cm before stocking them in fish ponds, mortality could be reduced and every tank could be used three times in one spawning season.

According to the report presented above, the future of mass production of mullet fingerlings is optimistic, but there is another side to our experience. As shown in Table 1, the ratio of spawners that produced larvae in 1971/1972 was 33.3% which was lower than the 39.3% in 1970/1971, which, in turn, was still lower than that in 1969/1970[1]. In 1971/1972, 20% of the spawners died as the result of injury, and this rate was almost double that in 1970/1971. It appears that the likelihood of getting good spawners is becoming less and less due to improvement of fishing technique and the increase in the number of fishing boats. Under such circumstances, only a small part of the mullet school could escape from being caught and migrate to Tungkang's offshore waters, and most of these were either injured or suffered stress which greatly affected their development of ovaries. Recently, sampans fitted with outboard motors extended the fishing activity area thus adding more to the difficulty of getting good spawners.

Next comes the problem of the source of mature male mullets, the ratio of which was 4.6 ♂ : 1 ♀ in the early and mid-period of the spawning season when sexually mature males could be easily obtained. By the end of the season, however, most male mullets were spent. Late in the 1971/1972 spawning season, there was a lack of good male fish with the result that the ovulated eggs could not be fertilized. The same experience was reported in Israel[5]. Although induced breeding of pond-reared mullet is feasible as reported[2], but almost all the large pond-reared fish have been found to be females, and this does not solve the problem. Therefore, the preservation of milt should be studied.

The response to hormone treatment in 1971/1972 was faster than that in 1970/1971 as shown in Tables 2 and 3. The time needed from the first injection to ovulation was 37 hours and 21 minutes and 43 hours and 15 minutes in 1971/1972 and 1970/1971 respectively. The reason for the difference of six hours was the higher temperature of 22.5-24.6°C in 1971/1972 as compared to 19.1-20.1°C in 1970/1971. The hormone dosage of the two years was the same except that the dosage of Vitamin E was slightly higher in 1971/1972 when some spawners were given two

injections of Vitamin E.

As shown in Table 3, in 1971/1972 the pituitary glands from hormone-treated spawners that had died after stripping were used to inject some other spawners with good effect on maturation and ovulation, producing just as satisfactory result as those injected with pituitary glands from live donors. This may be due to the fact that with the fish that had died after stripping, maturation and ovulation were brought about by the injected pituitary. Since the inherent supply of hormone of the spent fish had not been drawn upon, its effectiveness remained intact. However, this remains to be confirmed by histological studies.

The release of 7-8 pieces of white solid discharge usually precedes successful stripping within six hours. It is probably one physiological change within the spawner ready for ovulation. This has not been definitely ascertained and should be studied in the future.

Survival rate in the two years improved. The 1971/1972 record of 3.4% was the best when more feed was given, maintaining the density of rotifera and copepoda at 500-1,000 organisms per liter, this being 10-20 times that in 1969/1970. Two critical periods were reported in previous papers[1)4)], 3-4 or even up to 7-8 days and 11-13 days after hatching when the survival rate was as low as 2% or less. However, in the last two years, the survival rate was higher than 2% and improved to 15-20% in 1971-1972. Whether or not the low survival rate in previous years was due to insufficient feed needs to be studied. The problem of critical periods should also be studied.

Although no conclusion has been reached regarding the function of green algae and diatoms in larvae rearing, the survival rate of larvae in water with inoculated algae was higher than that in pure sea water. But the stomach contents showed that algae were not the main feed for mullet larvae. Thus, it may be concluded that algae only played a secondary role in rearing mullet, fulfilling the function of keeping the water in good condition and indirectly benefiting rearing.

During rearing period, "pop-eye" was found in some of the 14-day old larvae. Both eyes protruded, greatly reducing swimming ability so the larvae floated on the surface of the water most of the time. Experienced fish farmers said that light irritation was responsible for the "pop-eye" phenomenon in milkfish. In recent experiments, lights were often turned on at night for the convenience of examining water quality and feed density. This may be the cause of "pop-eye", but more evidence is needed for a final conclusion. The larvae with "pop-eye" do

not die and they recover after rearing for about 40 days under regular photoperiod in the fish pond.

Fish lice, one kind of parasite, was another problem. Although rotifera and copepoda were carefully checked and examined before feeding, larvae and eggs of fish lice were still introduced. A feasible method of preventing fish lice is needed. Besides, large numbers of the 30-38 day old larvae died in 1971/1972. The cause is not clear. The density of larvae at that time was higher than before. The large amounts of feed given and the faeces excreted might have affected water quality. The pH value was down to 7.7-7.8 even in the case of sufficient aeration. Also, there was not enough fresh water available for renewal. The necessity to freshen rearing water should be studied again. If freshening of rearing water is not absolutely necessary, then sea water can be used for renewal to raise the survival rate for mass production.

The warming equipment used in 1970/1971 was so crude that water temperature fluctuated between 18-23°C, not steady at all. Cold snaps occurred so often that water temperature was once as low as 13°C when many larvae died. In 1971/1972, a nursery house was built to keep the water temperature steady. Unfortunately the gas heater leaked twice, causing the death of many larvae. This was the main reason that only 23,695 larvae were produced in 1971/1972.

Furthermore, the optimum number of eggs for each tank needs to be studied in the future. Either too many or too few would not do. As shown in Fig. 4, 1,188,000 fertilized eggs were put into the large cement tank No. 6 producing 1,069,200 larvae at a hatching rate of 90%. By the 15th day, the survival rate was 18.7% with 200,000 larvae. At this time the water depth was 0.8 m and water volume, 28 tons, at a density of about seven larvae to a liter. The quality of water turned bad soon on account of the excess of feed given. Starting from the 30th day, many larvae died. By the 40th day, the survival rate was down to 0.94%. Finally only 7,056 fingerlings remained.

358,450 fertilized eggs were put into the large cement tank No. 3 producing 12,181 fingerlings. From experience the number of eggs put into each tank should not be too large. This is an important principle. Around the 30th day, part of the larvae could be transferred to another tank to reduce density and prevent unnecessary death. To save labor and attain the highest production, the problem of the optimum number of eggs for each tank must be determined as soon as possible.

In conclusion, 7,786 and 23,695 fingerlings were produced in 1970/1971 and 1971/1972 at 2.23% and 3.4% survival rate respectively. This is some progress.

After stocking in fish ponds for 137 days, the young mullets measured 17.0 cm and the survival rate was 92.9%, almost twice as high as that of fingerlings collected from natural waters. However, more research is needed to devise a more successful mass production program of the grey mullet with the aid of basic physiological and ecological studies.

Summary

The stage for mass production through artificial propagation of grey mullet has now been reached in Taiwan. 7,786 and 23,695 artificially propagated fingerlings were produced in 1970/1971 and 1971/1972 respectively. The primary technique for mass production has been established. The work of the past two years is summarized as follows:

1) In 1970/1971, 11 out of 28 spawners used ovulated and the eggs hatched at the ratio of 39.3%. In 1971/1972, 10 out of 30 spawners produced larvae at the ratio of 33.3%

2) In 1971/1972, the time for response to hormone treatment, i. e. from the first injection to ovulation, averaged 37 hours and 21 minutes, six hours shorter than before. This is because the newly built nursery house helped to maintain a steady water temperature of 22.5–24.6°C, about 3.5°C higher than before.

3) The result of using pituitary glands from hormone-treated spawners that died after stripping to inject other spawners was as good as using those from mature unspent mullet.

4) There is a close relationship between feed density and survival rate. Amounts of feed such as rotifera and copepoda were given in a density of 500–1,000 organisms per liter in 1971/1972, and the mortality during the two critical periods reported in previous papers was not so serious. The survival rate of 15-day old larvae was still maintained at 15–20%, much higher than before.

5) During the rearing process, "pop-eye" was found, but it was not serious. However, fish lice that came mixed with rotifera and copepoda from fish ponds were a serious threat. Remedial measures are needed to keep them out.

6) No conclusion is reached regarding the function of green water. It seems that green water is more important in controlling water quality than as direct feed.

7) In 1971/1972, the survival rate was as high as 9.4% by the 25th day in one tank where there were about 100,000 larvae. Later most of them died leaving only 7,056 fingerlings at a survival rate of 0.59%. This was partly due to the lack of fresh water for renewal. An evaluation of the necessity of salinity freshening should be done. Besides, the optimum number of eggs for each tank should be determined lest too many larvae in one tank cause a low survival rate.

8) 7,786 fingerlings were produced in 1970/1971. The highest record in one large cement tank was 2,577 at the survival rate of 0.44%. 430 fingerlings claimed the highest record for indoor 0.5 ton plastic tank at the survival rate of 2.23%. A total of 23,695 fingerlings was produced in 1971/1972. Large tanks were used and 12,181 was the highest record in one tank at the survival rate of 3.4%.

9) After stocking in fish ponds for 137 days, the young mullets measured 17.0 cm and the survival rate was 92.9%, twice that of the fingerlings collected from natural waters.

Acknowledgement

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臺灣淡水魚池底泥的初步調查

A Survey of the Chemical Properties of Bottom Soils of Freshwater Fish Ponds in Taiwan

江婉 • 趙秦育 • 謝安立 • 徐鴻森

W. Chiang, C. Y. Jaw, A. L. Hsieh and H. S. Shyu

Summary

The purpose of this paper is to present some chemical data on the survey of bottom soils of selected freshwater fish ponds in Taiwan. The bottom soil of fish ponds plays an important role in nutrient supply, since it actively contributes to the nutrients in the water. The preliminary results of the survey are presented here.

Soil texture is classified into eight classes: clay, silty clay, silty loam, silty clay loam, clay loam, sandy loam, sandy clay loam, and loam. The analysis of soil samples for texture indicates that the soil is not homogenous.

The pH value of bottom soil generally ranges from 5 to 7.5 which is considered suitable for nutrient conversion in the water.

The organic matter content of the soil ranges from 0.65% to 10.02%. The total nitrogen content ranges from 0.09% to 0.70%. It has been observed that the higher organic matter content results in higher total nitrogen content.

The total inorganic phosphorus content generally ranges from 141.93 ppm to 2,531.43 ppm. The concentration of calcium phosphorus, iron phosphorus, aluminum phosphorus and soluble phosphorus is 70.34%, 22.81%, 6.62% and 0.23% respectively of the concentration of total inorganic phosphorus. The concentration of phosphorus in the bottom soil influences the concentration of phosphorus in the water.

The average content of sodium ranges from 0.01% to 0.04%, potassium from 0.01% to 0.05%, calcium from 0.03% to 0.6% and magnesium from 0.01% to 0.11%.

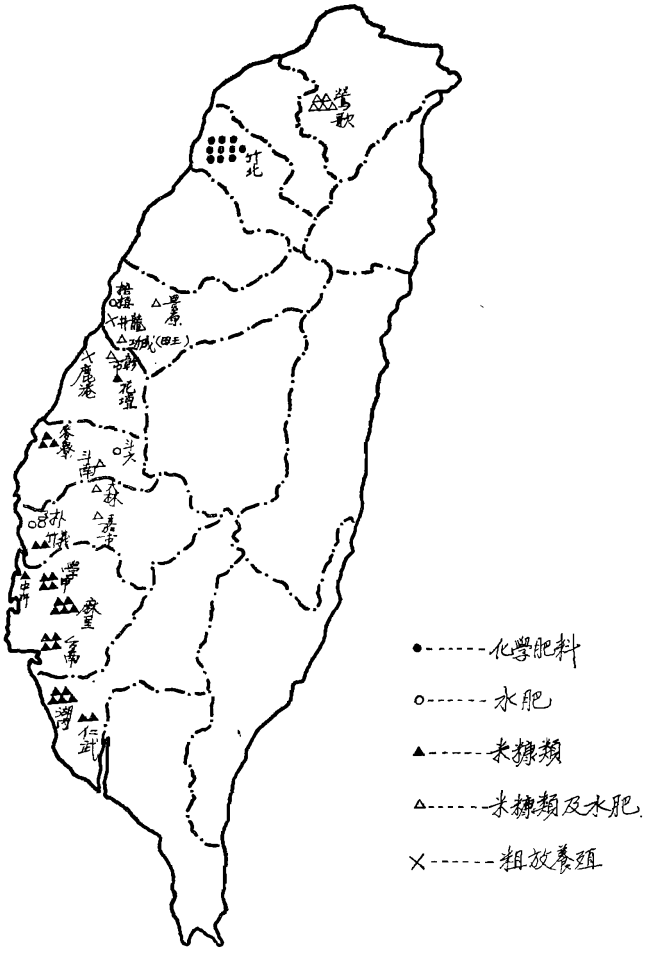
More studies are required for a more adequate interpretation of the relationships among water, bottom soil, food chain, and the most important one, the mineral nutrient cycle in fish ponds.

引　　言

本省淡水養殖漁業在人工繁殖，水質調查，浮游生物等各項研究，都頗有成就，尤其是施肥的研究，但對於各種營養鹽類在水中底泥及各種生物間之關係尚未有所瞭解。基於農田土壤肥料應用及土壤間鹽類的化學變化等經多年研究，對農業助益頗大，筆者等乃在農復會與洛氏基金之支助下從事臺灣淡水魚池底泥調查。

本調查係1971年10月至全省各地逢機選擇魚池，採取底泥樣品，並進行各項分析；目的在知道魚池底泥之物理及化學性質，並與農田土壤比較，進一步的對魚池施肥的生態環境圖有所瞭解。

此次調查採樣的魚池共計54口，包括臺灣北部，中部及南部各地，其詳細位置及施肥情形如圖一所示，全爲草、鰱、鯉等的養殖魚池。魚池年齡則詳見表一。採土時間除竹北各池在1970年7月採取外，其餘各池均於1971年10月至11月間採取。



圖一：採樣之淡水養殖魚池分佈及其施肥概況。

表一、取樣魚池池年齡

池齡	五年以下	5～10年	10～20年	20～50年	50年以上
	臺北鶯歌(5)	臺中王田(1)	新竹竹北(10)	臺中龍井(1)	彰化市(1)
	臺中豐原(1)	嘉義義竹(2)	雲林麥寮(3)	臺中梧棲(1)	彰化鹿港(1)
	雲林斗六(1)	高雄湖內(2)	嘉義市(1)	嘉義大林(1)	彰化花壇(1)
	嘉義朴子(1)		嘉義朴子(1)	高雄湖內(1)	雲林斗南(1)
	臺南學甲(4)		臺南市(4)	高雄仁武(2)	
	臺南麻豆(5)		臺南中州(1)		
	高雄湖內(2)				

註：（ ）內係魚池數目

方　　法

1971 年十月至十一月至臺灣北、中、南部採集飼養草鱵魚之魚池底泥。各魚池均曾施用有機肥，其分佈位置見附圖一。將每一口池均分成 6 區，利用自製採土器（直徑 10公分）分別採取各區底表約10公分厚之泥土，包裝於塑膠袋中，除 pH 值於當場測定外，其他各項帶回臺大湖沼學實驗室，將各池 6 區之底泥均勻混合成二樣品，經風乾磨碎過 2 mm 篩處理，再做下列各項測定：

1. 質地 (Texture)：測定底泥中所含不同大小顆粒之組成，依美國農部分級標準分爲砂粒 (Sand, 2mm-0.02mm)，粉粒 (Silt, 0.02mm-0.002mm) 及粘粒 (Clay, 2μ以下)。用比重計法 (Hydrometer method, Black 1965) 測定。
2. pH 值：底泥採上後直接用 E. M. System soil tester 測定。
3. 有機物質 (Organic matter)：以 Chromate method (Modified Walkeley and Black method) 測定。
4. 磷：利用 Flow sheet for soil phosphate system (Jackson 1962) 抽出底泥中之可溶性磷 (Soluble-P)，鈣結合磷 (Ca-P)，鋁結合磷 (Al-P)，鐵結合磷 (Fe-P)，再以 Single solution method (Murphy & Riley 1968) 測得各種磷之含量。
5. 鎂、鈣、鉀、鈉：利用 1N 醋酸銨 (pH=7)溶液抽出這些金屬離子後，以Atomic absorbance spectrophotometer 測定 (Jackson 1962)。
6. 總氮 (Total nitrogen) 用 C.N.Coder (Model MT500) 直接測定。

結果與討論

1. 質地：

土壤質地的疏密與水分的保持，無機鹽類的保持及滲透作用均有密切關係，可反映土壤供應營養鹽類的情形。臺灣省農田土壤之質地共分五等，即粗質地，中粗質地，中質地，中細質地，細質地。其中屬粗質地及細質地者僅佔小部份，大多數均屬中粗質地，中質地與中細質地。新竹、苗栗、斗六等西部海岸一帶屬中粗質地；臺中、嘉義、桃園一帶則屬中質地；東部土壤亦屬中質地；花蓮一帶則屬中細質地或中粗質地。就全省農田而言粗質地與細質地僅佔 2%强，中粗質地則佔36%强，中質地佔43%，中細質地佔19%强 (林家棻 1967)。

魚池土壤經調查結果見圖二及附錄，大別可區分爲八類；粉砂質黏土佔全省淡水魚池33.33%，壤土佔 16.67%，粉砂質粘壤土佔 14.82%，粉砂質壤土佔 12.96%，砂質壤土佔 9.26%，粘土佔 9.26%，另粘質壤土及砂質粘壤土各佔 1.85%。

不同的質地對於魚池中所放養的魚種也有影響，如虱目魚池中爲泥質粘土或粉土時底藻生長好，而質地爲砂土時底藻生長不良，因此可以影響到虱目魚之生產量 (Tang 1967)。

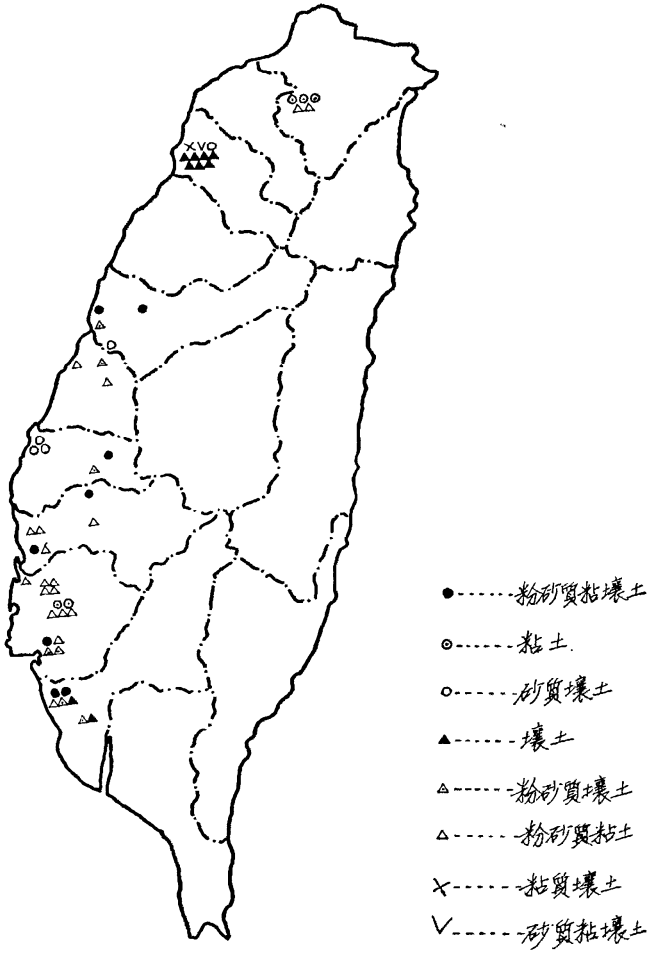
顆粒極小之土質例如粘土對魚池並不適合。又有機物含量超過了底泥所能分解之量時，每年須乾池一次，清除底泥 (Matida 1967)。

至於何種底泥質地對某一魚種較爲適當，目前尚無足够的資料，須待進一步研究。

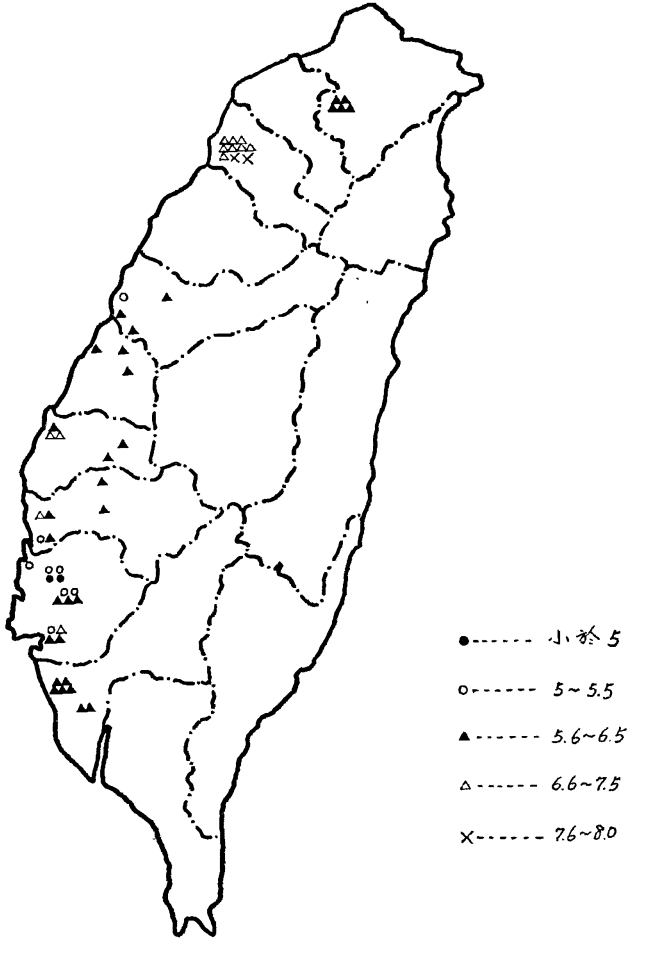
2. 底泥 pH 值：

土壤中所含之膠體粒子如粘粒與腐植質等皆帶負電荷，表面會吸附鈣、鎂、鈉、鉀與氫等帶正電荷之離子，使土壤溶液呈平衡狀態，所以會影響土壤的 pH 值。

在强酸性土壤中 (pH5.6)，其所含鈣、磷的有效性較低而鋁鎂的含量甚高。一般言之，交換性鹽基在酸性狀態下容易洗出。土壤 pH 值達到中性致鹼性反應時，除鉬外，其他微量元素如鋅、銅、鐵、錳與硼的有效性均減低。因此酸性土壤在施用過量石灰時有導致微量元素缺乏之虞。



圖二：淡水養殖魚池底泥質地分佈概況。



圖三：淡水養殖魚池底泥 pH 分佈概況。

臺灣省北部土壤多屬强酸性；臺中以南多屬中性乃至微鹼性；丘陵地則屬强酸性，有些屬中性反應；東北部丘陵地多屬强酸性；蘭陽平原呈中酸性；東部花蓮一帶呈中性至鹼性，也有部份呈微鹼性而臺東多屬强酸性。一般言之，本省農田土壤强酸性佔33.2%，中酸性佔25.2%，中性佔16.0%，微鹼性佔 22.3%，鹼性佔 3.4%（林家棻 1967）。魚池底部土壤的 pH 值經調查得知北部至臺中、彰化、雲林多屬中酸性；嘉義地區魚池部份屬中性或中酸性；臺南除安南外屬中酸性，學甲一帶更低呈强酸性，高雄魚池則呈中酸性。據統計知本省魚池極强酸性佔5.8%，强酸性佔 14.8%，中酸性佔56.3%，中性佔20.6%，微鹼性佔2.4%（圖三及附錄）。

土壤中鹽基之飽和百分度，交換性鹽基之百分比皆會影響到土壤之 pH 值（Lyon 1959）；有機物質在池底無氧狀態下或受微生物等作用分解後產生的有機酸或無機酸會使 pH值降低。又泥土 pH 值並隨季節(乾季時高、雨季時低)及魚池的水量而改變（Tang 1967），時間久後，底池有趨向酸性而致酸度增高之現象(Lyon 1959)。這可能是在實驗結果中多年的老魚池 pH 值較低的原因之一。

3. 底泥有機物質及總氮：

有機物質乃由土壤中所含之腐爛生物及腐植質等經黴(Fungus)，嫌氣性細菌（Anaerobic bacteria）及藻類（Algae）等分解所產生；與土壤中水份的保持及滲透，離子之交換，質地之組成均有關係。一般土壤有機物質大多只存於表層中，含量僅佔 1 %至 6 %，而成分以礦物質爲主，但在湖沼池底泥中有機物質乃由水中沉積而來，所以可高達95%以上，一般約在20—25%至 90—95%之間，平均約80%（Lyon 1959）。各地土壤中所含有機物的性質，變異很大，其碳／氮比例（C/N ratio）與其所吸附之金屬，鹽類也不同；因此僅由有機物質之含量不易了解土壤之性質，也很難作爲施肥之依據。

臺灣農田土壤在桃園以北地區冲積土一帶有機物質含量多屬中或高等級，其他則屬低或極低等，南部地區也屬低或極低等級，而屏東、恆春、潮州一帶屬中等級，東部地區除少數外大多屬中或高等級。就全省土壤而言，約有半數以上地區其有機物含量是在低等以下（林家棻 1967）。

根據本調查，臺北地區魚池有機物質含量屬極低等級，竹北魚池則屬低等級，臺中魚池屬中或高等級，嘉義除少數外屬中或高等級，臺南屬低等級而市區一帶則屬中等級，高雄大部份屬中等級，少數屬高等級。一般而言臺灣淡水魚池屬極低等級者佔3.1%，低等級佔45.7%，中等級佔21.3%，而高等級佔29.9%（圖四及附錄）。

魚池底泥中之氮素，主要由池水中生物之沉澱與施放之氮肥而來。一般施入農田中之氮素需經過微生物之作用，使有機氮發生複雜變化分解而成簡單之胺態氮，氨態氮及硝酸態氮後才能被作物吸收利用。在魚池中底泥所含氮素也需經過相似之變化才能爲藻類所吸收。

本省魚池底泥總氮含量在0.09%～0.70% 之間，其中含 0.1% 以下者佔 1.85%，0.1～0.25% 者佔74.08%，0.26～0.50%者佔 20.3%，0.5%以上者佔 3.7%（圖五）。

土壤中碳氮比常維持一定關係，一般耕作土壤中其比值平均大約在 10～12：1（Lyon 1959）。有機物質與總氮含量之間的關係可以下式表示（圖六及附錄）：

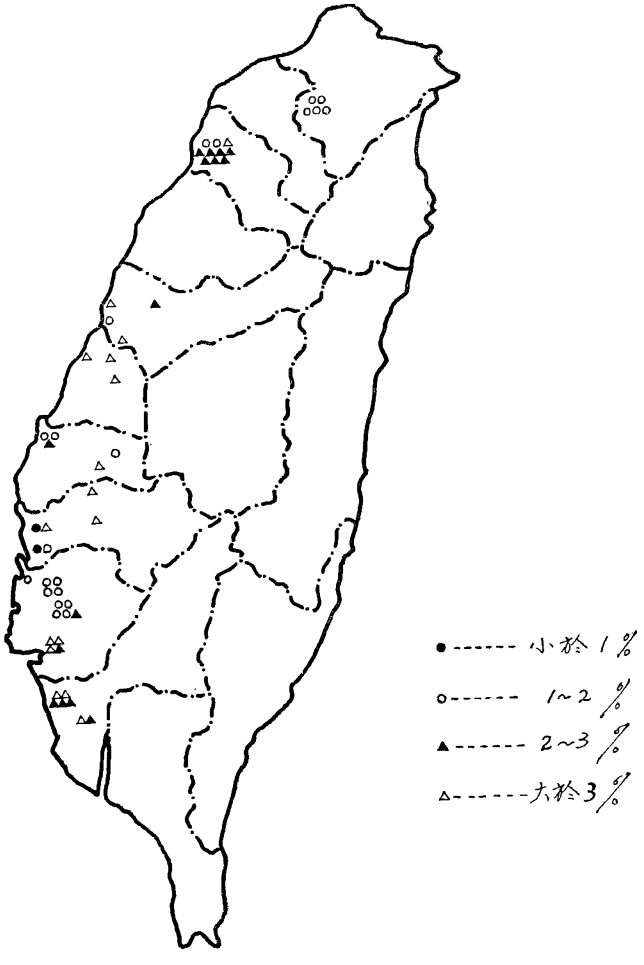
有機物質含量=12.8734（總氮含量）+0.0694

概而言之，溫度，雨量，土壤質地，排水，石灰質含量等因子對土壤之有機物質及氮含量均有關係，相互交錯影響，至於對魚池最爲適當之有機物質及總氮含量應爲若干，仍需待進一步研究。

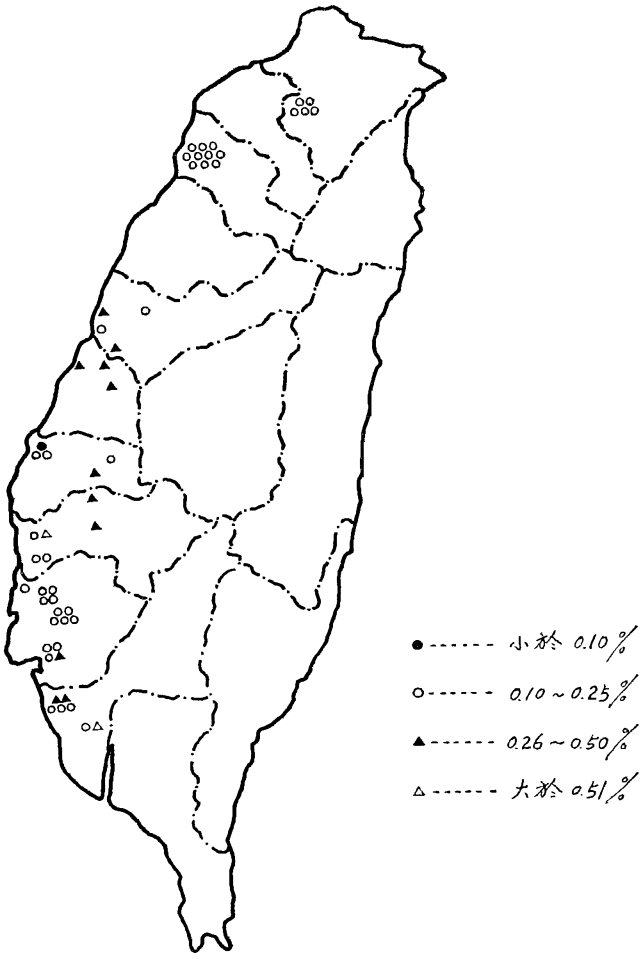
4. 底泥中磷酸：

土壤中磷大別可分爲有機磷與無機磷，而後者又以可溶性磷，鐵結合磷，鋁結合磷和鈣結合磷爲主。

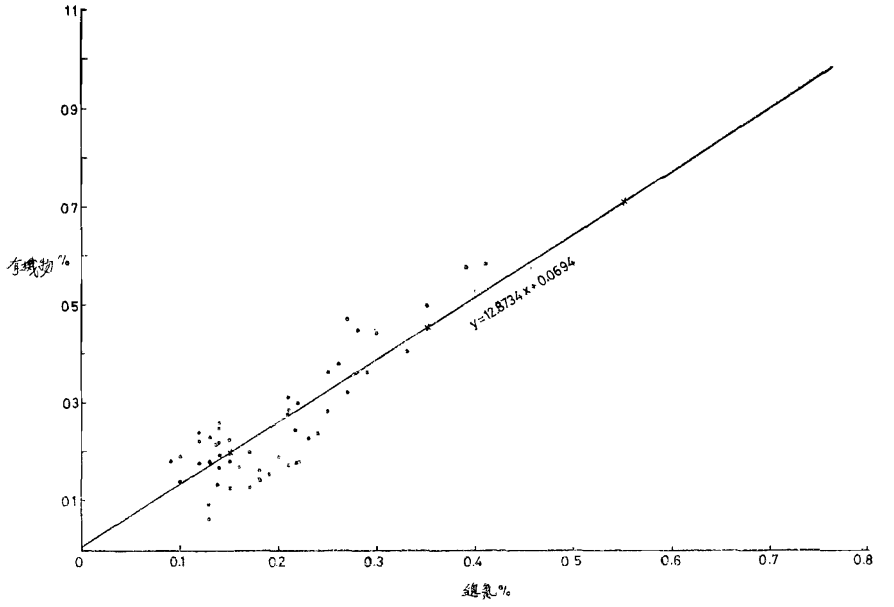
無機磷之分佈情形，在農田土壤中紅壤土以鐵結合磷爲主；粘板岩冲積土，片岩冲積土，泥岩



圖四：淡水養殖魚池底泥有機物質含量分佈概況。



圖五：淡水養殖魚池底泥總氮含量分佈概況。



圖六：淡水養殖魚池底泥有機物質及總氮含量之關係。

冲積土及鹽土均以鈣結合磷爲主；而酸性砂岩，頁岩冲積土則以鐵結合磷與鈣結合磷爲主（張守敬 1951）。在魚池底泥中，調查結果顯示主要爲鈣結合磷，約佔無機磷的77%。

臺灣的農田土壤，桃園、苗栗一帶含磷較低，而豐原臺中間的土壤含磷特高，彰化至嘉義間若干表土中含磷仍低，新營附近含磷也不高，恒春附近半數以上表土磷含量居於低位，東部花蓮一帶含磷也低，就全省農田表面積而言，磷含量很低（林家棻 1967）。

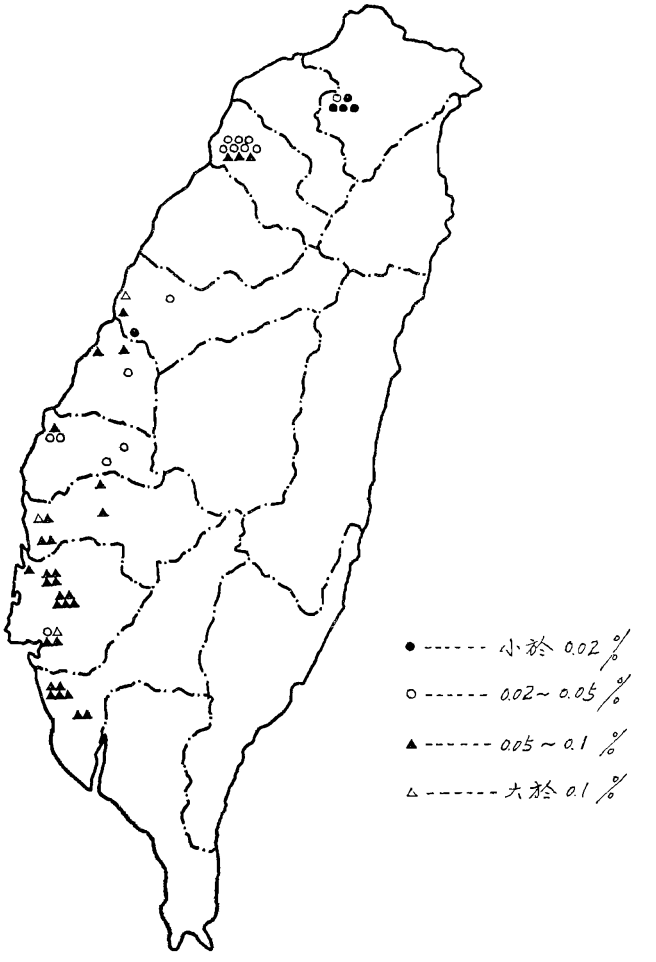
至於魚池的底泥中，臺北魚池的無機磷含量最低，臺中豐原也低，雲林一帶也低，而臺南安南、麻豆、學甲一帶磷含量則相當高，另外高雄、海埔、仁武一帶含量也相當高。而高雄湖內之魚池無機磷含量最高，其所以含量特別高的原因之一，可能與該地魚池施放大量的鴨糞肥料有關。根據竹北魚池資料比較（Lin *et al.* 1971）可推測其池水中磷含量一定頗高，應屬於極肥沃之魚池。底泥中PO_4-P之含量與水中PO_4-P之含量可以下式表示：

(水中PO_4-P含量)=0.00038×(底泥中PO_4-P含量)−0.08340 (Lin *et. al 1971*).

臺灣魚池底泥中無機磷含量少於 200 ppm 者佔9.26%，在 200-500 ppm 者佔27.78%，500～1000 ppm 者佔 57.41%，而超過 1000 ppm 者有5.55%；大致而言，一半以上都屬高等級。在無機磷中以可溶性磷含量最少，只佔無機磷總含量的 0.23%，其次爲鋁結合磷佔 6.62%，鐵結合磷佔 22.8%，而鈣結合磷最多約佔 70.34%。在湖沼底泥中則以鐵結合磷佔最大部份（Serruya 1971）（圖七及附錄）。

魚池底泥中各種無機磷的濃度除受施肥種類，施肥量及時間等因素影響（Lin *et al.* 1971）之外，池水中鈣離子濃度影響到水中PO_4-P之沉澱(Hepher 1958)，會形成磷酸鈣沉澱於底泥中，底泥質地之組成亦影響磷含量，砂粒多者磷含量較低（Lin *et al.* 1971）。

魚池底泥深層之有機物質分解，可使 pH 值略爲降低，此時魚池底部表層土之 pH 較深部泥土之 pH 略高（Hutchinson 1957），而底泥在 pH 爲 7～8 之間時鐵之化合物如氫氧化鐵，磷酸鐵等會吸附水中之磷，而使底泥中之鐵結合磷加多；此次調查得知各池底泥之 pH 位在 7 以下者佔 90%以上，推測這可能是鐵結合磷含量不高的原因之一。又水中之 pH 值在大於 7 以上時，水中之



圖七：淡水養殖魚池底泥無機磷含量分佈概況。

磷酸也會形成磷酸鐵而沉於底部或被氫氧化鐵吸附於底泥上（Golterman 1967）。

當土壤呈還原狀態時，鐵結合磷會自底泥中放出，若是有過量的有機物沉澱於池底，必發生分解作用而消耗大量的氧，使底泥呈還原狀態，而會影響鐵結合磷的含量，所以有機物含量降低時，鐵結合磷含量亦會降低；底泥中有機物之改變量與鐵結合磷之改變量呈正相關（Lin *et al.* 1971）。全省魚池調查結果亦顯示此關係。又泥土僅在表層1mm厚左右可以吸附磷(Hayes *et al.* 1958)。

當魚池施放之磷肥加多時，底泥中鐵結合磷也會加多(Lin *et al.* 1971)；而磷肥施入魚池時，會經碳酸鈣之作用而形成鈣結合磷（Hepher 1958），故在水中施過量之碳酸鈣無用（Golterman 1967)；又光合作用加快時，pH 值升高，也會使鈣結合磷增加（Gooch 1967)。

總而言之，土壤中磷酸之含量與土壤之 pH 值有密切關係，另外土壤中之有機物在分解過程中之產物及土壤微生物都可以影響到磷酸的含量及其有效性。

5. 鈉、鈣、鉀、鎂：

土壤中之金屬鹽類可分爲：①存在於礦物中需經風化作用才可溶出者，②交換性鹽類，吸附在土壤膠體粒子的表面，可與土壤中帶有正電荷的離子發生置換作用者，③非交換性鹽類，存在於土

壤膠體內部，不會與土壤溶液中之帶正電荷離子發生置換者，④水溶性鹽類，乃指存在於土壤溶液中者；在土壤中除第一種外，其他三者之間經常保持平衡狀態。

金屬鹽類在土壤與水之間的反應可以下式表示：

[Na. K. Ca. Mg] Alumino－Silicate＋CO_2＋H_2O→insoluble residue＋H_4SiO_4＋[Na＋K＋Ca＋Mg]＋H_2CO_3

此反應進行得很慢（Brunskill *et al.* 1971）。

底泥的物性，化性與金屬鹽類的分佈與水的深度，施肥情形，生物的利用等均有關。土壤中之鉀及鈉主要是經由風化作用而來，而在魚池底泥中除經由風化作用而來的外，注入水中所含的金屬鹽類也是影響底泥金屬鹽含量之一大因素，例如龍井魚池曾在當年夏季發生海水倒灌，所以使其底泥鈉含量高達 0.17%，而安南魚池因係由淡鹹水魚池改造的，所以其底泥鈉含量也高達 0.14%，學甲也有魚池含量達 0.12%。

一般言之，近海的魚池泥中含鈉量較高，就全省魚池調查知底泥含鈉量平均約在 0.01% 到 0.04%；含量在 0.01%以下者，佔48%，在0.01～% 0.02%者佔13%，在 0.02%～0.04%者佔11%，大於0.04% 者佔 28%（圖八及附錄）

土壤中，除砂土外，鉀含量甚豐富，約90～98%，但大多爲礦物成分，而交換性鉀甚少。土壤中之鉀易因排水而流失，因有效鉀易溶解於水中。土壤中膠體粒子也會影響鉀之含量。不同之土質其含鉀之量也不同。石灰之施放可減少鉀之流失，但過量施放，則使鉀之有效性降低。

臺灣省各類土壤中交換性鉀約在 0.005%～0.01%之間。就全省農田表土言，80%以下之土壤，含鉀量均屬低等級（林家棻 1967）。

魚池的低限含鉀量約在0.01%～0.05%，與農田表土比較含量甚高。全省淡水魚池鉀含量在0.01%以下者佔 0.5%，在 0.01%～0.03%者佔 31%，在 0.03%～0.05%者佔 22%，而大於 0.05%者佔 7%（圖九及附錄）。

全省淡水魚池的含鈣量平均約在 0.03%～0.6%之間，其中彰化鹿港含量特高約 1.43%，其原因不明。一般言，全省魚池鈣含量在 0.1%以下者佔 8 %，在 0.1～0.3%者佔 20%，在 0.3～0.5%者佔 52%，大於0.5%者佔13%（圖十及附錄）。

另鎂含量平均在 0.01%～0.11%。就全省言，少於 0.03%者佔 30%，0.03～0.06%者佔 27%，0.06～0.09%者佔30%，大於 0.09%者佔13%（圖十一及附錄）。

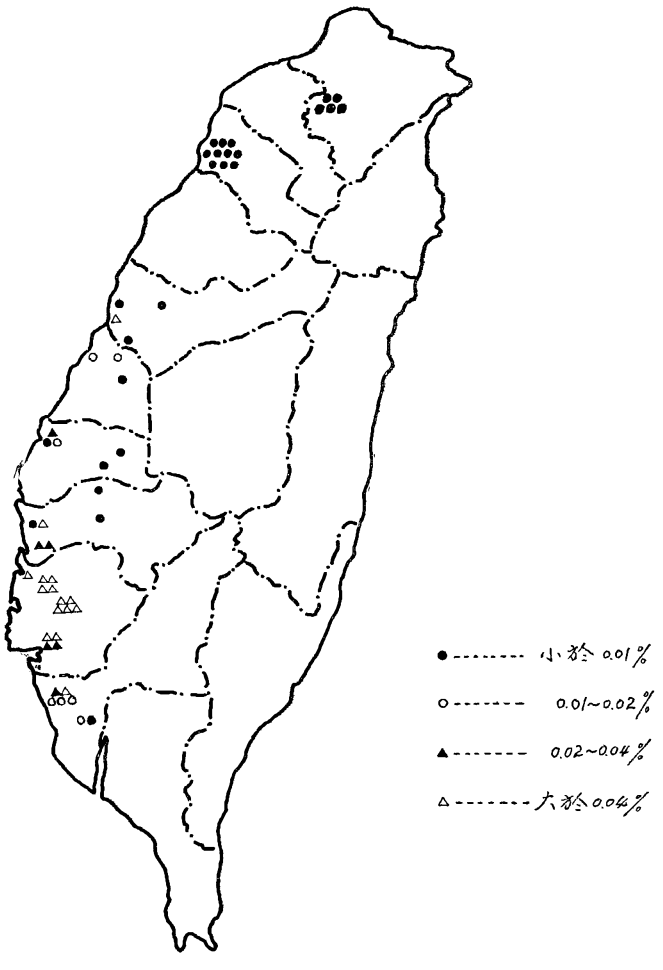
鈣及鎂之含量會影響到磷酸之有效性。在土壤施用適當量之石灰時，會使磷酸之有效性增加，但如鈣及鎂過多時則磷酸會沉澱。換言之，在酸性土壤中，有效磷會轉爲無效，但在農田施用適量石灰時會發生相反作用，在魚池中是否也發生這種情形，則須進一步的研究。

鎂可促進植物性浮游生物的生長（Henderson 1949），而鉀是植物性浮游生長所必須的，缺少了這些微量元素，會限制浮游生物之生長（Pearsall *et al.* 1939）。

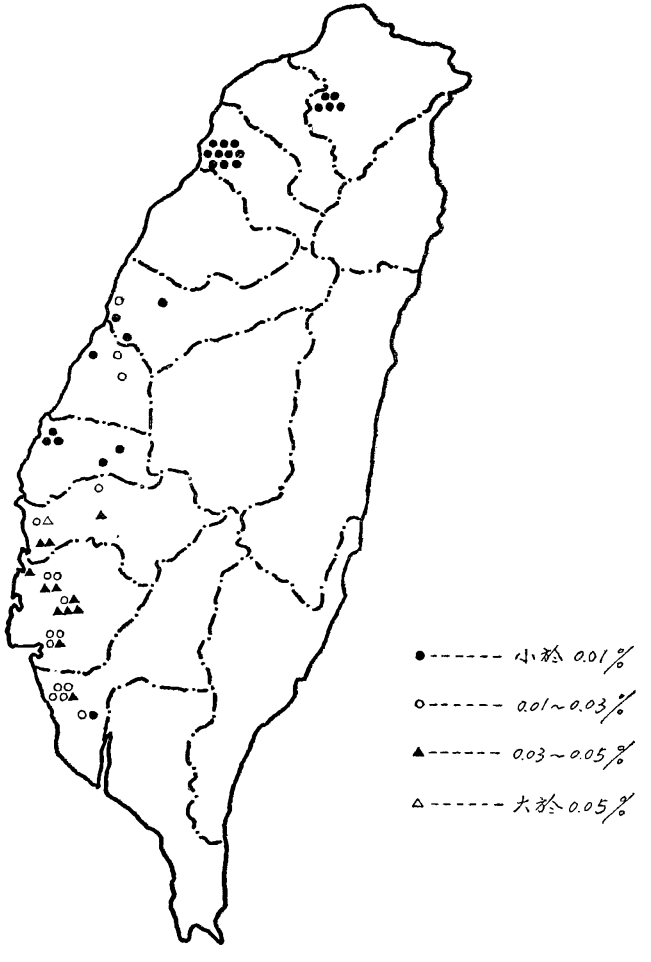
另有一說，認爲鉀、鈣、鈉、鎂等對浮游生長並無影響（Wolny 1967）；而底泥中之鉀對於虱目魚池底藻之生長並無影響（Tang 1967）。然而欲了解底泥中鉀、鈉、鈣、鎂等之作用，必須先了解底泥中膠體粒子及各種鹽類的化學變化機構。

後　　記

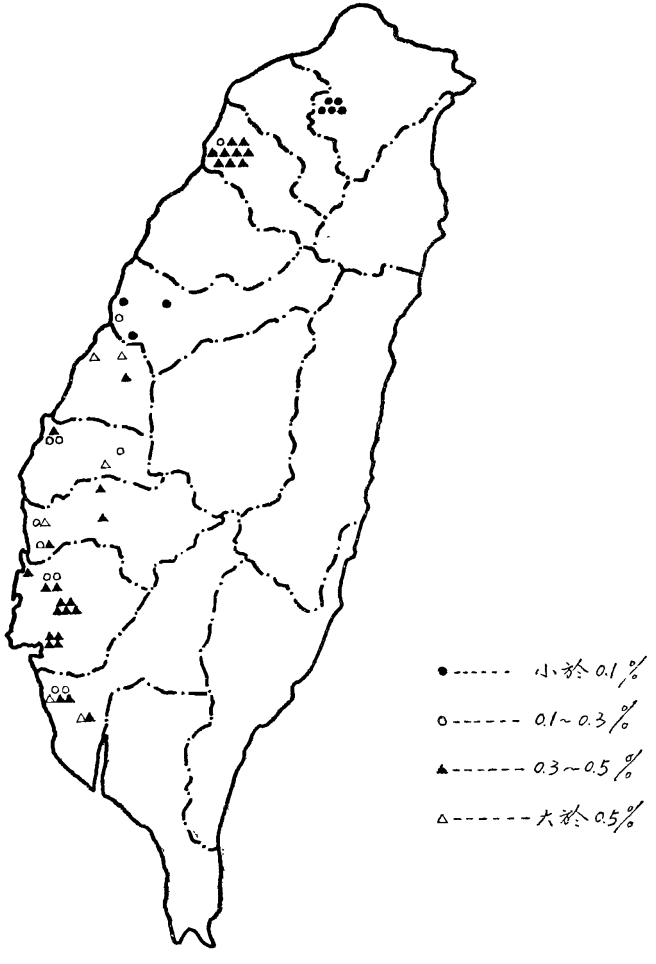
農田土壤及魚池底泥無論在物理性質，化學性質上皆有不同，而且差異頗大，因而魚池的施肥與農田的施肥亦不盡相同。水中生物欲利用土壤中的養分主要須待沉積物等分解溶出後，方可利用；而農田作用則直接可以吸收土壤的養分。魚池底泥與農田唯一相同的是二者在乾燥時，以及初放水的這一階段中所發生的化學變化。故二者之施肥情形及其鹽類的化學變化是否可以相提並論仍須進一步的研究。



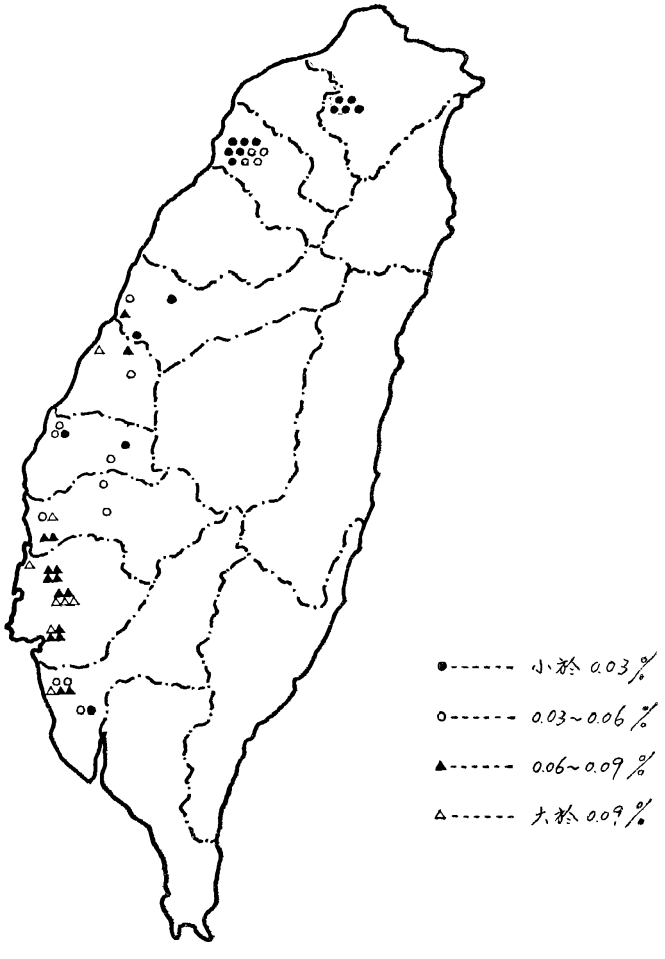
圖八：淡水養殖魚池底泥鈉鹽含量分佈概況。



圖九：淡水養殖魚池底泥鉀鹽含量分佈概況。



圖十：淡水養殖魚池底泥鈣鹽含量分佈概況。



圖十一：淡水養殖魚池底泥鎂鹽含量分佈概況。

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臺灣淡水魚池底泥有機物總氮總碳 pH 值及質地一覽表

採土地點		pH	有機物%	總碳%	總氮%	砂粒%	粘土粒%	粉砂粒%	質地
鶯歌	(1)	6.00	1.83	1.45	0.15	2.60	60.09	37.31	粘土
	(2)	6.20	1.71	1.24	0.16	6.90	57.93	35.17	粘土
	(3)	6.42	1.70	1.22	0.14	14.25	47.53	38.22	粘土
	(4)	6.30	1.81	1.18	0.13	13.00	42.47	44.53	粉砂質粘土
	(5)	6.23	1.79	1.24	0.13	13.08	45.53	41.39	粉砂質粘土
竹北	(1)	7.43	3.14	1.83	0.21	34.67	24.67	40.66	壤土
	(2)	7.40	2.26	1.08	0.15	42.67	21.00	36.33	壤土
	(3)	7.45	2.23	0.99	0.14	46.67	18.33	35.00	壤土
	(4)	7.60	1.78	1.04	0.12	52.33	16.00	31.67	砂質壤土
	(5)	7.60	2.30	1.54	0.13	49.67	18.00	32.23	壤土
	(6)	7.30	2.42	1.56	0.12	26.00	27.67	46.33	壤土
	(7)	7.25	2.61	1.48	0.14	35.00	26.00	39.00	壤土
	(8)	7.20	2.49	1.53	0.14	29.67	31.00	39.33	粘質壤土
	(9)	7.25	2.25	1.37	0.12	53.00	21.00	26.00	砂質粘壤土
	(10)	7.38	1.91	1.54	0.10	46.00	21.67	32.33	壤土
臺中	豐原	6.35	2.48	1.59	0.22	22.39	33.39	43.82	粉砂質粘壤土
	王田	6.02	4.75	2.01	0.27	52.88	19.28	27.84	砂質壤土
	梧棲	5.18	10.02	3.55	0.43	15.86	31.00	53.14	粉砂質粘壤土
	龍井	6.45	1.95	1.41	0.14	15.07	23.04	61.89	粉砂質壤土
彰化	花壇	5.88	5.04	2.76	0.35	13.33	44.41	42.26	粉砂質粘土
	鹿港	6.50	3.24	2.45	0.27	15.65	44.28	40.07	粉砂質粘土
	彰化市	5.62	5.81	3.85	0.39	5.98	18.50	71.52	粉砂質壤土
雲林	斗六	6.42	1.35	1.06	0.14	15.38	36.12	48.50	粉砂質粘壤土
	斗南	6.18	4.50	2.64	0.28	31.12	1.94	66.94	粉砂質壤土
	麥寮(1)	6.60	1.82	1.70	0.09	59.93	5.05	35.02	砂質壤土
	(2)	6.27	2.22	1.98	0.14	54.44	12.45	33.11	砂質壤土
	(3)	6.52	1.40	1.43	0.10	56.03	8.18	35.79	砂質壤土
嘉義	嘉義市	6.05	5.87	3.52	0.41	5.03	42.96	52.01	粉砂質粘土
	義竹(1)	5.42	1.93	1.53	0.20	12.61	35.37	52.02	粉砂質粘壤土
	(2)	5.93	0.95	1.07	0.13	4.44	46.72	48.84	粉砂質粘土
	朴子(1)	6.32	9.83	5.27	0.70	11.93	48.23	39.84	粉砂質粘土
	(2)	6.67	0.65	0.90	0.13	14.10	41.89	44.01	粉砂質粘土
	大林	6.28	4.47	2.67	0.30	18.38	33.74	47.88	粉砂質粘壤土
臺南	中州	5.50	1.65	1.39	0.18	3.41	50.40	46.19	粉砂質粘土
	麻豆(1)	5.65	1.58	1.37	0.19	7.26	54.80	37.94	粘土
	(2)	5.10	1.40	1.31	0.18	10.44	49.99	39.56	粉砂質粘土
	(3)	5.35	2.27	1.64	0.23	2.94	56.97	40.09	粉砂質粘土
	(4)	5.80	1.80	1.36	0.22	5.18	59.00	35.82	粘土
	(5)	6.48	1.76	1.33	0.21	3.01	52.71	44.28	粉砂質粘土
	學甲(1)	5.22	1.63	1.24	0.19	1.36	52.47	46.17	粉砂質粘土
	(2)	4.90	1.71	1.26	0.18	1.44	54.52	44.04	粉砂質粘土
	(3)	5.55	1.26	1.15	0.15	8.90	43.48	47.62	粉砂質粘土
	(4)	4.70	1.29	1.10	0.17	2.22	45.77	52.01	粉砂質粘土
	臺南市(1)	5.00	3.65	2.29	0.29	11.93	47.26	40.81	粉砂質粘土
	(2)	6.50	3.66	2.21	0.25	13.49	33.11	53.40	粉砂質粘壤土
	(3)	6.49	3.01	1.74	0.22	19.95	16.86	63.19	粉砂質壤土
	(4)	6.68	2.84	1.91	0.25	25.96	9.30	64.74	粉砂質壤土
高雄	湖內(1)	5.68	2.03	1.51	0.17	14.47	33.40	52.13	粉砂質粘壤土
	(2)	5.98	2.87	1.96	0.21	11.45	35.20	53.35	粉砂質粘壤土
	(3)	6.23	4.11	2.64	0.33	8.48	45.76	45.76	粉砂質粘土
	(4)	6.08	3.82	2.17	0.26	13.99	25.44	60.57	粉砂質粘土
	(5)	5.98	2.77	1.88	0.21	28.79	21.26	49.95	壤土
	仁武(1)	6.03	2.41	1.99	0.24	52.76	9.47	37.77	壤土
	(2)	5.97	3.47	5.40	0.60	10.60	11.76	77.64	粉砂質壤土

臺灣淡水魚池底泥無機磷含量表 (mgP/kg soil)

採土地點		溶解性磷	鋁結合磷	鐵結合磷	鈣結合磷	無機磷總和
鶯歌	(1)	0.19	8.00	39.66	113.25	161.10
	(2)	0.23	11.34	37.91	92.46	141.94
	(3)	0.32	9.74	37.05	152.23	199.34
	(4)	0.20	7.83	39.79	154.91	202.73
	(5)	0.21	8.69	39.79	104.51	153.20
竹北	(1)	0.60	57.80	105.00	203.00	366.40
	(2)	0.60	27.60	86.00	124.30	238.50
	(3)	1.00	45.80	135.40	178.80	361.00
	(4)	3.20	87.20	236.30	241.00	567.70
	(5)	4.40	193.10	352.30	396.90	946.70
	(6)	1.00	46.00	103.50	90.40	240.90
	(7)	1.30	44.90	137.10	82.60	265.40
	(8)	0.90	58.70	145.60	82.50	287.70
	(9)	1.00	92.50	267.70	175.10	536.30
	(10)	0.70	40.40	159.80	114.90	315.80
臺中	豐　原	0.25	5.67	89.20	210.91	306.03
	王　田	0.34	3.82	82.09	51.33	137.58
	梧　棲	0.77	24.42	2,034.41	471.83	2,531.43
	龍　井	0.69	18.42	164.99	377.55	561.65
彰化	花　壇	0.35	29.64	294.29	155.88	480.16
	鹿　港	1.38	16.29	5.03	645.08	667.78
	彰化市	1.47	29.86	246.28	569.56	847.17
雲林	斗　六	0.75	32.19	205.53	100.19	338.66
	斗　南	0.68	27.98	36.89	339.81	405.36
	麥　寮(1)	1.14	7.53	5.42	408.93	423.02
	(2)	1.56	9.45	8.24	483.88	503.13
	(3)	1.09	8.72	1.04	370.09	390.30
嘉義	嘉義市	1.62	66.26	136.92	670.74	875.54
	義　竹(1)	0.28	4.70	11.84	497.77	514.59
	(2)	0.78	19.72	81.09	644.14	745.73
	朴　子(1)	27.62	242.06	655.03	1,118.19	2,042.90
	(2)	0.37	23.89	254.91	313.10	592.27
	大　林	0.41	10.64	128.88	383.67	523.60
臺南	中　州	0.37	50.89	53.50	604.96	709.72
	麻　豆(1)	0.43	8.40	6.31	661.30	676.44
	(2)	0.36	7.62	16.85	605.73	630.56
	(3)	0.38	9.24	21.25	599.70	630.57
	(4)	0.32	7.53	43.40	559.32	610.57
	(5)	0.28	5.00	12.09	539.20	556.57
	學　甲(1)	0.45	13.41	75.91	545.46	635.23
	(2)	0.39	10.34	56.28	658.21	725.22
	(3)	0.42	8.60	55.56	633.57	698.15
	(4)	0.44	7.70	50.39	726.15	784.68
	臺南市(1)	1.17	75.14	192.50	761.87	1,030.58
	(2)	1.15	34.41	118.62	455.84	610.02
	(3)	1.20	63.71	94.59	508.36	667.86
	(4)	1.31	26.38	94.98	370.63	493.30
高雄	湖　內(1)	1.12	26.72	70.49	772.22	870.55
	(2)	5.06	65.05	49.09	827.05	946.25
	(3)	3.65	75.04	52.21	860.47	991.37
	(4)	3.35	38.59	39.89	564.81	646.64
	(5)	6.69	54.68	30.75	601.59	693.71
	仁　武(1)	1.61	46.93	259.11	408.16	715.81
	(2)	2.71	38.74	73.37	712.05	826.87
百分比%		**0.23**	**6.62**	**22.81**	**70.34**	**100.00**

臺灣淡水魚池底泥鉀鈉鈣鎂含量表

採土地點		N_a^+%	K^+%	C_a^{++}%	M_g^{++}%
鶯歌	E1	0.0012	0.0083	0.0467	0.0210
	E2	0.0010	0.0073	0.0449	0.0170
	E3	0.0010	0.0058	0.0348	0.0193
	E4	0.0010	0.0050	0.0534	0.0172
	E5	0.0010	0.0069	0.0330	0.0208
竹北	A1	0.0031	0.0075	0.4661	0.0289
	A2	0.0025	0.0057	0.3711	0.0263
	A3	0.0022	0.0054	0.3441	0.0242
	A4	0.0026	0.0060	0.2487	0.0255
	A5	0.0023	0.0051	0.3607	0.0251
	B1	0.0026	0.0077	0.3498	0.0314
	B2	0.0031	0.0075	0.3775	0.0372
	B3	0.0030	0.0079	0.3605	0.0322
	B4	0.0032	0.0078	0.3534	0.0315
	B5	0.0037	0.0078	0.3279	0.0280
臺中	豐原	0.0012	0.0062	0.0794	0.0257
	王田	0.0028	0.0067	0.0876	0.0286
	梧棲	0.0091	0.0131	0.0945	0.0538
	龍井	0.1702	0.0254	0.1846	0.0825
彰化	花壇	0.0093	0.0144	0.3045	0.0541
	鹿港	0.0120	0.0027	1.4304	0.1098
	彰化市	0.0104	0.0246	0.5776	0.0643
雲林	斗六	0.0019	0.0064	0.2139	0.0202
	斗南	0.0049	0.0094	0.5432	0.0418
	麥寮(1)	0.0265	0.0009	0.3408	0.0345
	(2)	0.0101	0.0032	0.2992	0.0304
	(3)	0.0061	0.0021	0.2312	0.0182
嘉義	嘉義市	0.0079	0.0349	0.5357	0.0536
	義竹(1)	0.0385	0.0404	0.3305	0.0879
	(2)	0.0253	0.0324	0.2891	0.0884
	朴子(1)	0.0562	0.0829	0.6488	0.1149
	(2)	0.0046	0.0216	0.2593	0.0536
	大林	0.0034	0.0127	0.4174	0.0303
臺南	中洲	0.0443	0.0362	0.3847	0.0771
	麻豆(1)	0.0429	0.0436	0.3337	0.0863
	(2)	0.0426	0.0210	0.3321	0.0814
	(3)	0.0538	0.0433	0.3272	0.0920
	(4)	0.0567	0.0450	0.3356	0.0933
	(5)	0.1489	0.0413	0.3377	0.0917
	學甲(1)	0.0498	0.0329	0.3078	0.0847
	(2)	0.0436	0.0357	0.3398	0.0774
	(3)	0.0488	0.0299	0.2659	0.0624
	(4)	0.0516	0.0299	0.2977	0.0743
	臺南市(1)	0.1241	0.0443	0.3847	0.0980
	(2)	0.0437	0.0231	0.3633	0.0712
	(3)	0.0375	0.0191	0.3394	0.0614
	(4)	0.0342	0.0197	0.3602	0.0817
高雄	湖內(1)	0.0107	0.0187	0.3295	0.0463
	(2)	0.0135	0.0214	0.4323	0.0630
	(3)	0.0253	0.0305	0.6110	0.0976
	(4)	0.0958	0.0263	0.2972	0.0648
	(5)	0.0183	0.0207	0.2986	0.0511
	仁武(1)	0.0029	0.0067	0.3804	0.0213
	(2)	0.0105	0.0152	0.8974	0.0527

虱目魚越冬溝之生態研究

Ecological Study of Milkfish Wintering Pond

陳 弘 成 • 劉 熾 揚

Hon-cheng Chen and Chi-yang Liu

Abstract

The late fingerlings of the milkfish, *Chanos chanos*, one of the most important commercial fishes in Taiwan, must be stocked in wintering ponds to survive the winter. For the past ten years, the mortality of fish in these ponds averaged 14%. This study on the ecosystem - physical, chemical and biological succession - of wintering ponds was carried out from 1969 to 1971. The vertical distribution of salinity and some of the inorganic ions suggest that there is no water stratification, although there was always negative Redox potential in the bottom soil. The dominance of *Olisthodiscus* sp., which makes up about 90% of the total plankton, results from low temperature and the application of peanut cake. The phenomenon that the decreasing Redox potential and rising I_2 consumption coincide with an increase in dissolved oxygen is peculiar. In the wintering pond, low temperature and oxygen deficiency are the two main factors causing fish kills. High ammonium concentrations, I_2 consumption and plankton population, and negative Redox potential may, more or less, influence fish mortality, which was not influenced by pH value, salinity and the concentration of phosphate, silicate and nitrate.

Some suggestions were made to increase the survival rate of the milkfish in wintering ponds.

一、前　　言

魚苗供應不穩定及冬季水溫易達虱目魚之致死溫度爲虱目魚養殖之重要問題。爲保冬季魚苗之生存，俾能有效利用春季魚池之生產力，必須設有越冬溝及搭架防風屏。水產試驗所臺南分所之越冬溝爲一上寬 6 m、底寬 1.6 m，深 1.6～1.8 m，長 210 m之深溝。每年於11月初排乾溝水，清除污泥整修溝岸，並曝晒數日，以稻草或茅草在北邊架成防風屏。此後注入海水，點算魚苗入溝越冬。越冬期間常餵以米糠及花生餅。由於殘餌，浮游生物及魚類排泄物之腐敗，易使水質惡變，必須常常換水。換水視潮汐狀態，浮游生物，水溫及魚類浮頭與否而定，一般約每星期一次，如此繼續至四月初爲止。

十年來此型越冬溝內虱目魚苗死亡率在 3～60%之間，平均爲14%，損失可謂甚鉅。養殖業者亦知每當寒流來臨，夜晚下霜時，魚苗卽有凍死之慮。在午夜至翌晨溶氧最低時，魚類亦常浮頭泛池而死。此類死亡概受水中各環境因素之相互作用所影響，故了解越冬溝環境因子之變動與關係，實爲減低魚苗死亡率之先決條件。

二、材料與方法

在上述之越冬溝，使用小木船於距離水門50 m、100m、150m等三處分上、中、下三層採水。上層係水面下20 cm處，中層爲水深 60～90 cm 處，下層係底泥上10 cm之水層，其水深隨排水，

注水及採水位置之不同而有所差異，約爲 130～180 cm。採水都在上午10時舉行，以塑膠管垂至所欲之深度，利用虹吸作用將水裝入採水瓶，如此可減少因攪動水層所造成之誤差。採水時並同時測定水溫、氣溫、透明度、水中及底泥之氧化還原電位差。測定方法簡述如下：

㈠水溫及氣溫以 0～50 °C 之水銀溫度計直接測之。

㈡鹽度（Salinity）由海水比重經溫鹽曲線求得。

㈢透明度（Transparency）係以直徑 5 cm 之白色圓磁板沒入水中消失與拉上出現時之深度平均而得。

㈣混濁度（Turbidity）以 Hach 水質分析箱測定。

㈤pH 值由 HM-5型之 pH meter 測定。

㈥溶氧（Dissolved Oxygen）以 Winkler's method 測定。

㈦銨鹽（Ammonium）由 Rochelle salt 將 Ca、Mg 吸附後，加 Nessler reagent 使之變色，再以波長 430 mμ測定（Barnes 1959）。

㈧亞硝酸鹽（Nitrite）係加 Sulphanilamide 及 N-(1-Naphthyl)-Ethylenediamine 形成紅色，再以 543 mμ 測定（Strickland 1960）。

㈨硝酸鹽（Nitrate）以 Hydrazine sulfate 還原爲亞硝酸鹽後再由上法測定。

㈩矽酸鹽（Silicate）以 Mullin & Riley's method 用波長 810 mμ測定。

㈪磷酸鹽（Phosphate）以鉬酸銨、硫酸混液與其作用生成磷鉬酸，再以氯化亞錫還原成青色物後用波長 705 mμ 測定。

㈫碘消費量（I_2 consumption）是加碘後，再用硫代硫酸鈉滴定未經作用之碘量而求出。

㈬水中及底泥之氧化還原電位差 Eh（Redox Potential）由携帶用 RM-1 型之Eh meter 測定。

㈭浮游生物之含量，以離心機 3500 r.p.m. 離心 15分鐘後之沉澱量而得。

三、結　　果

越冬溝水 pH 值之變化範圍在 8.0～9.2之間，平均 8.5。pH 值和深度有關，即 pH 值隨着水深而遞減（圖一）。但隨着換水後之天數而遞增（圖二）。同一越冬溝中，由於位置的不同 pH

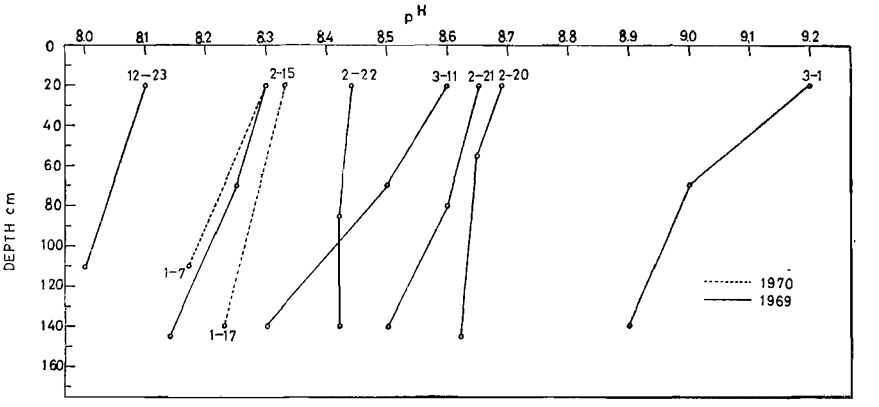

Fig. 1 Vertical distribution of pH value at 10 a.m. on different dates in wintering pond.

圖 一 越冬溝上午十時 pH 值之垂直變化。

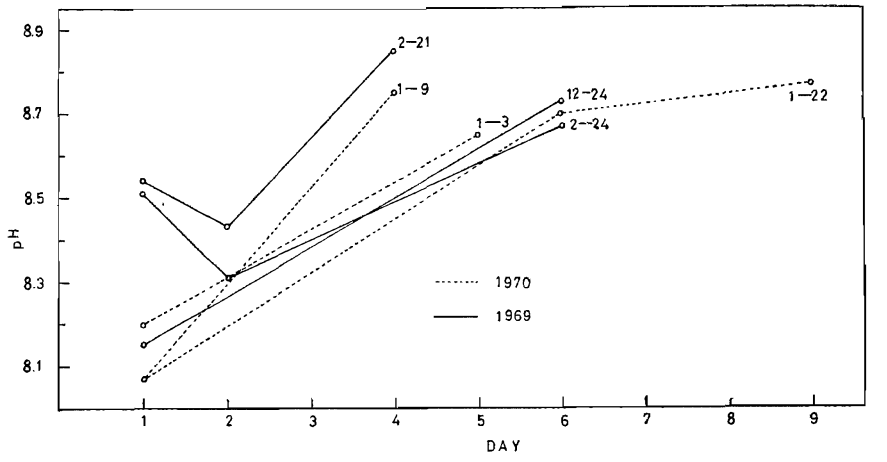

Fig. 2 Daily variation of pH value at 10 a.m. in wintering pond after water renewal.
圖 二 越冬溝換水後上午十時 pH 值之日變化。

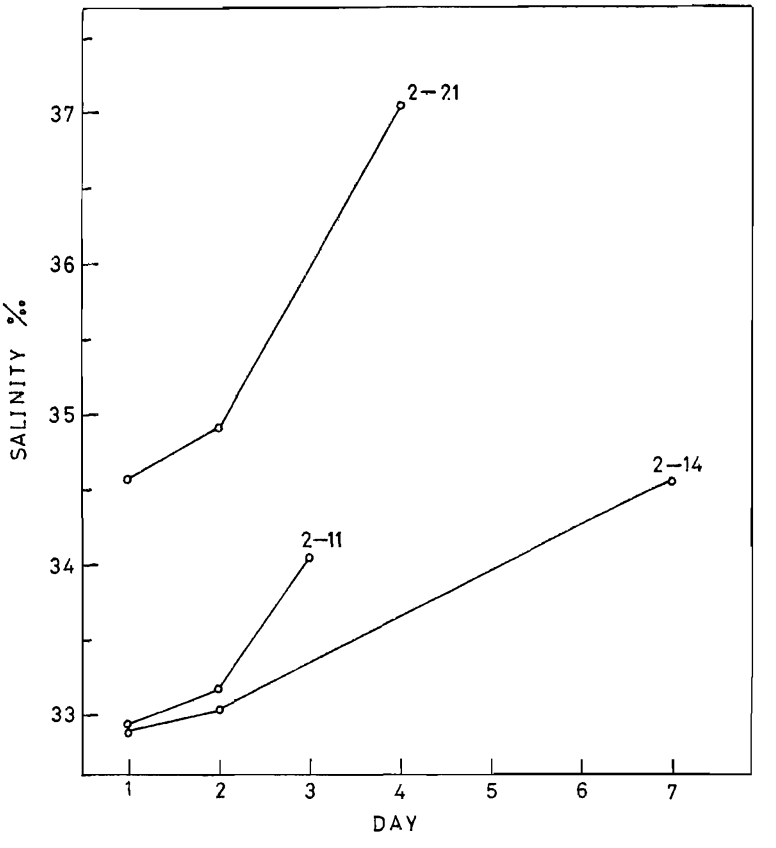

Fig. 3 Daily variation of salinity in wintering pond after water renewal.
圖 三 越冬溝換水後鹽度之日變化。

值亦不同，但相異甚少，最大約爲0.3。

鹽度一般都在32～39‰之間變動，平均爲35‰。鹽度隨換水後之天數而遞增（圖三），約可增加 4‰。同一越冬溝中，不同的位置有不同的鹽度，相差曾達3.3‰，但與深度無關（圖四），無明顯一致的趨向，亦無上下分層現象。

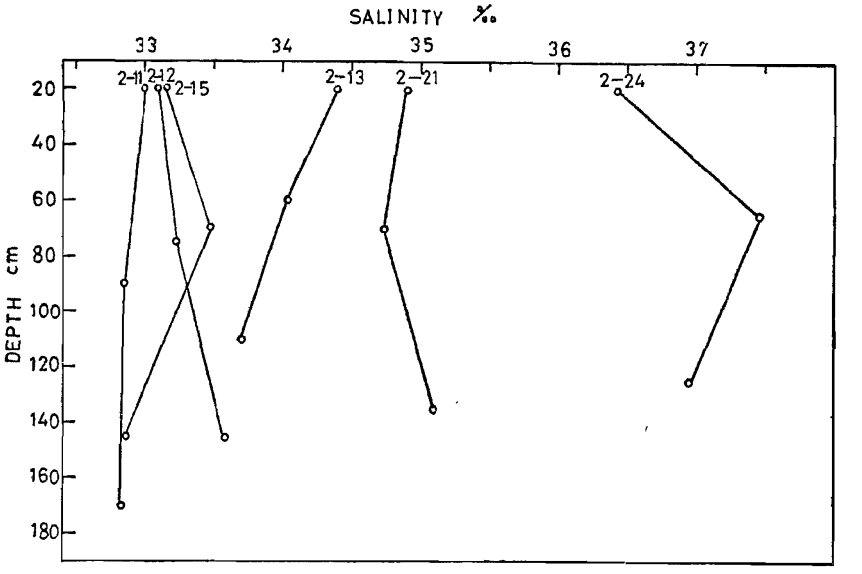

Fig. 4 Vertical distribution of salinity at 10 a.m. on different dates in wintering pond.
圖 四 越冬溝上午十時鹽度之垂直變化。

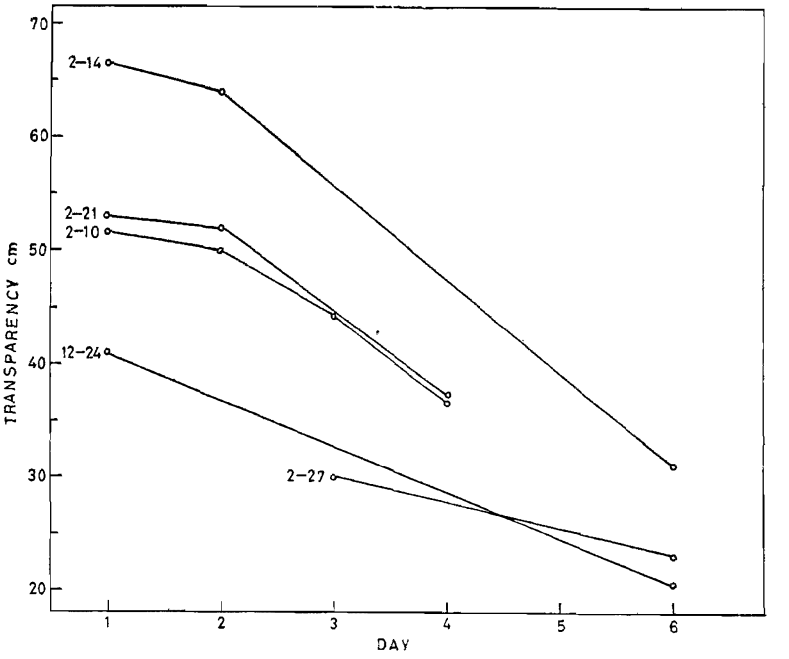

Fig. 5 Daily variation of transparency at 10 a.m. in wintering pond after water renewal.
圖 五 越冬溝換水後十時透明度之日變化。

透明度之變化範圍爲 20～80 cm，平均爲 40 cm，透明度與水深無關，但隨着換水後之天數而遞減（圖五）。由於浮游生物易聚集之特性，故不同位置有不同的透明度，相差最大時可達20 cm。

混濁度和透明度正恰相反其變化範圍爲 18～70 J.T.U.，它隨着水深而遞減（圖六），上下層相差曾達 52 J.T.U.，但隨着換水後之天數而遞增（圖七）。不同的位置亦有不同的混濁度。

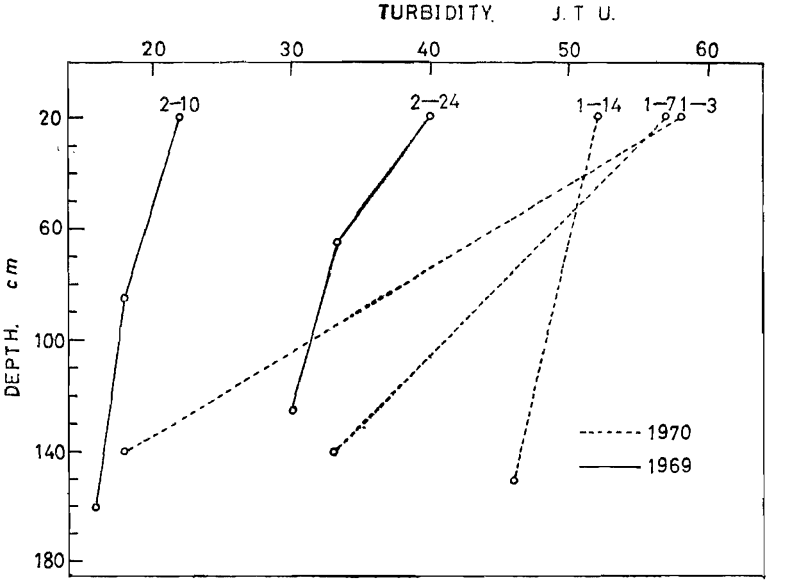

Fig. 6 Vertical distribution of turbidity at 10 a.m. in wintering pond.
圖 六 越冬溝上午十時混濁度之垂直變化。

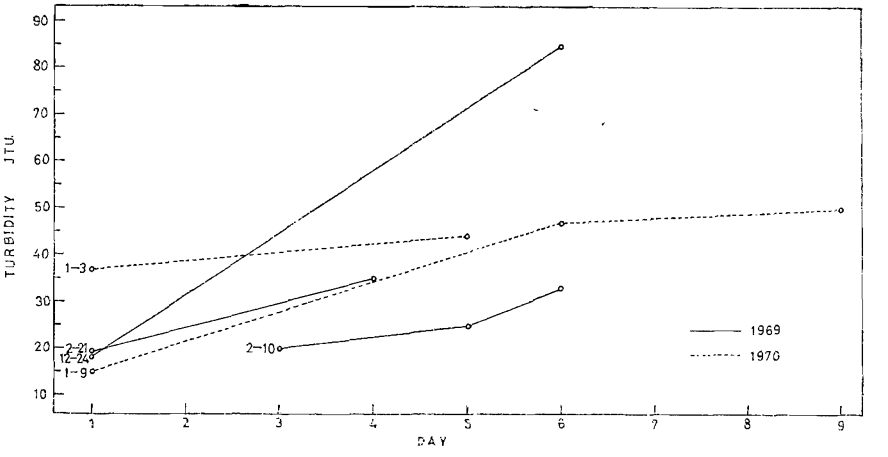

Fig. 7 Daily variation of turbidity in wintering pond after water renewal.
圖 七 越冬溝換水後混濁度之日變化。

溶氧量係一非常重要之因子，一般隨着換水後的天數而遞增（圖八），但隨着水深而遞減（圖九）。在換水後的初期上下層相差少，而後期卽換水前相差大。溶氧之週日變化與普通之魚池相同以下午 3 時爲最高，夜晚3～6時爲最低(圖十)。又不同位置有不同的溶氧，相差曾達 3 ppm。

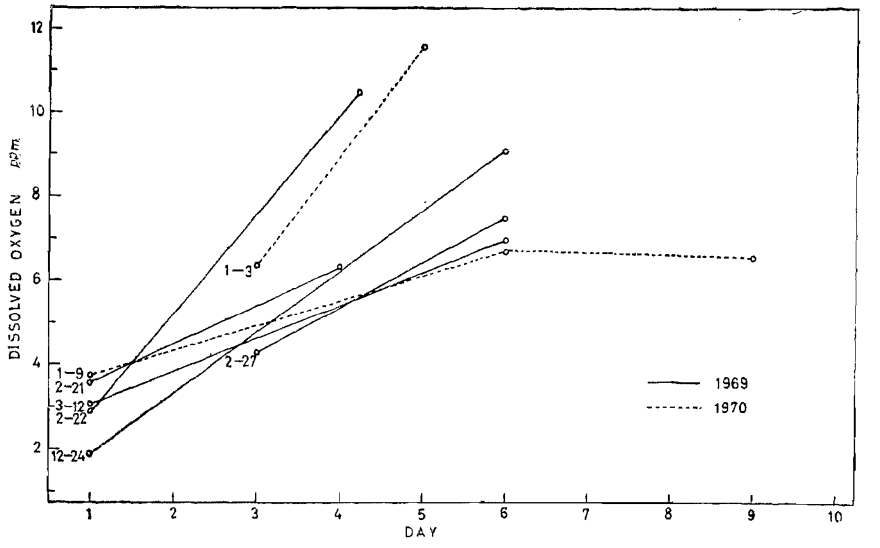

Fig. 8 Daily variation of dissolved oxygen at 10 a.m. in wintering pond after water renewal.

圖 八 越冬溝換水後上午十時溶氧之日變化。

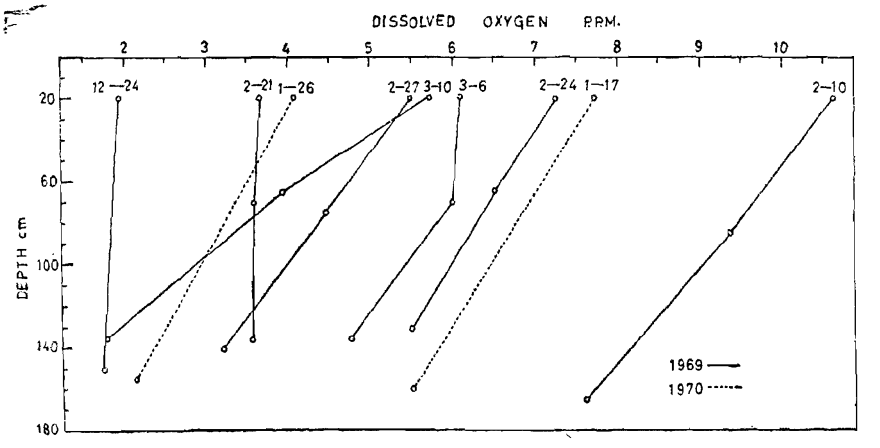

Fig. 9 Vertical distribution of dissolved oxygen at 10 a.m. on different dates in wintering pond.

圖 九 越冬溝上午十時溶氧之垂直變化。

池水中銨之濃度在 0.04～0.35 ppm 之間，平均爲 0.15 ppm 。一般在注水時上層多底層少，換水前則相反。它隨着換水後之天數而遞減，但若經較長的時間仍未換水或溫度升高時，則含量又增多。不同位置其之濃度雖有變化，但相差不大。

水中亞硝酸鹽之含量在 0～0.19 ppm 之間。高含量係因注入外水路之水所致。它與水深無明顯關係，但若注入水的含量多時則隨着換水後的天數而遞減，反之注入水的含量多時，則增加。不同的位置其含量相差很少。

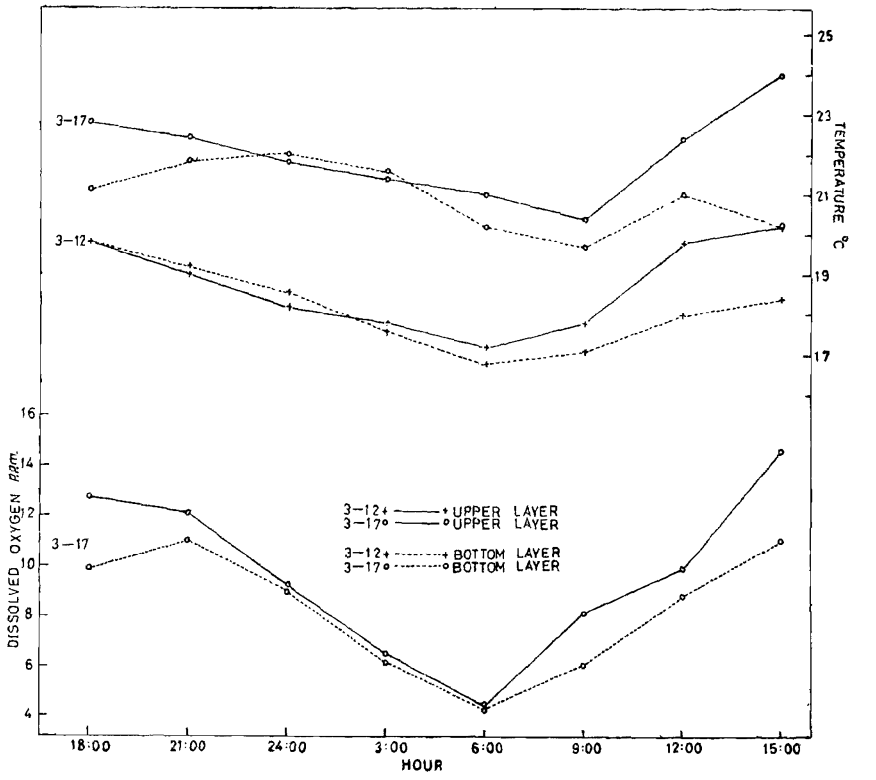

Fig. 10 Diurnal variation of dissolved oxygen and water temperature in wintering pond.
圖 十 越冬溝溶氧與水溫之週日變化。

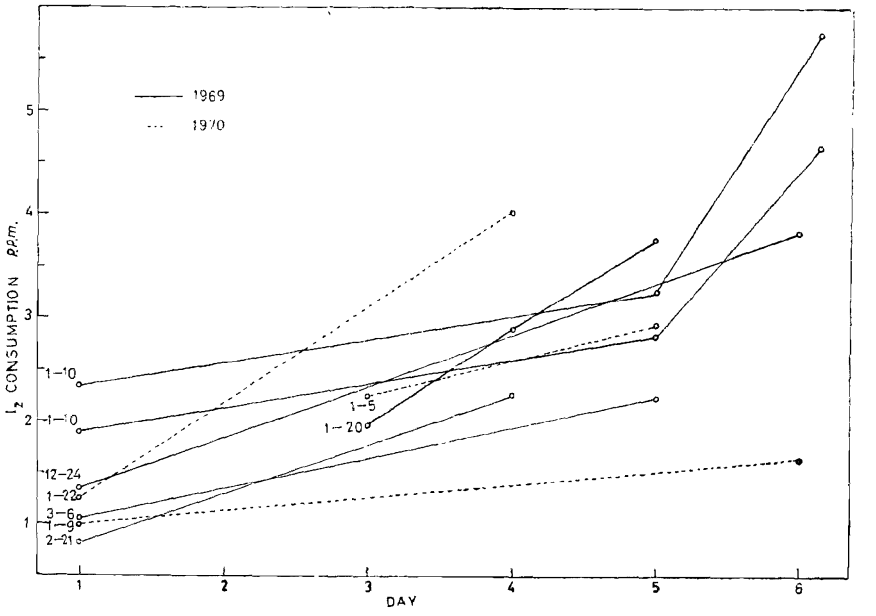

Fig. 11 Daily variation of I_2 consumption at 10 a.m. in wintering pond after water renewal.
圖十一 越冬溝換水後十時碘消費量之日變化。

矽酸鹽之濃度最多，爲 0.18～1.2 ppm。磷酸鹽次之，爲 0.07～0.38 ppm。而硝酸鹽最少，爲 0.007～0.3 ppm 之間。一般言之，此三種植物營養物質和水深或不同位置無明顯之關係，但硝酸鹽隨着換水後之天數而遞增，而矽酸鹽及磷酸鹽則隨着換水後之天數而遞減（表一）。

表一　越冬溝養成池及外水路之水質

Table 1. Comparison of water quality in wintering pond, rearing pond and main water canal

	Pond & Canal No.	Nitrite—N ppm	Nitrate—N ppm	Phosphate—P ppm	Silicate—S_i ppm
Wintering Pond	A_1	0.026	0.058	0.07	0.4
	A_2	0.01	0.022	0.218	1.2
	A_3	0.016	0.028	0.099	0.97
	A_4	0.007	0.074	0.078	0.32
	A_5	0.018	0.046	0.118	0.64
	A_6	0.028	0.305	0.118	0.18
	A_7	0.17	0.249	0.092	0.87
	A_8	0.014	0.019	0.072	0.22
	A_9	0.05	0.016	0.189	0.54
	A_{10}	0.013	0.057	0.380	1.06
Water Canal	St_1	0.008	0.040	0.282	4.08
	St_2	0.017	0.022	0.278	1.40
	St_3	0.018	0.068	0.372	2.24
	St_4	0.005	0.016	0.172	1.88
	St_5	0.009	0.051	0.312	1.23
	St_6	0.007	0.022	0.430	1.88
	St_7	0.012	0.046	0.218	1.12
	St_8	0.011	0.063	0.213	1.00
	St_9	0.007	0.028	0.322	1.40
Rearing Pond	P_1	0.008	0.037	0.322	0.36
	P_2	0.008	0.022	0.248	0.44
	P_3	0.004	0.016	0.268	0.496
	P_4	0.007	0.019	0.268	0.42
	P_5	0.006	0.022	0.169	0.18
	P_6	0.015	0.046	0.268	0.44
	P_7	0.007	0.034	0.171	0.32
	P_8	0.008	0.013	0.181	0.56

碘消費量與硫化氫（H_2S）有關，其變動範圍爲 0.4～5.75 ppm，平均爲 2.5 ppm。它受注水時外水路的含量及溝中有機物腐敗分解多寡之影響。一般言之，其含量隨着換水後之天數而遞增（圖十一）。不同的位置其含量亦不同，離入水口愈遠者含量愈高。但與水深之關係則隨着月份而變，在12及1月時隨水深而遞減，2 月時隨水深而遞增（圖十二）。

池水氧化還原電位差 Eh 值之變動範圍爲 +155～－120mv 之間，它隨換水後之天數而遞減（圖十三），又隨月份之推移而減少，即在12月時 Eh 爲 +90 mv 左右，1月爲 +70 mv，2月中旬爲正零，以後即爲負值。其與水深之關係和碘消費量與水深之變化相同，即在12及 1 月隨水深而遞增，在 2月則遞減（圖十四）。同一越冬溝中不同的位置，Eh 相差曾達80 mv，故知溝中有許多不同性質之水塊。當 Eh 爲負值時，很特別的水中溶氧並未缺乏。

底泥 pH 值之變化範圍爲7.95～8.55，它和水中 pH 值不同，即與換水後之天數無關。不同位置雖有不同的 pH 值，但相差不大。底泥之 Eh 一般都爲負值，且隨着換水後之天數而遞減（圖十五），又不同位置的底泥 Eh 值相差甚大，曾達 210 mv（－270～－60 mv）。

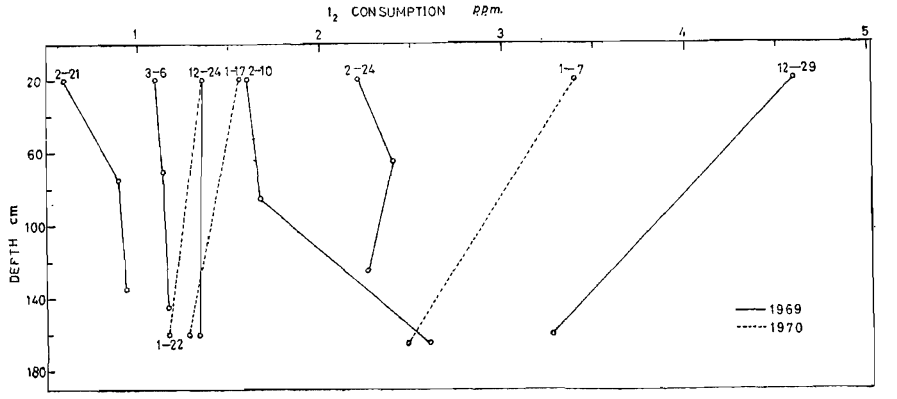

Fig. 12 Vertical distribution of I_2 consumption at 10 a.m. in wintering pond.
圖十二 越冬溝上午十時碘消費量之垂直變化。

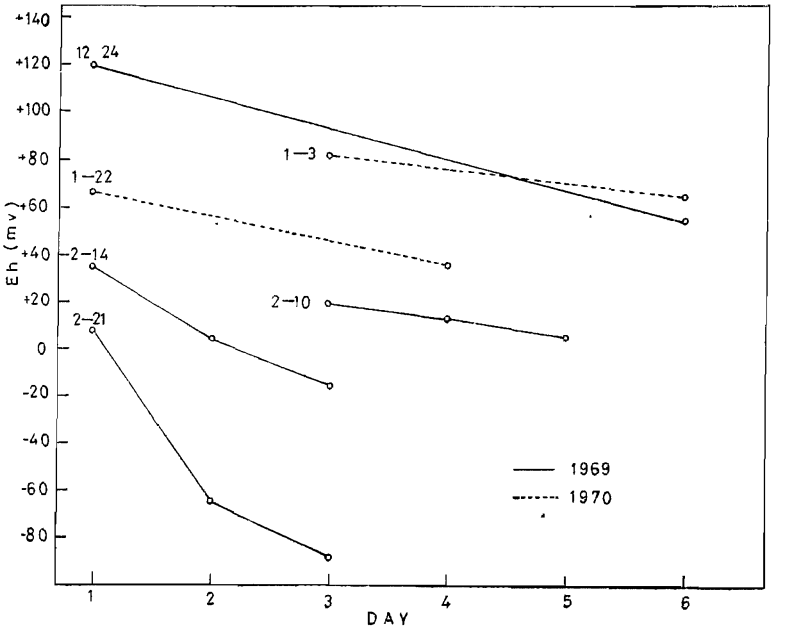

Fig. 13 Daily variation of Redox potential in wintering pond after water renewal.
圖十三 越冬溝換水後氧化還原電位差之日變化。

水溫爲影響越冬魚苗死亡之最重要因素，它隨着水深而遞減（圖十六）。在夜間上下層水溫之差異小而日間差異大（圖十）。水溫隨月份之推移而異，在越冬期間一般以1、2月爲最低，4 月初爲最高。同深度之不同位置亦有不同之溫度，一般差異不大約爲 0.4～0.5°C。表面水溫與氣溫有關，成直線關係（圖十七）。

浮游生物之含量可由水中混濁度表示之，混濁度愈大者愈多，它隨着水深而遞減，隨着換水後的天數而遞增（圖十八）。不同的位置有不同的含量。一般言之，進水時以矽藻（Diatoms）及綠藻類(Chlorophyceae)居多。水溫超過 20°C 時綠藻類一直持續成爲主要種，水溫低於 20°C 時則被 Dinoflagellata 所取代，其中以 *Olisthodiscus* sp. 爲最多，約佔90%。它有垂直移動之現象，

在夜間，早晨及黃昏時聚集於上層，隨着光線之增强，可下降到水深 40 cm左右之處，因而影響溶氧。又 *Olisthodiscus* sp. 之繁殖頗受有機物種類所影響（圖十九）。

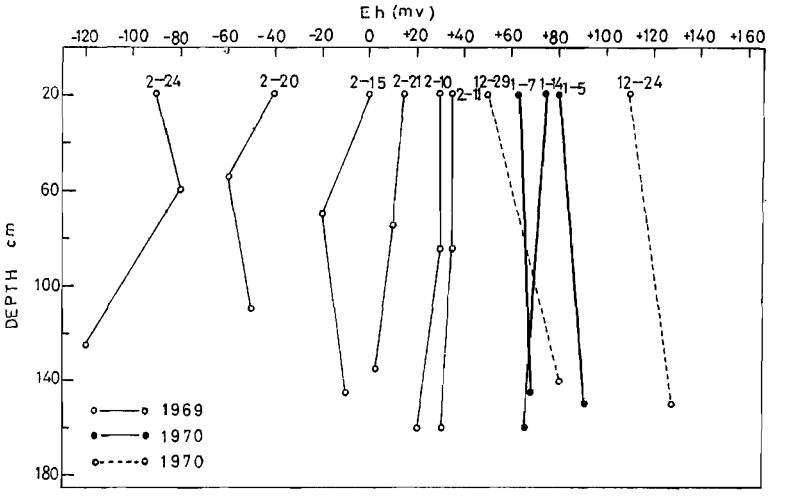

Fig. 14 Vertical distribution of Redox potential at 10 a.m. on different dates in wintering pond.

圖十四 越冬溝上午十時水中氧化還原電位差之垂直變化。

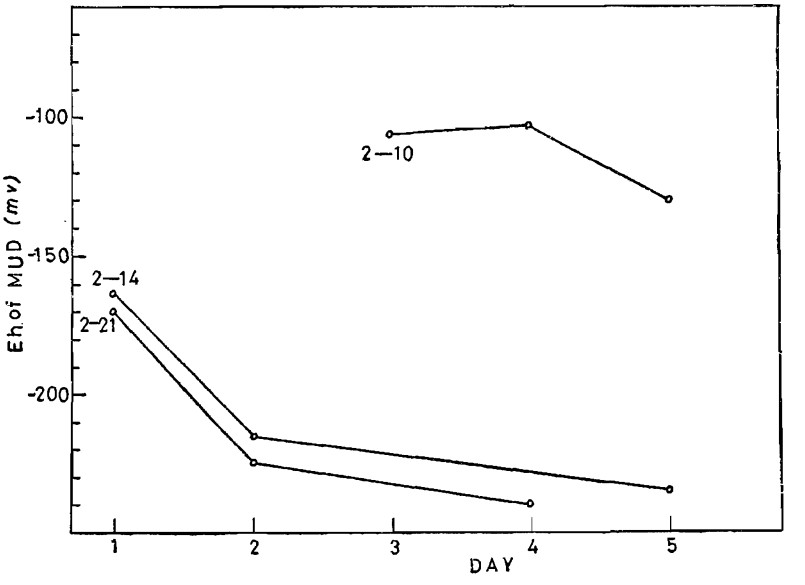

Fig. 15 Daily variation of soil Redox potential in wintering pond after water renewal.

圖十五 越冬溝換水後土中氧化還原電位差之日變化。

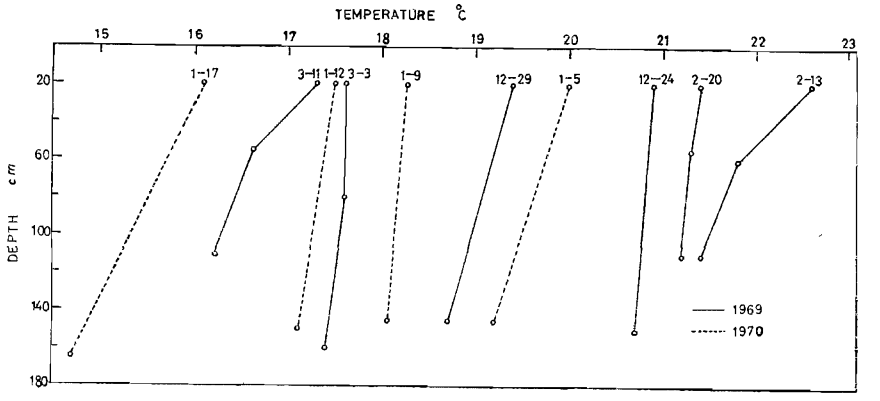

Fig. 16 Vertical distribution of water temperature at 10 a.m. in wintering pond.
圖十六 越冬溝上午十時水溫之垂直變化。

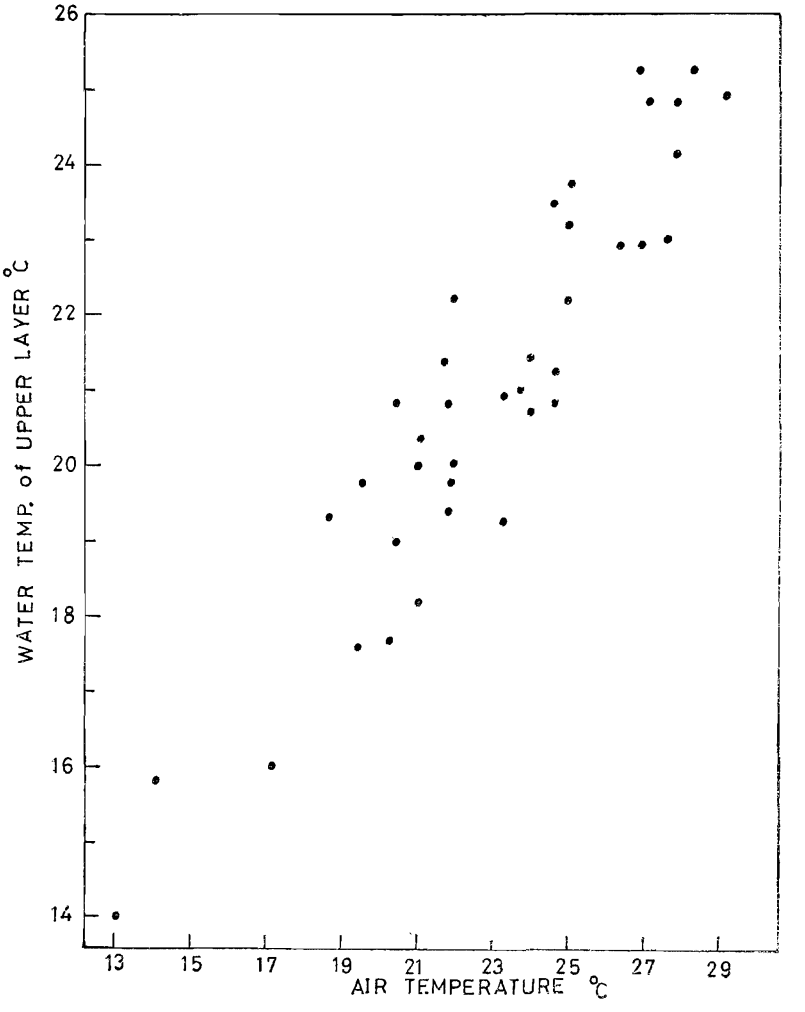

Fig. 17 Relationship between air temperature and water temperature at upper layer.
圖十七 氣溫和表層水溫之關係。

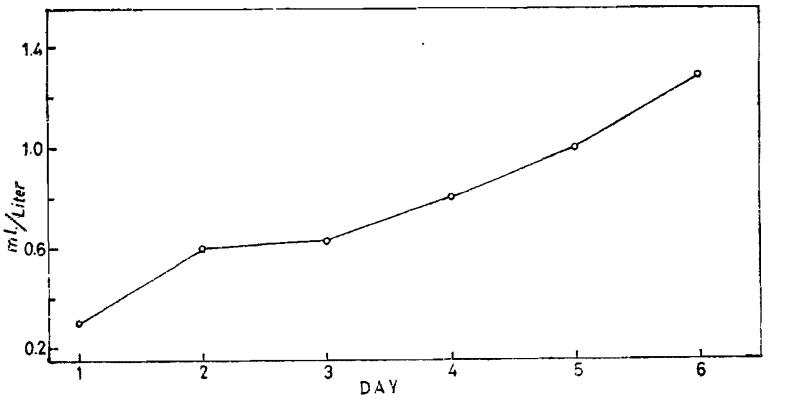

Fig. 18 Daily variation of concentration of plankton at 10 a.m. in wintering pond after water renewal.

圖十八 越冬溝換水後浮游生物量之日變化。

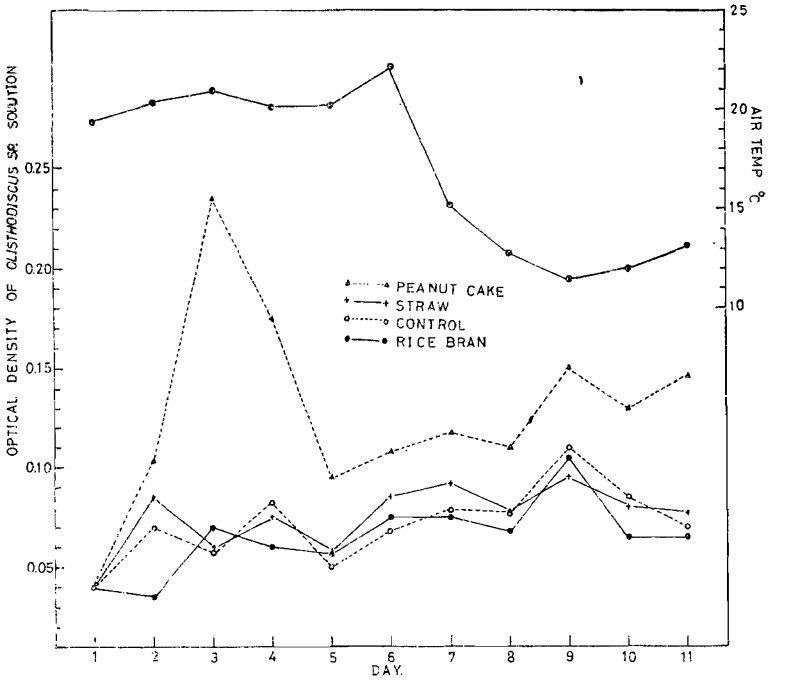

Fig. 19 Growth rate of *Olisthodiscus* sp. fed on various organic matter. The concentration of *Olisthodiscus* is judged by visual density.

圖十九 不同的有機物對浮游生物之生長影响。

四、討　　論

越冬溝水中之 pH 值一般比養成池之 pH 值 (8.5～9.5) 低，此爲常交換新鮮海水之故。而換水後 pH 值之遞增，係鹽度及浮游生物量的增加所致。且浮游生物多聚集於上層，當行光合作

用時使 pH 值升高，下層則因有機物及污染物之腐敗分解產生大量 CO_2 及有機酸而降低 pH 值，故 pH 值隨深度而遞減。Swingle (1961) 和 Stroud (1967) 指出 pH 值在9.5以下時仍適宜魚類生長，故溝水之 pH 值並不影響魚之生長及生存。

越冬期間因雨量少及受蒸發作用之影響，故鹽度隨着換水後之天數而遞增。一般的鹹水湖或內灣，鹽度隨着水深而遞增（小久保1965），但越冬溝之水深不超過 2 m，且表層之水溫常受氣溫所左右（圖十七），而致影響比重產生對流，故無普通湖沼之上下分層現象。鹽度雖比海水高，但增加之幅度不大（32～39‰），因此對於魚類及浮游生物之生理生長無明顯之影響。

透明度與水中溶存的物質及浮游生物有關，在越冬溝中受浮游生物之影響最大，換水後浮游生物之逐日增加，導致透明度之遞減。混濁度可表示浮游生物之含量，故混濁度與透明度略成曲線關係。由上層混濁度爲 70 J.T.U.，下層爲 18 J.T.U. 顯示出浮游生物大部聚集於上層，故混濁度隨水深而遞減。混濁度高，增加魚類之洗滌運動 (Cleaning motion) 次數，故對魚之呼吸可能有影響。

溶氧爲生物生存之最重要因素，與浮游生物之呼吸及有機質之腐敗有關。在低水溫之月份如12，1及2月，溶氧概受浮游生物之量所影響，如溶氧有時在中層多即因中層浮游生物較多，故換水後浮游生物之增加，使溶氧量遞增。但在3、4月則受有機質腐敗所左右，尤以水溫升高時加速其之腐敗及生物之氧化作用而減少溶氧。浮游生物在剛換水後分布均勻，故上下層的溶氧差異少，換水前浮游生物多聚集於上層，而下層日光之透入不易及底泥有機物腐敗分解，故二層溶氧相差甚大。溶氧之週日變化中，在剛換水後浮游生物及腐敗有機物少，因而晝夜之間的差異少，而在換水前浮游生物及腐敗有機物多，使差異大（圖十）。故溶氧缺乏之最可能時間當在剛換水後之夜晚或高水溫時有機物腐敗分解快之夜晚。溶氧降到 0.22 ppm 時可使虱目魚浮頭死亡 (Lin 1968)，故爲影響虱目魚生存率之重要因子。

碘消費量可爲水中硫化氫含量之指標，且與水中之亞硫酸、亞硝酸、有機酸，Phenol 及其他還原性的物質有關，故主要受生物屍體、分泌排泄物及殘餘飼料之腐敗分解所影響。換水後由於浮游生物之增加及殘餌之腐敗，導致碘消費量遞增（圖十一）。一般停滯性的水域，碘消費量隨水深而遞增（小久保1965）。但浮游生物聚集於越冬溝之上層，分泌多量有機酸及排泄物，且12、1月時更新後之溝底，溶氧情況良好，阻礙硫化還原細菌之生長，故其量隨深度而遞減。2 月以後溝底呈老化現象，溶氧少引起屍體、殘餌之分解，加速碘消費之形成，故底層居多。在放養期間 8 ppm之碘消費量對健康且肥滿度 (Degree of well being) 較大的虱目魚生長有影響，12 ppm 可致死亡（山村1942）。而越冬時之魚體消瘦，健康情況差，抵抗不良環境之能力減低，故溝中碘消費量之濃度相信對魚之生長及生存均有影響。

Eh 值主要受水中碘消費量所影響，故與碘消費量之變動頗爲一致。但有時不同之碘消費量，却有相異的 Eh 值，故知 Eh 值還與水中之有機酸及 Fe^{++}、Mn^{++}離子有關。12、1月之 Eh 爲正值而 2 月以後爲負值，此即表示越冬溝有老化之現象。一般停滯性之水域，Eh 值和碘消費量完全受溶氧量所影響，溶氧低至 8 %之飽和濃度時，才產生硫化氫及使 Eh 爲負值(Mortimer 1942)，但溝水之情況正恰相反，即換水後溶氧增加而 Eh 值却遞減（圖八與圖十三）。此可能是 *Olisthodiscus* sp. 大量增加且能於 Eh 爲負值之水域行光合作用而增加溶氧，但生物分泌之有機酸、屍體、殘餌之大量腐敗及多量之 Fe^{++}、Mn^{++} 離子，却使溝水 Eh 值遞減，再加上 H_2S 被溶氧氧化的速度較慢所致 (Richards 1965)。Eh 值雖少受溶氧影響，然 Eh 值爲負時，相信對虱目魚之生理活性將有不良影響。

有機污染物雖可在水中進行分解，但一般在底泥行之。因底泥滲水性及透氣性差，氧氣交換困難，而成還元狀態，加速分解沉積於其上之有機物，故底泥之 pH 及 Eh 都比水中之值低。不同

位置的底泥 Eh 值一般都爲負值且相異甚大，有些呈强還原性有些呈弱還原性。故對生物生存生長之影響頗大，使底棲生物如鹽水蜈蚣難於生存。

溝水營養鹽主要受注水時之含量，細菌及浮游生物之吸收及有機物腐敗分解之溶出所影響。由於浮游生物之增加導致矽酸鹽，磷酸鹽及銨之遞減，故低溫時營養鹽之溶出速度比浮游生物之吸收速度慢。而硝酸鹽之增加係因溶氧多使銨、亞硝酸氧化所致。注水後初期銨量在上層多下層少，卽因注入之水在上層居多，未完全掛換舊水之故。0.03 ppm 之銨對於魚之呼吸作用有影響，當濃度達 0.3 ppm 時其影響將更顯着。其他營養鹽對魚無多大影響。

水溫受氣溫及池水吸收太陽的熱量所影響。曬坪時的養成池雖然沒有防風屏，但鹽度較高能吸收較多之熱能，故白天之水溫常較有防風屏的越冬溝高。水色較深或浮游生物較多者，亦因能吸收較多之熱能，故比換水後初期浮游生物少時高出 0.5～1°C 左右。水溫之變化以受氣溫之影響爲最主要。在夜間氣溫低和表面水溫相接近，影響表面水溫不大，上下層之水溫差異小；白天氣溫高使上下層之水溫差異大。所以表面水溫和氣溫成迴歸直線之關係（圖十七）。因此可知越冬溝之保溫能力不良。水溫在 11°C 時可使肥滿度較大、健康良好的虱目魚冷昏（林1969）。越冬期間在飢餓及其他不良的環境下，致死之水溫當在 11°C 以上。今年 2月冷氣團長期滯留，致使四千多萬之魚苗死亡，卽因水溫低降之故。

適量之浮游生物可增加溶氧，但在過量及高溫下因其屍體腐敗分解需消耗大量溶氧，常引起泛池。*Olisthodiscus* sp. 主要受水溫、有機物及營養塩所影響，水溫較低其生長繁殖之速度較快，此爲冬季常繁生此種藻類之故。又越冬期中所投之飼料，如花生餅，亦加速 *Olisthodiscus* sp. 之繁殖，然米糠與防風屏之乾草却無顯着之影響(圖十九)。其垂直移動受光照所左右，因其不喜 20,000 Lux 以上之强光，故在中午光照最强時常下降至水深 40 cm 之處。浮游生物之繁殖變化速度快影響其他因子甚巨，增加因子間之複雜性，故爲相當重要之因子。

越冬溝之環境特殊，且各因子又相互影響變化甚大，爲減低魚苗之死亡率，故在構造，設備及管理上有改進之必要12月24日及1月3日同樣是進水，但銨之含量相差甚大，且有時含腐敗物及工業污染物，使注入水呈粉紅色，影響溶氧。故注入水宜加選擇。排水口與注水口須分開，否則排出之舊水混合新鮮海水後，又再被注入。離入水口 150 m 處（St. 3）之硫化氫、銨及混濁度一般都比其他地方高，顯示注排水並不徹底。故最好利用大潮連續三天排換，或施放嘉禾立得，健魚素以吸收有毒物，保持水質良好。泛池因可預知，故最好設有水車或以鼓浦瀑氣法增加溶氧。又殘餌之腐敗引起水質污染，增加 *Olisthodiscus* sp. 之生成，故飼料之種類與數量及浮游生物之控制宜加研究。至於水溫之提高，以較高溫之地下水或養成池之曬坪水注入，或將越冬溝加長，一部份較深(180 m)，一部份較淺（120 m），或以電力加熱溝水，均須加强研究以確保魚苗之生存。

五、摘　　要

虱目魚是臺灣養殖漁業的主要種類之一，因屬熱帶魚類不耐寒冷，爲了增加生產，其魚苗必須越冬。十年來在越冬時期的死亡率平均達14%，損失甚鉅，故須查明越冬溝之生態系統，了解死亡原因，以爲管理及改善之參考。本試驗是從民國 58 年到 60 年每年冬天在越冬溝所作，獲得如下結果：

1. 上午10時之 pH 值、溶氧、水溫、混濁度及浮游生物量，雖隨水深而遞減，但變化率小。且銨、亞硝酸、硝酸、矽酸塩、磷酸塩及塩度之分布與水深無關。而碘消耗量、Eh 值則隨月份而變，故溝水無顯着垂直分層之現象。

2. pH 值、溶氧、塩度、混濁度、硝酸塩、碘消費量及浮游生物量皆隨換水後之天數而遞增。而磷酸塩、矽酸塩、水中及土中之 Eh 值則遞減。至於亞硝塩、銨塩則不一定。

3. 碘消費量和 Eh 值之變動頗爲一致。且二者皆不受溶氧所影響。Eh 爲負值且碘消費量高之水中溶氧仍在飽和溶度之上，此可能是 *Olisthodiscus* sp. 能在此種環境下行光合作用所致。

4. 混濁度與透明度約略成曲線關係，二者都可表示浮游生物之含量。越冬溝之棕色水以 *Olisthodiscus* sp. 爲最多，約佔浮游生物總數之90%，具有垂直運動之現象。在低水溫且花生餅含量較多之水中，可加速其繁殖，在高水溫下則綠藻類取而代之爲優佔種。

5. 底泥之 pH 及 Eh 都比水中之值低，且 Eh 爲負值呈還元狀態，故物質之腐敗分解溶出大部在此進行，使底棲生物難於生存。

6. 低溫爲魚苗致死之主要因素，受氣溫影響最大，表層水溫與氣溫成迴歸直線之關係。現有越冬溝之保溫能力不完善，有改進之必要。

7. 溶氧主要受浮游生物之多寡及有機物腐敗速度所影響，故溶氧之缺乏可以預測。其發生必在剛換水後之當天夜晚或高水溫下有機物腐敗分解快速之夜間。若用水車或鼓浦曝氣法當可避免泛池。

8. 除水溫及溶氧外，多量之銨、碘消費量、浮游生物及負值之氧化還原電位差可能影響魚苗之生存與生長。至於 pH、塩度、亞硝酸及硝酸塩、矽酸塩、磷酸塩則無關重要。

六、謝　　辭

本研究工作承農復會林書顏先生及省水產試驗所臺南分所謝錫欽分所長之指導；日本淡水區研究所里見至弘博士給予許多有價值之啓發和討論；臺南分所丁雲源、黃丁郎等先生提供寶貴意見；及臺南分所各位同仁在工作上之協助；又圖表由謝明鏗先生協助繪製；本稿並得農復會陳組長同白之核閱。謹致最大謝忱。

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虱目魚塭褐水之防治

Studies on the Control of Brown Water in Milkfish (*Chanos Chanos*) Ponds

沈時霖・江永棉

Abstract

Formation of brown water in milkfish ponds used for wintering purpose was found to be due to a bloom of *Olisthodicus carterae*.

To find a method to control the formation of the bloom, *Olisthodiscus carterae* was cultured in different salinities and treated with various concentrations of $CuSO_4$, CaO and bleaching powder.

Olisthodiscus carterae grew well in a wide range of salinities, but growth was completely suppressed at salinities from 3.55 to 8.87‰. The organisms of this species did not grow at higher concentration of $CuSO_4$ and bleaching powder, but its growth was not affected by CaO.

前　　言

本省虱目魚塭雖均分佈於於北緯 23°40′ 以南[1]，但除最南之東港地區外，每年 11 月至翌年3月均因溫度較低，不適於虱目魚之生長，故需修築東西走向之越冬溝，水深 1.5～1.8 公尺，於其北面架有傾斜之擋風草棚，以避寒風，於擋風草棚上留有通風窗，當氣溫較高時打開以免池水缺氧。越冬溝前有淺坪供虱目魚運動及覓食，二者間以水門相連[2]。由於越冬溝內單位體積之放養密度大，可達 1.3 kg/m³ 或更多，致使魚類之排泄物聚集頗多，再加上草棚落下茅草之腐敗及隨雨水流下之茅草浸出液，致使水中含有多量之有機物，造成一種褐色浮游性之鞭毛藻 *Olisthodiscus carterae* 之大量繁殖，使整個越冬溝之池水均呈深褐色，卽一般漁民所謂之醬油水。由於 *O. carterae* 之大量繁殖，致使池水於夜間之溶氧降低至零[3]，造成虱目魚之窒息而死，此乃於晨間發現泛池之原因。或因水中溶氧缺乏，虱目魚浮頭時造成凍傷，而漸死亡[3]。如果天氣良好時可時常換水，以避免*O. carterae* 之爲害。但是如果碰到長時間的寒冷無法換水時，*O. carterae* 就會造成危害。爲防止 *O. carterae* 對魚塭的危害，我們試用各種無顯著毒性的藥物處理，以謀解決的方法。

材料及方法

本實驗所採用之實驗用水是採自水產試驗所臺南分所第三號越冬池，以抽水機抽起，用浮游生物網過濾後加熱至 70°C 放冷備用。於40公升容量之玻缸內注入消毒過之海水30公升，及土壤抽水液 (Soil Extract) 100 ml[4] 再加入 *O. carterae* 使水變成暗褐色，靜置於 3000 lux 之日光燈下 (7 a.m.-6 p.m.) 。一日後分別加入各種濃度之各種藥品，並於每日下午三點時用 Shimadzu Spectronic-20 以 430 mμ 之波長測其混濁度，然後以百分比表示 *O. carterae* 之生長情形，同時爲實驗所加藥品對虱目魚是否有不良影響每一缸內各加入五尾長 4.1～4.8 公分之虱目魚。

結　　果

爲抑制 *O. carterae* 之生長，茲用各種化合物處理並獲得其結果如下。

1. 鹽度 (Salinity)

將池水中加入蒸餾水使成各種鹽度，然後觀察 *O. carterae* 之生長情形。由表一可看出鹽度 3.55 至 8.87‰ 時能抑制 *O. carterae* 之生長，鹽度在 17.75‰ 時繁殖最快，鹽度在 26.63～35.5‰ 時生長率無變化。因虱目魚系廣鹽性之魚類，故鹽度由 3.55～35.50‰對其生長皆無影響。

2. 硫酸銅 ($CuSO_4$)

將已溶好之硫酸銅濃溶液，慢慢加入各玻璃缸至所需之濃度。溶有 3，5 和 7 ppm 硫酸銅之培養液中 *O. carterae* 之生長被抑制並沉到玻璃缸之底部。可是 0.5 ppm 之硫酸銅對 *O. carterae* 之生長並無大影響。1 ppm 之硫酸銅最初影響不顯著，但一週後約可抑制30%之生長。 10 ppm 以下之硫酸銅對虱目魚無顯著的毒性發現。

3. 生石灰 (CaO)

由表三可看出生石灰對於 *O. carterae* 之生長無顯著的影響。 15 ppm 以下時對於虱目魚無顯著的危害，但是高達 15 ppm 以上時，則不利於虱目魚之生存。

4. 漂白粉 (Bleaching Powder)

先將漂白粉於有栓的三角燒瓶內溶解成濃溶液，然後分別依所需之濃度加入各玻璃缸內。 由於初生態氯的作用使各玻璃缸均發生顯著的變化， 20 和 30 ppm 者立刻變爲乳白色 ，顯然將各種浮游生物漂白之故，所養之虱目魚亦因中毒立刻死亡。 15 ppm 之量雖不致立刻完全變白，但是魚因慢性中毒在數小時內逐漸死亡。5～10 ppm 者毒性比較不烈，但亦能使 *O. carterae* 死亡50%。

表一：鹽度對 *O. carterae* 生長的影響， 係與對照比較之生長百分比及其毒性對虱目魚致死之比率

鹽　　度	3.55	8.87	10.65	17.75	26.63	28.4	31.98
O. carterae 之生長比	0	10	40	110	98	100	100
虱目魚之死亡比	1/5	0	0	0	1/5	0	0

表二：硫酸銅對 *O. carterae* 生長之影響，係與對照缸比較之生長百分比及其毒性對虱目魚之致死比

硫酸銅 ppm	0.5	1	3	5	7
O. carterae 之生長比	100	70	20	10	3
虱目魚之死亡比	1/5	0/5	1/5	0/5	1/5

表三：生石灰水溶液對 *O. carterae* 生長之影響，係與對照缸比較之生長百分比及其毒性對虱目魚致死之比

生石灰 ppm	5	10	15	20	25
O. carterae 之生長比	100	90	99	89	85
虱目魚之死亡比	1/5	2/5	3/5	5/5	5/5

表四：漂白粉對 *O. carterae* 生長之影響，係與對照缸比較之生長百分比及其毒性對虱目魚致死之比

漂白粉 ppm	5	10	15	20	30
O. carterae 之生長比	50	45	30	0	0
虱目魚之死亡比	$^{0}/_{5}$	$^{3}/_{5}$	$^{4}/_{5}$	$^{5}/_{5}$	$^{5}/_{5}$

表五：三次試驗對照缸虱目魚死亡之比率

次數	一	二	三
虱目魚之死亡比	$^{2}/_{5}$	$^{0}/_{5}$	$^{1}/_{5}$

討　論

越冬池虱目魚苗常因天氣嚴寒而大量被凍死，此外水池中之溶氧量的缺少也可引起魚苗之死亡[3]。水池中之溶氧量在正常狀況下不會有缺乏的現象。但是如果水池中之浮游生物大量增加，同時再加上其他環境因素之改變則將引起缺氧現象。由前報[5]我們發現 *O. carterae* 之大量發生常使越冬池水呈濃醬油顏色。我們雖然沒有發現 *O. carterae* 對虱目魚有任何直接危害，但是很顯然地該藻之大量發生，將使越冬池在夜間易呈缺氧之現象。

由本實驗結果我們發現改變池水之鹽度能防止 *O. carterae* 的大量繁殖。即使池水之鹽度保持在10.65‰以下就可以。實際工作上，要減低鹽度之唯一方法爲加入淡水。

今年水產試驗所臺南分所之越冬溝不斷換水，使池水保持良好，所以虱目魚之死亡率較去年同月份越冬溝水色呈深褐色時虱目魚之死亡率爲小。今年（61年）2 月 28 日寒流來襲，延續達一週之久，造成虱目魚之大量死亡，但是於越冬溝中加入無鹽份之地下水者（如布袋之新塭）却能防止虱目魚之死亡。加入無鹽份之地下水一者可使水溫增加，再者鹽度減低，浮游生物大量死亡，減少溶氧之消耗。更由於加入地下水使池水之溶氧增加，由於溶氧之增加，使虱目魚能獲得充份之溶氧，進而增加對寒冷之抵抗力。故於虱目魚塭處開鑿深水井爲一值得推廣的方法。

除利用淡水冲淡越冬溝之池水防止 *O. carterae* 繁殖外，利用 $CuSO_4$ 抑制 *O. carterae* 亦爲可行之方法。尤其是利用 1 ppm $CuSO_4$ 以每 4～5 日處理一次，至水色轉好爲止，或用 2～3 ppm 處理待水色轉壞時再處理一次，均爲可行之方法。此法不致把 *O. carterae* 或其他藻類全部殺死，而僅是使其密度變得較小，使其於日間可行光合作用，增加池水之溶氧，於夜間時不致消耗過多的溶氧，以免危害虱目魚之生存。少量植物性浮游生物的存在，可維持越冬溝中生態的平衡，以免植物性浮游生物之全部被消滅而使橈脚類，輪蟲類等餓死或被毒死，而使虱目魚喪失食料[5]。低濃度之硫酸銅似乎對虱目魚沒有顯著毒性。所以用硫酸銅的處理是很可應用的。至於 Cu^{++} 對於魚體的聚集情形有待進一步之研究。

漂白粉遇水即產生初態氯，具有很大的毒性，對虱目魚及 *O. carterae* 皆能致死。而石灰對 *O. carterae* 無顯著的影響，故皆爲不適利用之藥物。

根據 Igonifagha 於水產試驗所臺南分所 31，33 號試驗池養殖虱目魚之經驗，每池面積各爲 0.3475公頃，各池均飼養一千五百條，由於放養數量少，底藻不致被虱目魚吃完，所以底藻發育良好，以致水色清澈，同理若夏季在越冬溝前淺坪施肥，曬坪，培養底藻，則不但能供給越冬魚之餌料，減少餌料費用之支出；而且可因藻類之繁殖，使水質良好。

謝　　辭

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Some Parasites Found in Pond Fishes of Taiwan (I)

Yen-pin Li and Shiu-nan Chen

Introduction

It has been known that under culture conditions, some parasitic diseases of fishes may occur frequently, causing catastrophic losses. On Taiwan there are over 5,000 hectares of fish culture ponds. To prevent catastrophic losses, studies of parasitic diseases of domestic fishes are necessary.

Although several general surveys of land animal parasites have been made here, no extensive investigation of parasites of fishes has been done. The present work was undertaken in an effort to gain some knowledge of parasitic fauna in the fishes used for pond stocking in Taiwan. This report is limited to the species of parasites we collected. All the species of parasites described were based on observations of the parasites collected. Whenever possible, a biological discussion and treatment of the specific parasite are included. All photographs and drawings were made from specimens collected in this survey.

The present study deals with data on fish parasites collected from September 1971 to March 1972. Collections were made mostly in northern Taiwan. This survey is not complete, so we hope that the work will be continued.

Review of Literature Published in Taiwan

In classifying the parasites, Harada (1930) reported one species of parasitic copepod, *Ergasilus japonicus*, a new species, infecting *Pseudorasbora parva* and *Pararasbora multrechti* in the Tamsui River. In 1938 Harada also found *Micracanthocephalus motmurai* infecting *Zacco temmindki* and *Zacco platypus; Micracanthocephalus dakusuiensis* n. sp. infecting *Zacco temmindki; Rhadinorhynchus nudus* n. sp. infecting *Trachurus japonicus;* and *Eosentis formosanus* n. sp. infecting *Zacco temmincki.* Lu (1954) stated that costia frequently infected the skin of fish; and lernaea, the mouth cavity and gill of freshwater fishes. Genus *Lernaea* found on Taiwan fresh water fishes was studied by Ho in 1961 who described two species: *Lernaea cyprinacea elegans* and *Lernaea parasiluri* Yü in detail. Wu (1968) reported that, in Taoyuan, of the two lernaea species *Lernaea parasiluri* Yü was the more harmful.

As to eel parasites, Ko (1969) stated that *Lernaea* sp. was found on the ventral fin, dorsal fin and in the mouth cavity of the eel. An (1967) identified a parasite in the air bladder of the eel as *Anguillicola globicep* Yamaguti.

Concerning the treatment of fish parasitic disease, Lu (1954) treated costia infected fish with 2% NaCl; gyrodactylus infected fish with 1:1,000 0_3; and lernaea infected fish with Ca(C10)C1. Chen (1954) suggested changing the water as soon as argulus infection was detected. Ko (1969) claimed that lernaea on eel was cured by 3 ppm Dipterex. Chang (1968) treated the last stage of lernaea larvae with 0.5 ppm of Dipterex and found it to be 91.4% effective.

Material and Method

Specimens of fish and parasites were taken every two or three weeks in the six months from September 1971 through March 1972. In addition, pond fish suspected of infection or disease were brought to the Laboratory for examination as soon as the pond owner noticed the symptoms. Most of the specimens were taken from the ponds in northern Taiwan.

Roger's method (1967) was adopted for the collection of trematodes. During this process, the gills were removed from the fish and put in a container of 1: 4,000 formalin solution, while the body was placed in another. Trematodes collected from the solutions were studied immediately or preserved in 5% formalin solution for further examination.

Protozoans were studied in vivo and in smears fixed in Schaudinn's solution or 10% formalin and stained with iron hematoxylin. Copepods were preserved in 70% alcohol or 10% formalin and then examined.

Results and Discussion

(A) Protozoans

1. *Ichthyophthirius multifiliis* (Fig. 1)

Host and locality: *Hypophthalmichthys molitrix, Ctenopharyngodon idellus, Cyprinus carpio, Aristichthys nobilis, Anguilla* sp., on fins and skin.

Remarks:

Ichthyophthyriasis, or white spot disease, has long been known as one of the major problems of fish culture in Taiwan, (Lu 1954, Chen, 1954). In the course of this survey, this parasitic disease was found mostly in March (1972) when water temperature suddenly rose. The disease was caused by ciliated *Ichthyophthirius multifiliis*, which when fully grown is round, about 1 mm in diameter, having a number of contractile vacuoles and granules scattered throughout the body.

The infected fish is characterized by the appearance of numerous small white spots on the fins and the skin. The ecology of *I. multifiliis* has been fairly well studied. The parasite penetrates the mucous coat and the upper layer of the epidermis, forming a bladder under the skin and growing in it. When the parasite is full grown, it ruptures the bladder and leaves the the host, settling down on some object and secreting a cyst. Within the cyst, the parasite undergoes rapid division forming 500-1,200 young parasites. The young parasites swim in the water for a few hours, searching for hosts. According to Suzuki (1935), temperature is a major factor affecting the development of this parasite.

Due to the fact that no known chemical is effective in killing the parasite in the skin of fish, the chemotherapeutic treatments of this disease are directed towards the extermination of cysts and young parasites in the water. For this purpose, baths containing NaCl, formalin and quinine are effective.

2. *Trichodina* sp. (Fig. 2)

Host and locality: *Anguilla* sp., on gills and skin.

Remarks:

This parasite was found in eels in Taoyuan in March 1972. Six sluggishly swimming eels were examined and found infected by this protozoan. Massive attachment of *Trichodina* on the gills and skin caused the increase of mucus secretion, sluggishness and loss of appetite. Egusa (1970) mentioned that the presence of *Trichodina* did not injure the gills directly but might cause difficulty in breathing.

Trichodina is very easy to control. Davis (1953) proposed the use of a 3% NaCl solution or a 1:500 solution of acetic acid or a 1:4,000 solution of formalin.

3. *Myxobolus* sp.

Host and locality: *Carassius auratus*, in muscle and connective tissues.

Remarks:

Although the common carp, silver carp and grass carp are cultured with the goldfish (*Carassius auratus*), the infection of this parasite is strictly restricted to the goldfish. The infected fish grows two large tumor-like masses on the dorsal region just posterior to the head, as shown in Fig. 3. There is no age limit to the infection by this parasite. The infection does not cause the death of fish, but the fish loses commercial value.

This parasite belongs to the order *Myxosporidia* (Kudo, 1954). Spore is ovoid, posterior slightly wider, suture straight, iodophilous vacuole present,

two polar capsules are of equal size. Spore measurements, 11.7 micron by 7.6 micron; polar capsule, 4 micron by 2.7 micron (Fig. 4).

Up to now, there is no known specific cure for sporozoan diseases.

4. *Myxidium* sp.

In the present survey, three species of the genus *Myxidium* were encountered in the eels collected from Shihlin in October 1971.

a. *Myxidium matsuii* (Fig. 5)

Host and locality: *Anguilla japonica,* on skin.

Remarks:

Whitish pimples of about 1.2 mm in diameter were noticed on the body surface of an eel. By smearing the content of the pimple onto a microscope slide and examining it under high power lens, the writers observed that the spores morphologically agreed with the description given by Hoshina (1952) for *Myxidium matsuii* Fujita. In fresh preparation, the spore was 12.4 micron by 8.0 micron in size, oval shaped and obtusely pointed at both ends. The shell exhibited longitudinal striation on the surface. The sutural ridge and the line were indistinct. The two polar capsules were equal in size and almost spherical.

According to Hoshina (1952), *M. matsuii* invades the corium of the host and develops by forming spores in the cysts. When the spores mature, the cysts break easily and discharge a large number of spores. However, as soon as the contents of the cysts are completely discharged, the wound heals itself.

b. *Myxidium* sp.

Host and locality: *Anguilla japonica,* on gill.

Remarks:

Four large eels (all over 42 cm in length) were found excreting mucus in the gill excessively. When the gills were examined, a number of white opaque spots of 0.6-1.0 in diameter were observed. Under microscopic examination, these spots were aggregations of spores. The spindle-shaped spore (Fig. 6) was 10.7 micron by 4.6 micron; the two polar capsules were of equal size, pear-shaped, 3.6 micron by 3 micron.

The attack of this organism on the gill may cause hypertrophy of both epithelial and connective supporting tissue of the gill filaments, which,

in turn, may result in difficult breathing of the victim.

c. *Myxidium* sp.

Host and locality: *Anguilla japonica,* in kidney.

Remarks:

In two eels, microsporidian was found in the muscles and myxidium was found in the kidney. The kidney infected by myxidium was abnormally large. The spore was 12.5 micron long by 4 micron wide, showing two polar capsules which were equal in size, pear-shaped, 3.5 micron long by 3.2 micron wide. The coiling of filament in polar capsule was indistinct (Fig. 7).

5. *Plistophora anguillarum* Hoshina, 1951

Host and locality: *Anguilla japonica,* in muscle.

Remarks:

This parasite belongs to the order *Microsporida.* Plistophora disease is found in almost every eel pond in Taiwan. Because the course of this disease is not acute and the sick fish remains alive for a considerably long time (Hoshina, 1951), the infection has been observed in eels of every growing stage.

The eel infected by *Plistophora anguillarum* shows a deformation of trunk muscle, as shown in Fig. 10. In the swollen portion, there are cysts scattered among the muscle fibers (Fig.8). Hoshina (1951) stated that the swollen parts indicated the developments of cysts in the tissue which had not yet been disintegrated. The collapsed parts indicated complete disintegration of the muscle tissue. In the cysts, there are many sporonts, each of which contains numbers of spores (Fig. 9), some containing more than 16 spores. In the fresh preparation, there is a vacuous portion in the posterior portion of the spore where several transverse lines can be observed. The sporoplasm looks like a narrow girdle located near the middle of the spore. The polaroplast which has two parts, the chromophilic portion and the chromophobic portion (Putz, 1970), extends from the anterior end to the posterior part of the spore.

There is no known treatment of this disease so far. The only method to prevent the prevalance of this desease is to remove the infected fish from the healthy ones.

(B) Trematoda

1. Dactylogyrus sp.

Host and locality: *Anguilla* sp., on gill.

Remarks:

In the six eels taken from Taoyuan in March 1972, in addition to *Ichthyophthirius multifiliis* and *Trichodina* sp., *Dactylogyrus* sp. was found on the gill (Fig. 11). The *Dactylogyrus* sp. is about 3.05 mm long by 0.8 mm wide, having two pairs of eyespots near the anterior end, 8 pairs of hooks of similar shape and size except one pair which are smaller (Fig. 12).

Davis (1953) indicated, "If the parasites become very abundant, injury to the gill may be so extensive as to cause the death of the host .....When the same fish is infected with the ectoparasitic protozoans, the results may be disastrous." The massive mortality of the eels in the Taoyuan ponds in March 1972 might have been due to the dual infection of *Trichodina* sp. and *Dactylogyrus* sp. on the gill.

(C) Parasitic copepod

1. *Lernaea* sp.

In the present study, two species of lernaea were found.

a. *Lernaea cyprinaea elegans*

Host and locality: *Carassius auratus*, on skin.

Remarks:

This species was found in Taoyuan only. According to Harding (1950), there are two forms of this parasite. The difference is based on Y-shaped or T-shaped anchor process. Our specimens are all of Y-shaped, so-called Japanese form. The same conclusion was reached by Ho (1961).

b. *Lernaea parasiluri* Yu, 1938

Host and locality: *Hypophthalmichthys molitrix*, *Aristichthys nobilis*, *Ctenopharyngodon idellus* and *Carassius auratus*, on skin and fin.

Remarks:

This species of *Lernaea* is found in Taoyuan, Neili, Lukang and Tainan. It is better known, more widely-spread and causes more harm (Ho 1961, Chang 1968, Wu 1969). According to the anchor process of this species, Ho (1961) divided it into 8 types. In our specimens, type 1&1 predominated.

The lernaea usually lives on the surface of the body. It eats away the scales, penetrates into the subcutaneous tissue and causes considerable structural damage. It may even destroy the fin. From the injury to the

skin and the fin, other bacterial infection may result. The high infection intensity causes the death of fish. This genus of copepod was found in each of the months from September 1971 to March 1972. It is probable that the parasite is found on the fish throughout the year. As for the cure of this parasitic disease, Chang (1968) used Dipterex 0.5 ppm to kill the larvae. NaCl in 1.023-1.024 % concentration is also effective in lernaeosis.

2. *Argulus* sp. (Fig. 13)

The number of species of *Argulus* in Taiwan has not been determined, but the writers collected only *Argulus japonicus* in November 1971.

Argulus japonicus Thiele, 1910

Host and locality: *Tilapia* sp., on skin.

Remarks:

This species was collected from tilapia in the Tainan Fish Culture Station ponds. The body lengths of the specimens: female 2.7-4.8 mm and male 1.0-3.2 mm.

Argulus infestation usually occurs from October to following April. In Taiwan argulus not only kills the fingerlings but also adult fish. It killed tilapia in Tainan. Living on the fish gill or the skin which it penetrates with its proboscis and sucking the blood of the host, argulus causes general weakening of the victim. According to a number of authors, argulus also causes other bacterial or fungus infection in fish causing more serious damage than general weakening.

An effective method of treatment for argulus infection is BHC in 0.5 ppm. In his review, Herman (1970) mentioned the ill effects of BHC treatment, and recommended the use of Dylox (Dipterex, Neguvon) instead to treat this parasitic copepod.

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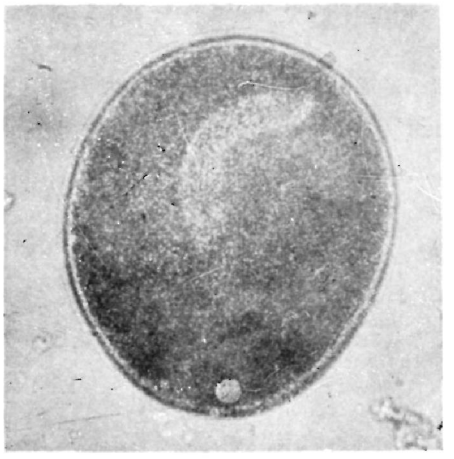

Fig. 1. Adult of *Ichthyophthirius multifiliis* (125 X).

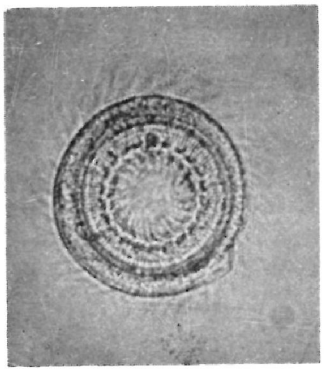

Fig. 2. Fresh preparation of *Trichodina* sp.

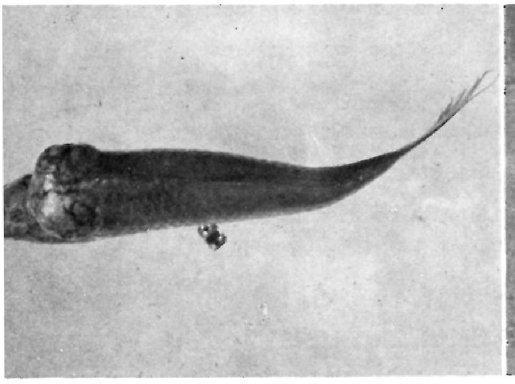

Fig. 3. Dorsal view of the goldfish infected by *Myxobolus* sp.

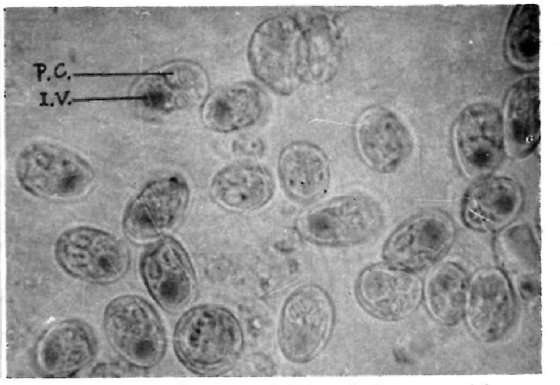

Fig. 4. Spores of *Myxobolus* sp. with iodophilous vacuole (1125 X). I.V., Iodophilou vacuole P.C., Polar capsule

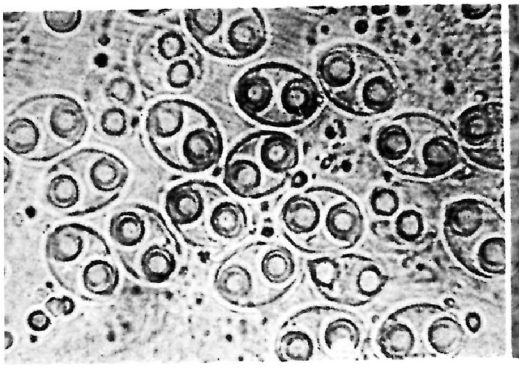

Fig. 5. Spores of *Myxidium matsuii* (1125 X).

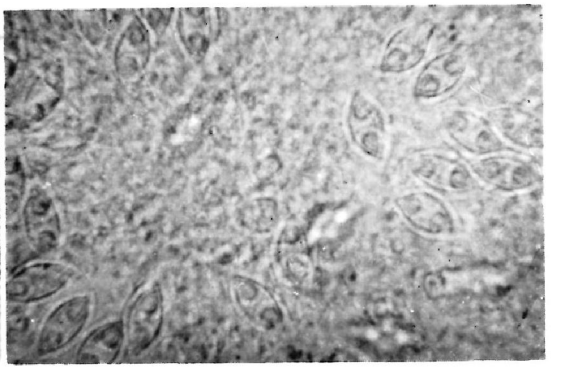

Fig . 6. Spores of *Myxidium* sp. from the gill of *Anguilla japonica* (1125 X).

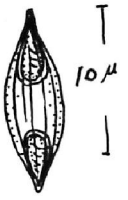

Fig. 7. Spore of *Myxidium* sp. from the kidney of *Anguilla japonica*.

Fig. 8. Spore cysts in muscle of *Anguilla japonica* (125 X).
M., Muscle
S.C., Spore cyst

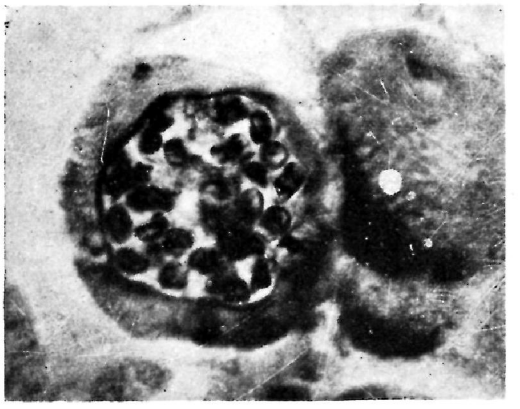

Fig. 9. Spore cyst of *Plistophorus anguillarum* in muscle fiber stained with iron hematoxylin (1125 X).

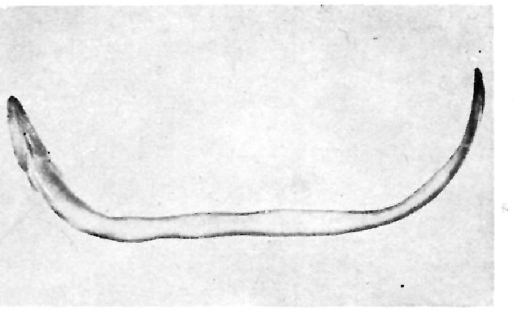

Fig. 10. Body deformation of *Anguilla japonica* caused by *Plistophorus anguillarum*.

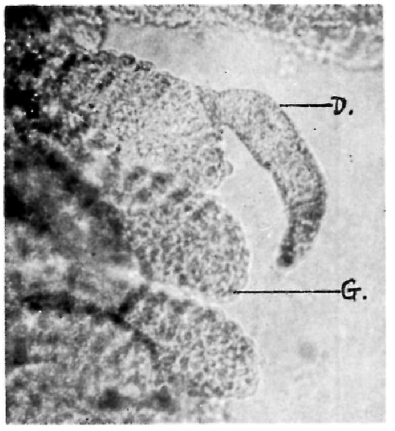

Fig. 11. *Dactylogyrus* sp. on the gill of *Anguilla* sp.
D., *Dactylogyrus* sp.
G., Gill

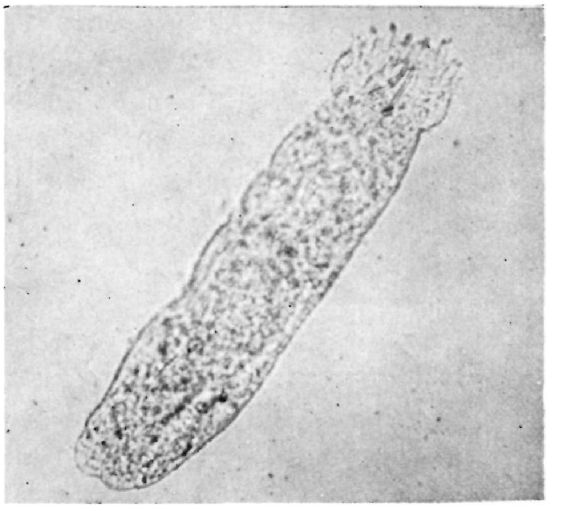

Fig. 12. *Dactylogyrus* sp.

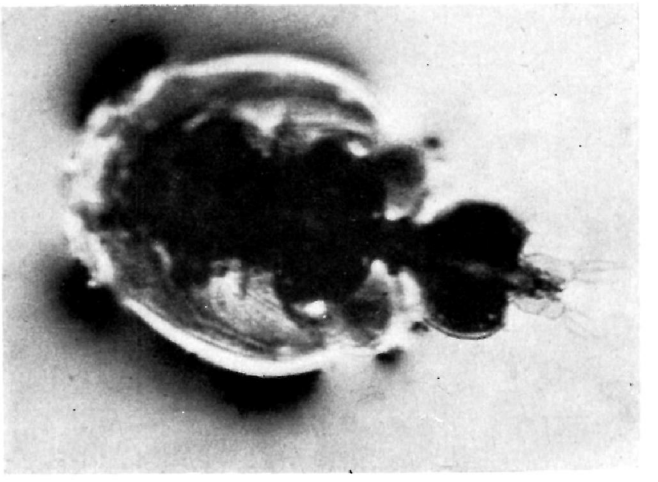

Fig. 13. *Argulus japonicus.*

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塘虱魚之人工繁殖試驗

Experiment on Artificial Propagation of the White-Spotted Freshwater Catfish, *Clarias fuscus* (Lacépède)

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Abstract

The purpose of this experiment was to produce by induced spawning fingerlings of the white-spotted freshwater catfish for culture in ponds. Fertilized eggs were obtained from four spawners that received injections of pituitary gland and Synahorin. The milt for fertilization was obtained by cutting open the sperm roes. The fertilized eggs were hatched in aerated water.

The two spawners that received fresh pituitary gland of common carp plus Synahorin achieved 100% ovulation, 90% fertilization and 95% hatching rate. The two spawners that received vacuum dried pituitary extract from common carp plus Synahorin achieved only 60% ovulation, 60% fertilization and 85% hatching rate.

The larvae were fed with egg yolk and brine shrimp larvae. The survival rate on the 40th day after hatching was 80 to 90%.

一、前　　言

塘虱魚 *Clarias fuscus* (Lacépède) 在本省俗稱「土殺」，產於全省各地河川沼澤或田野圳溝中，喜成羣棲息於洞穴土窟，嗜食動物性食物。通常每年四月至九月期間爲其生殖季節。一般成熟之種魚，其體重約在150～200公克。雌魚之抱卵數爲4,000～6,000粒。雄魚軀體較小。

塘虱魚煮湯，味美甘芳，一般人認爲極富營養，可滋補身體。市價頗高，目前每臺斤約50元左右。此魚生存力極强，可耐惡劣環境，生長迅速，值得推廣養殖。不過，近年來因本省工業發達，工廠所排出之廢水以及農村普遍使用之農藥殘餘等，嚴重污染魚類棲息之湖泊河川，以致一些淡水魚類之種苗愈來愈缺乏。此外電捕毒殺皆嚴重損害幼魚。

爲發展是魚之養殖，筆者等三人於民國59年9月19日至10月29日，在屏東縣某養鰻場以鯉之腦下腺及胎盤性腺刺激賀爾蒙（Synahorin）混合注射，共處理雌魚八尾，採卵授精，作人工繁殖試驗，共獲稚魚6,000餘尾，存活良好，成長第40天時體長達三公分。此次成功爲本省塘虱魚人工繁殖成功之首例。茲將其試驗經過結果報告如下：

二、材料與方法

㈠ 材料

1. Tainan Fish Culture Station, Taiwan Fisheries Research Institute
2. Tungkang Marine Laboratory, Taiwan Fisheries Research Institute

種魚　塘虱魚雌雄各八尾，平均體重約 170公克，爲已在魚池中飼養約一年者。雌魚腹部肥大柔軟，約已成熟，雄魚腹小堅實。雌雄以手觸摸其腹部卽可辨別。

腦下腺（Pituitary gland）　本試驗中使用兩種不同之活鯉腦下腺與瓶裝乾製之鯉腦下腺精製液*。活鯉係魚池養成者，每尾重 600公克以上。瓶裝之腦下腺有 a 瓶與 b 瓶兩種，a 瓶爲來自二尾鯉魚之腦下腺（魚共重610克），b瓶則爲來自三尾者（魚共重1,100克）。

胎盤性腺刺激賀爾蒙（Synahorin）　瓶裝，每瓶爲 20 R.U.（家兎單位）係日本帝國臟器株式會社製品。

其他材料　一切實施人工繁殖之器材及孵化設施，如剪刀、注射針筒、乾羽毛、紗布、小盆、吊網、箱網、水族箱等。

㈡ 方法

賀爾蒙之處理　將雌魚分 A、B 兩組處理，每組各四尾。A 組以活鯉之腦下腺混合 Synahorin，每尾注射藥量相同，皆爲0.5個腦下腺及 10 R.U. 之 Synahorin，隔六小時後注射第二針，其量爲腦下腺每尾 0.5個，Synahorin 每尾 5 R.U.。B 組則使用乾製之鯉腦下腺碎出液，亦混合 Synahorin 使用。第一針共用兩個 a 瓶之腦下腺及 40 R. U. 之 Synahorin，六小時後之第二針則改用兩個 b 瓶腦下腺與 20 R.U. 之 Synahorin。兩組皆行肌肉注射。

人工授精　行乾導法授精。以剪刀解剖活的雄魚，取出其體內的精巢，再予剪碎擠出精液，然後混入乾盆中已採出之卵中（採卵時儘量避免水混入），迅速以乾羽毛攪拌均勻後，加入些許清水，再予攪拌後，靜置片刻，用清水滌洗數次，以去除多餘之精液雜物，如此便完成人工授精之步驟。

孵化方法　此次試驗因在野外之養鰻場實施，孵化之器材設備受到限制。此次僅採用簡單之吊網、箱網，水族箱等方法孵化。其中吊網以流水式行之，箱網置於止水中，水簇箱則加以打氣。另外攜部份受精卵返回實驗室進行吊網孵化及觀察孵化過程。

三、結　　果

此次試驗共獲塘虱魚苗6,000餘尾。茲將其經過與結果分述於後：

表一　塘虱魚人工繁殖之經過與結果

組別	第一針 時間	第一針 份量(4尾)	第二針 時間	第二針 份量(4尾)	排卵 尾數	排卵 %	採卵 尾數	授精 時間	授精 %	孵化 時間	孵化 %	活存 尾數	活存 %	備註
A	9月19日 8：00 p.m.	2p ＋ 40R.U.	9月20日 2：00 a.m.	2p ＋ 20R.U.	4	100	2	9月20日 15：30 p.m.	90	9月21日 23：00 p.m.	95	4,800	90	A組採得卵數較多
B	同上	2a瓶 ＋ 40R.U.	同上	2b瓶 ＋ 20R.U.	3	70	2	同上	60	同上	85	1,300	80	B組採得卵數較少

註：本次試驗因孵化設備有限，排卵七尾中僅採卵施行受精四尾。本表之孵化率是在流水吊網中者。活存率則計算至孵化後第40天，體長達三公分者。

1. 注射腦下腺與 Synahorin 於第一針六小時後未見雌魚腹部膨脹，第二針六小時後（卽第一針12小時後）始見有明顯之膨脹，A組與B組之反應時間皆相同。

2. 在第一針之15～20小時後，壓擠雌魚腹部時，已開始有少許卵被排出，此時約可採卵授精。

*爲臺灣省水產試驗所鹿港分所洛氏兼任研究員林宏德所提供。

3. 採卵時無法一次採盡，每次僅能流出部份，約隔半小時採卵一次，此種採卵情形與其他魚類不同。

4. A組所能採得卵數較B組者多，A組四尾皆能排卵，B組有一尾無法排卵（但腹部頗膨大）。

5. 剛採下之卵，其卵徑約爲 0.18公分，色淡綠而稍帶一紅點。受精卵初不具粘性，30分鐘後開始有粘着性，常有多數卵粘成一堆。45分鐘時卵周圍出現小水泡，開始有上浮之現象。

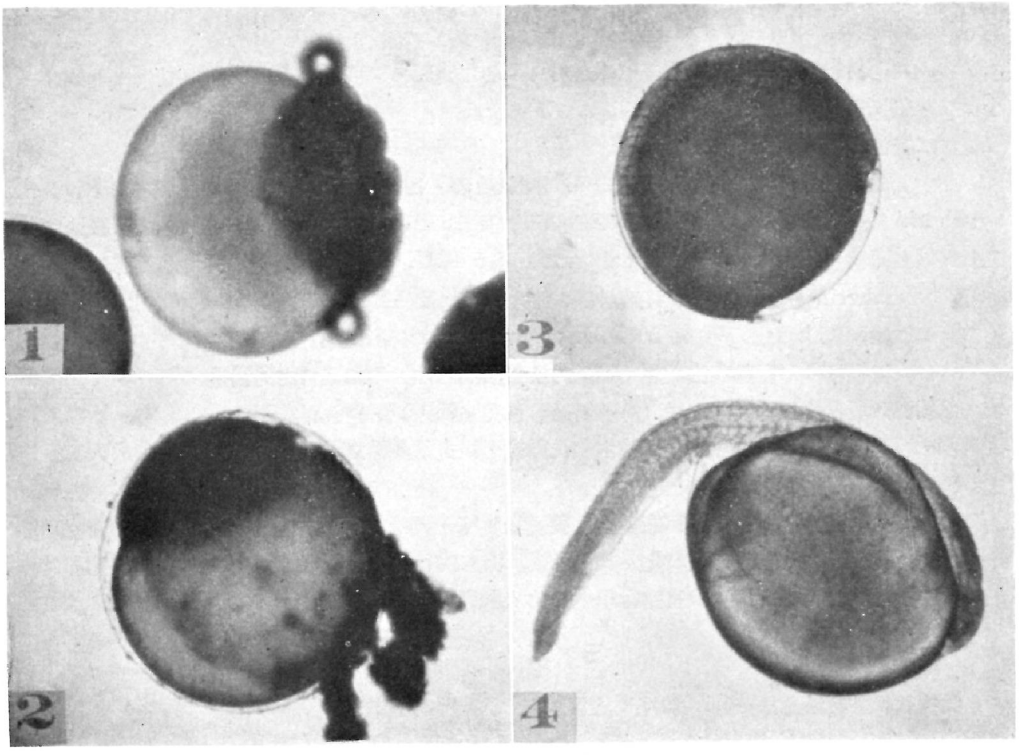


圖 1：受精後3小時30分；32分裂卵，卵徑約爲 0.18cm。

2：受精後6小時，卵周圍固着粘物。

3：受精後17小時，體節出現，胚體佔卵周$^{3}/_{4}$。

4：剛孵化之幼魚（受精後31小時），體長約 0.46cm，臍囊寬約 0.18cm。

6. 受精後 3小時30分爲32分裂卵（圖1）。6小時後，卵外圍有很多粘物出現（圖2）。17小時後體節分明，胚體已佔卵周$^{3}/_{4}$（圖3）。32小時後剛孵化，其幼魚臍囊甚大（圖4）。

7. 孵化以流水式吊網效果最好，受精卵均粘着於吊網周圍上。水族箱（兼打氣）效果次之。箱網（靜置於室外小水泥池中）最差，未能孵化。

8. 孵化率以流水式吊網者最高，約在96%，活成率亦高達90%以上。水族箱者最差。

9. 水溫27～28°C時，孵化約需30小時，至臍囊消失約需3～4天，此時幼魚已能自由泳動與攝食。

10. 孵化後7小時，口眼俱未形成（圖 5），31小時後，口已開裂而眼仍未形成，臍囊下有一具粘性之帶狀物存在，此時上顎鬚尚未出現（圖6）。55 小時後，眼已形成，顎鬚已有兩對出現，此時已略能泳動。

11. 孵化後3天又 7小時，臍囊消失，口鬚俱全並開始自由泳動攝食。此時飼以熟蛋黃及剛孵化之豐年蝦（Brine shrimp）之幼生（可在淡水中活存 3～4 小時），飽食該種幼生之塘虱魚苗，腹呈

微紅色。孵化後第40天，幼魚體長已達 3公分（圖 7），成活率高，嗜食貝肉，豐年蝦，碎魚肉，牡蠣等動物性餌料以及米糠等。稚魚習性如同成魚，懼怕日光及擾動，白天喜躲入埋置於水中之塑膠小管內，夜間外出索食。

12. 試驗期間，水溫相當穩定，平均約在27～29°C之間。

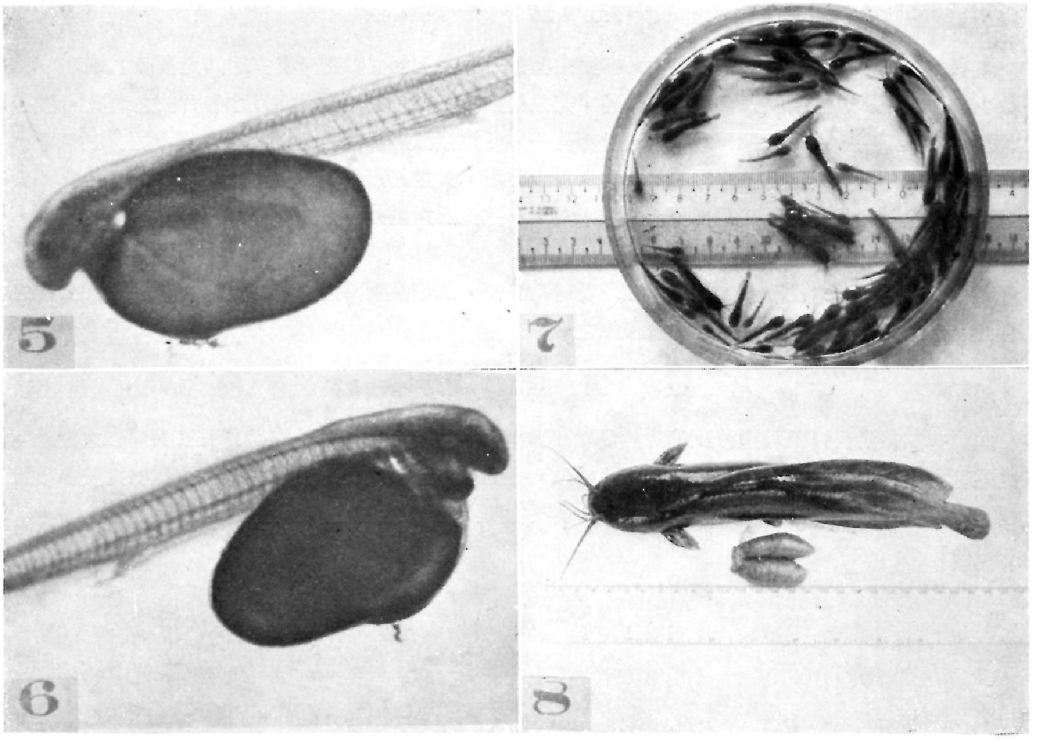


圖 5：孵化後7小時，口尚未形成。

6：孵化後31小時，口已開，眼未形成。

7：孵後第40天，體長約 3cm。

8：塘虱魚之雌魚及其卵巢。

四、討　　論

茲將以上結果討論分析如下：

1. B 組平均效果較差，有一尾不排卵。所用之腦下腺精製液其效果似較新鮮者爲差。

2. 採卵無法一次悉數採盡，其原因可能有三：(1)採用鯉腦下腺及 Synahorin 混合劑可能仍不是最佳之賀爾蒙處理，(2)所供試驗之八尾塘虱魚卵巢成熟不一，或可能爲分數次產卵之魚類，(3)採卵時間過早。

3. 第一針與第二針之時間僅隔六小時，似嫌過短，應延爲 8～10小時以上較爲適宜。

4. 流水式吊網效果最佳，因爲水質佳，且卵有網邊可固着。置於室外之箱網不孵化，可能是因受直射日光及日夜溫度變化之影響。

5. 塘虱魚之卵具有粘性，孵化後其初期之膜囊下具有一粘性蒂物，皆有供固着他物之效，此對幼魚在流動之河水中之生存是具有意義的。

6. 孵化後約 3～4天臍囊才消失，所需天數較其他一般魚類爲長，此對稚魚之活存甚有關係（一般情形爲時間長者，活存率較高）。

7. 此次試驗遠在塘虱魚生殖季節後期（九月下旬）。若改於生殖盛期實施，必能獲致較佳之成果。

五、結　　論

本省水產養殖近年來漸趨蓬勃盛行，唯養殖種類及規模仍極受限制，其主因乃是種苗之缺乏。現除少數魚類如草鱵魚能以人工繁殖供應外，其他種類多靠捕撈天然種苗。以本省目前之環境，濫捕毒殺、加以工廠廢水、農藥、電捕等，勢必使一些魚蝦類減產，甚至絕滅。現塘虱魚之人工繁殖已告初步成功，或可確保此魚之存在。今後應加以推廣，大量繁殖魚苗以供養殖。又本省人士尚不普遍嗜食此魚，可能爲其價格昂貴及習慣等因素，不過此魚之魚肉甚爲細嫩，尤以清燉者更爲芳香，將來必爲人們所喜愛。

本試驗應改進者爲改進賀爾蒙之處理及孵化設備，確定最適當之繁殖時期，選取及培養良好之種魚，改善幼魚之培育等，以達大量繁殖之目標。

謝　　辭

此次試驗能得以順利進行及成功，係得省水產試驗所東港分所廖一久分所長及諸同仁之協助。此外臺灣養鰻場蕭郁賓先生提供之場地與種魚，省水產試驗所鹿港分所林宏德先生提供之鯉腦下腺精製液，及省漁業局烏山頭淡水魚苗繁殖場侯英物技士授以雄魚剖腹授精法等，皆謹致謝忱。

鯰魚人工繁殖試驗

Induced Spawning of the Catfish, *Parasilurus asotus* (Linnaeus)

陳　景　福

Gin-fu Chen

Summary

Experiments on the induced spawning of *Parasilurus asotus* were carried out between October 1971 and May 1972. The spawners were two-year-old fish reared in the ponds of the Chupei Station of the Taiwan Fisheries Research Institute.

Identification of sex was made according to the difference in appearance of the urogenital popilla as shown in Fig. 1. Among the different hormone treatments shown in Table 1, those of pituitary mixed with tannic acid were found to be the most satisfactory. Spawning took place 12 to 20 hours after the first injection.

The highest hatching rate was 73% (Table 1) when pond water with pH 8.5-9.5 was used for hatching. The rate increased to 85% when the pH value of the water was controlled within the range of 6.7 to 7.5 (Fig. 2).

Observation on the development of the fertilized eggs in 20°C water was made from the time when fertilization was completed until the eggs were hatched (Table 3, Fig. 3).

Observation of the early growth of the larvae was also made (Fig. 4). Commencement of feeding was observed on the second or the third day after hatching; the yolk was totally absorbed between the third and the fourth day; the larvae had three pairs of barbels; the larval membrane disappeared on the 20th day; and on the 30th day, the larvae became morphologically identical to the adult and had only two pairs of barbels.

The growth of the larvae was different between those reared indoors and those reared outdoors. The indoor-reared larvae reached a total length of 71 mm on the 60th day after rearing, while it took only 37 days for those reared outdoors to reach the same size. The survival rate of the larvae was 14.50% when reared indoors and 67.13% when reared outdoors (Table 4, Fig. 5).

前　言

鯰魚 *Parasilurus asotus* (Linnaeus) 爲國人嗜食之淡水魚之一，其養殖種苗一向賴天然生產。近年來由於本省養殖事業之積極發展，其天然種苗供不應求，此魚之人工繁殖勢在必需。

有關本種之形態、生態、生活史等有 Atoda, K, (1935)、內田 (1939)、友田 (1962)、楊鴻嘉、陳同白 (1971) 等報告，但未見有關本種人工採卵及仔魚期的飼育報告。

筆者由1971年10月至1972年5月間，在臺灣省水產試驗所竹北分所從事淡水魚類繁殖及飼養工作，其間曾多次進行有關鯰魚的人工繁殖試驗，包括人工採卵、授精、觀察卵內發生過程及仔魚期的形態變化與飼育等。今將所得結果敍述於下。

本試驗得洛氏基金補助，並承臺灣省水產試驗所竹北分所各同仁之協助，始得順利進行，謹於此深表謝意。

材 料 及 方 法

1. 供試魚及雌雄識別

供試魚係於1971年10月20日，28日，11月5日及翌年（1972）3月13日、4月17日，5月8日等由臺灣省水產試驗所竹北分所在池中飼養之2年魚中選其腹部膨大，確知有孕卵者於流水無投餌狀態下蓄養1日後使用。供試魚的體長範圍爲 ♀ 226.0～295.2 mm，♂ 225.0～256.5 mm；體重範圍爲 ♀ 101.5～210.0 g，♂ 85.3～130.7 g。詳細測定值列於 Table. 1。

成熟的鯰魚其雌雄如 Fig. 1 所示，可由雌雄之泌尿生殖突起（urogenital papilla）之形狀不同而辨別，加以其體長與體寬之比，雄魚較雌魚大，換言之，即雄魚之體較狹。按此兩項特徵很容易識別。

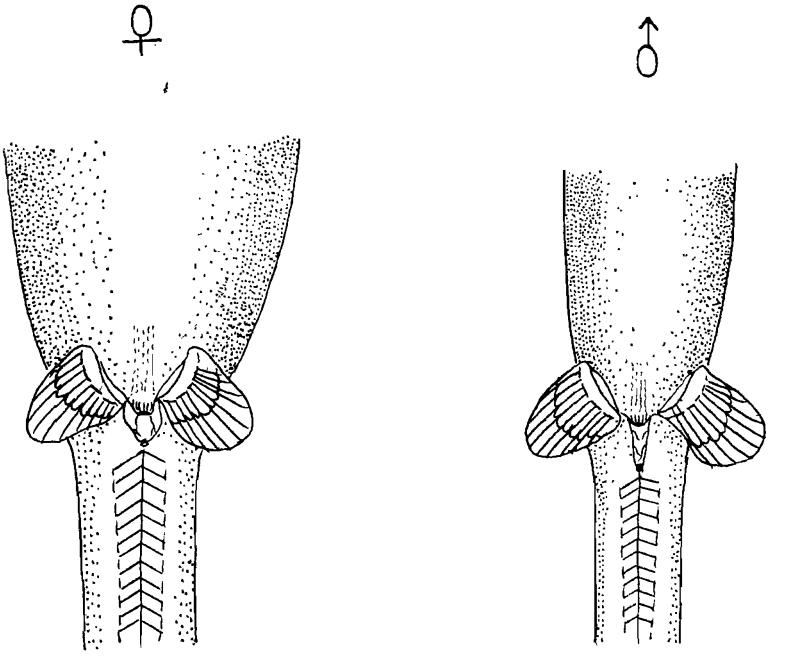


Fig. 1 The urogenital papilla of male and female *P. asotus*.

2. 使用之賀爾蒙劑、腦下垂體及注射方法

賀爾蒙劑使用日本帝國臟器 K. K.出品之性腺刺戟賀爾蒙之人體注射液(Synahorin)。

本試驗所使用之腦下垂體有2種：一爲體重 596.0～1,020 g 之鯉魚腦下垂體，一爲與種魚同重之鯰魚腦下垂體。

單寧酸（tannic acid）：稀薄爲0.5%使用。

注射方法：將上述藥品配合或單獨注射於供試魚背鰭基底體側筋肉中。藥物之配合、用量、及注射次數等列於 Table 1。

3. 注射後之管理及採卵時間之判定

經注射後的種魚，將雌雄各2尾收容於 65×45×30 cm 之通氣循環恒溫（24.0°C）玻璃水槽中，不給餌料蓄養。

爲要斷定可行採卵之時間，除觀察腹部膨脹程度外，經第1次注射10小時後，每隔2小時以手指輕按其腹部觀察是否有卵排出。

4. 人工授精及孵化方法

因成熟之雄魚無法擠出精液，故本試驗所使用的人工授精法都應用川村（1944）研究的泥鰍 *Misgurnus anguillicaudatus* 之人工授精法，即先將雄魚之腹部切開，摘出精巢，置於盛有林格爾氏液（Ringer's solution）之圓底玻璃皿中，攪碎，經鏡檢確認精子活力後，才擠出雌魚之卵，行人工授精。然後將授精後之卵倒入水中，使均勻付着於30×30 cm 之棕梠皮或玻璃板上，而後垂

直收容於60×30×30 cm，間隔 3 cm 之木製孵化器中以流水式（流量 200～500 cc/min）孵化。

5. 仔魚的飼育及供試之餌料

分室內及室外飼育：

(1)室內飼育：以1971年11月 5 日行人工採卵，所得孵化 3 天後的仔魚（體長平均 7.3 mm）600 尾供試之。飼育水槽爲 65×45×30 cm（底砂厚 3 cm）之通氣循環保溫(24.0°C)玻璃水槽。飼育期間由1971年 11 月 11 日至1972年 1 月10日。將上述供試仔魚 600 尾，分別收容於 3 個同形之上述水槽中(每水槽 200 尾)。由飼育當日起，即投放採自室外魚池之輪蟲（*Brachionus*）及小型橈脚類(Copepoda)，但因時值冬季，此等天然餌料難於採取，故由第 5 天開始以切細之絲蚯蚓（*Jubifex* sp.）供食之，1 天的投予量爲 7g（濕重量）。15天增加到 25g，飼育20天後漸次改以人工配合養鰻餌料（統一企業股份有限公司出品）及雜魚漿餵之。每日的投予量爲 7g（乾燥重量），其後視翌日的殘留餌料情形而增減其投量。每日投餌 1 次，投餌時間爲上午 10 時左右。飼育水每週更換 1 次。

(2)室外飼育：以1972年 3 月13日行人工採卵，所得孵化 3 天後的仔魚（體長平均 10.50 mm）4,500尾供試之。飼育水池爲 16.56m²×0.7m之水泥池（底泥厚10 cm）2 個。飼育期間由 1972年 3 月 20日至 5 月10日。飼育池於實施人工採卵前10天，予以消毒、施肥、大量繁殖 *Daphnia*（*Moina macrocopa*, *Bosmina longiroslis*），然後放養上述仔魚。放養量一池爲 2,500 尾（放養密度約爲 500尾／3.3m²），一池2,000尾（放養密度約爲400尾／3.3m²）。爲持續 *Daphnia* 的繁殖，並使仔魚適應餌料的變化，從飼育當天起，每天以煮熟過的人工配合養鰻餌料或雜魚漿少許，均勻地散布於池中。投量如下：飼育當日～第 7 天 3g/3.3m²/day（以養鰻餌料的乾燥重量計算，以下亦同）；第 8 天～第14天 7g/3.3m²/day；第 15 天～第 21 天 15g/3.3m²/day。第 22 天後仔魚已習慣於攝食人工配合養鰻餌料及魚漿，因此改以餌料盤（30×25×10 cm），沈於池底飼餵，並增加投量爲 30g/3.3m²/day，其後視翌日的殘留餌料情形，增減其投量。每日的投予次數及時間與室內飼育者同。飼育期的水溫每日於投餌時測定 1 次，其範圍爲 18.7～26.0°C。飼育水除 1 個月清池 1 次外，皆以止水飼育。

6. 成長度及生存率之測定

成長度：在上述飼育期中，每隔 5～7 日以逢機取樣（random sampling）方式，捕撈數十尾測定其體長以孵化後經過日數及體長平均表示之。

生存率：室內飼育試驗每 2 週點算生存尾數，而室外飼育試驗每月點算其生存尾數，以（生存尾數÷供試尾數）×100%表示之。

結果及考察

1. 產卵期及供試魚

據友田（1962）之報告，鯰魚之產卵期在日本琵琶湖爲 5～6 月，在韓國爲 5～7 月，而據筆者在臺灣北部地方之多次觀察，除12月初旬至翌年 2 月底期間外，全年皆可發現孕卵而腹部膨大之母魚，而且於 3 月底在本分所附近水溝曾見此種魚有產卵行動，故臺灣鯰魚之產卵期，較日本、韓國爲早，於 3 月底或 4 月初氣溫高昇時即開始。

本試驗於1971年10月20日～同年11月 5 日及翌年 3 月13日～ 5 月 8 日間實施，供試魚皆爲池中飼養者，經賀爾蒙處理後，皆可採卵並孵化。在臺灣實施鯰魚的人工採卵，可由 3 月中旬或下旬至 10月下旬間，選其腹部膨大，確有孕卵者即可。

2. 賀爾蒙處理

茲將賀爾蒙處理之經過及結果列於 Table 1：

Table 1. Hormone Treatment and Egg Collection

Date	Fish No.	Sex	Total length (mm)	weight (gm)	Hormone treatment						Time from 1st Inj. to egg collection (hr)	Number of eggs collected	Fertilization rate (%)	Hatching rate(%)	Health condition of spawner after egg collection
					1st Inj.		2nd Inj.		3rd Inj.						
					Dosage	Time	Dosage	Time	Dosage	Time					
1971 Oct. 20	1	F	295.2	187.8	1/2 CaP +5 RU	17:00	1/2 CaP	23:00			16	6,000 — 6,200	67.3	43.2	good
	2	M	256.5	130.7	〃	〃	〃	〃							
	3	F	273.1	165.0	1 CtP +5 RU	〃	1 CtP +5 RU	〃			18	7,000 — 7,500	68.5	43.4	good
	4	M	244.3	92.0	〃	〃	〃	〃							
Oct. 28	5	F	295.0	185.0	15 RU	12:00	15 RU	20:00							
	6	M	245.0	101.2	〃	〃	〃	〃							
	7	F	287.4	180.5	10 RU	〃	10 RU	〃	10 RU	7:00 (10/29)					
	8	M	241.0	89.8	〃	〃	〃	〃	〃	〃					
Nov. 5	9	F	278.0	169.0	1/2 CaP +0.1 V. 0.5% TD	15:00	1/2 CaP + 0.1 V. 0.5% TD	23:00			20	9,000 — 10,000	78.7	59.8	good
	10	M	225.5	85.3	〃	〃	〃	〃							
	11	F	285.3	179.0	1 CtP + 0.1 V. 0.5% TD	〃	1 CtP + 0.1 V. 0.5% TD	〃			22	11,000 — 12,000	80.1	62.1	good
	12	M	240.0	90.5	〃	〃	〃	〃							
1972 Mar. 13	13	F	275.0	170.0	1/2 CaP + 0.1 V. 0.5% TD	17:30	〃	23:30			12	8,000 — 10,000	87.0	69.2	good
	14	F	226.0	110.0	1/2 CtP + 0.1 V. 0.5% TD	〃	〃	〃			12	6,000 — 7,000	87.0	69.2	good
	15	M	255.0	100.0											
Apr. 17	16	F	265.0	200.0	1/3 CaP + 0.1 V. 0.5% TD	9:00	〃	16:00			11 1/2	10,000 — 11,000	91.0	71.0	good
	17	F	270.0	210.0	1/2 CtP	9:00	〃	16:00			16 1/2	10,000 — 11,000	91.0	71.0	good
	18	M	245.0	120.0											
May 8	19	F	239.0	101.5	1/2 CaP + 0.1 V. 0.5% TD	12:00					12	6,000 — 8,000	91.0	73.0	good
	20	F	240.0	113.5	〃	12:00					12	6,000 — 8,000	91.0	73.0	good
	21	M	225.0	92.0											

Note: CaP: Pituitary of Carp.
CtP: Pituitary of Catfish.
RU: Synahorin (Rabbit unit).
F: Female.
M: Male.
0.1 V. 0.5%TD: 0.5% Tannic acid, the volume was equal to 10% of the Ringer's solution used for diluting pituitary.

由此結果可知：(1)促進排卵注射用藥，只需鯉魚或鯰魚之腦下垂體加入少許之單寧酸卽可，不需配入 Synahorin。腦下垂體的用量，如爲鯉魚只須 1/2～1 個，如爲鯰魚須 1～2 個，本試驗之單寧酸配用法係參考久保田（1954）在泥鰍人工繁殖試驗中之用法及用量。比較第 1 次及第 3 至 5 次試驗，可發現對於鯰魚人工採卵，單寧酸亦有協調腦下腺促進卵巢成熟之效能。惟關於其濃度及用量尙須加以研究。(2)由1971年之 3 次試驗比較結果可發現 Synahorin 之效果不顯著，尤以第 2 次試驗之單獨使用，使雌雄種魚過度興奮，互相殘害，並不能促進排卵。(3)由第 6 次試驗之結果可知，賀爾蒙處理時，只須注射 1 次卽可，於12小時至20小時內採卵便可得相當滿意的結果。(4)使用鯰魚腦下垂體與使用鯉魚腦下垂體之效果，無顯著之差異。(5)由後 3 次試驗可知雄魚不必注射促進精子成熟，且 1 尾之精液可使用於雌魚 2～3 尾。

3. 受精率、孵化率及畸形率

受精率常因種魚之成熟度、卵及精子之健康狀態及人工授精技術而異。孵化率除上述各種因素外，並受孵化環境之因素不同而異。本試驗中除第 2 次試驗未能促進排卵外，其他皆可排卵、受精至孵化。第 1 次試驗之受精率及孵化率較低（分別爲 67.3～68.5%；43.2～43.4%）之原因，可能爲採卵時間稍早而受影響。因該次採卵時，雌魚之腹部稍硬，卵之流出狀態亦不甚理想。此後雖經多方面的細心留意，提高受精率至 80～90%，但孵化率不能提高到 73%以上。其原因除卵本身問題外，可能是孵化用水之 pH 值過高，因竹北分所的用水，其 pH 常在 8.5～9.5 間。筆者爲確定原因，曾以 0.1 N HCl 及 0.1 N NaOH 調節孵化用水，保持不同之 pH 值，卽在 pH 4.0 至 11.0 範圍內觀察受精孵化的情形，並以自然水爲對照。其結果發現鯰魚之卵在 pH 4.7～10.3 之範圍內，皆可受精孵化。但在 pH 不同的水中，其孵化率之差異甚大（Fig. 2）。在對照之自然水中（pH 8.5），孵化率最高爲73.0%，而經過調整 pH 6.7～7.5 之範圍內孵化率高達 85.0%。孵化用水 pH 較此範圍爲高，或較低時則孵化率漸低。由此推測鯰魚卵的孵化用水；應採用 pH 值近於 7 者爲佳。

畸形率之出現各試驗大致相同，約爲2.7～3.5%之範圍。

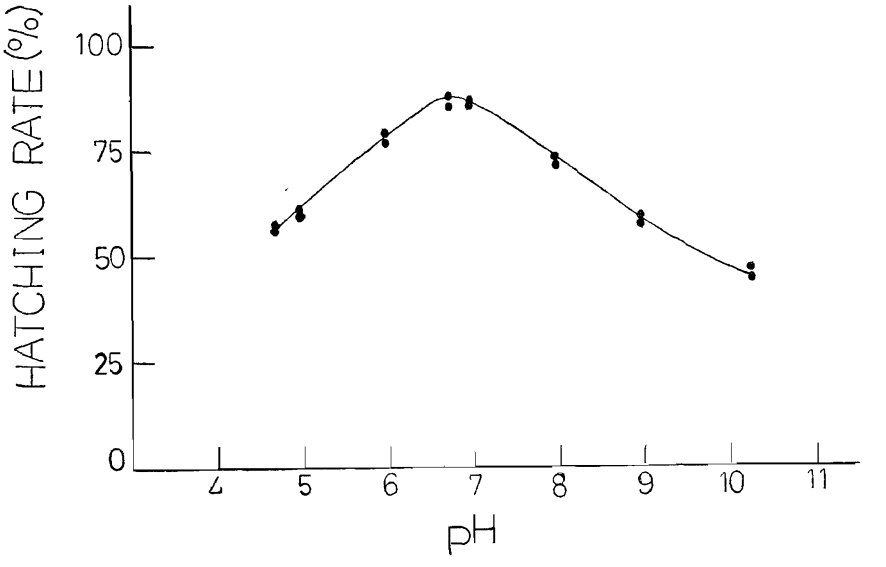


Fig. 2. Relationship between pH and hatching rate.

4. 卵及其發生過程

完全達到成熟的卵巢內之卵，在捕撈魚體時，若魚體受到刺激或以手指輕壓其腹部，便有大量之卵排出體外。卵爲球形的粘着沈性卵 (adhesive demersal egg)，卵黃呈淡綠色或深綠色，無油球，卵黃面呈微細的顆粒構造，直徑 1.548mm～1.980mm，卵膜薄而透明，外層包有厚 0.476～0.525mm 之透明 gel 狀物，加上此外層時，卵之直徑爲 2.500～3.035mm，然而在池中自然排卵時，此 gel 狀物能膨脹至厚度約 1.0～2.0mm。

卵之發生經過，常因水溫之差異影響孵化時間。因此，將晝夜水溫變化較小的 1972年 3 月14日 (水溫範圍爲 19.5～20.7°C) 爲例，記述所觀察的發生經過於下：

受精後的卵，經10～35分，卵膜卽扛擧，卵徑增加 0.1～0.15mm，平均卵徑爲 1.743mm。受精後經 1 小時 15 分大部份的卵卽分裂爲 2 細胞期 (2-cell stage) 。1 小時25分進入 4 細胞期 (4-cell stage)，7 小時後 (水溫 25°C 時只須 4 小時30分) 則達桑實期 (morula stage)。此後割球 (blastomere)越來越小，11～13小時後卽進入胞胚期(blastula stage)，此時的卵徑爲1.780mm，15～18小時後進入囊胚期 (gastrula stage)。受精後經19小時，原口 (blastopore) 卽閉鎖，胚體(embryonal) 形成。20小時後可觀察到脊索 (notochord) 及頭部之分化，此時的卵黃長徑爲 1.786mm，短徑爲 1.533mm。再經過45分～1 小時，胚體中央卽出現 3 個體節 (somite)。22小時30分後眼胞 (optic vesicle) 出現，體節數 7。28小時後 Kupffer's vesicle 出現，體節數18。32小時30分後耳胞 (auditory vesicle) 出現，體節數24，尾部末端與卵黃分離。36小時後眼球(eye ball)出現，腦分化，同時耳石 (otolith) 形成，Kupffer's vesicle 消失。此時的卵黃長徑爲 1.803 mm，短徑爲 1.640mm。受精後45小時，心臟已搏動，腦已分爲前腦(prosencephalon)、中腦(mesencephalon)，菱腦 (rhombencephalon)、且具有胸鰭原基及 3 對鬚原基，體節數43～47，卵黃較前些時向後延長。孵化須受精後54小時才開始，全部之卵須10～12小時才能孵化完畢。

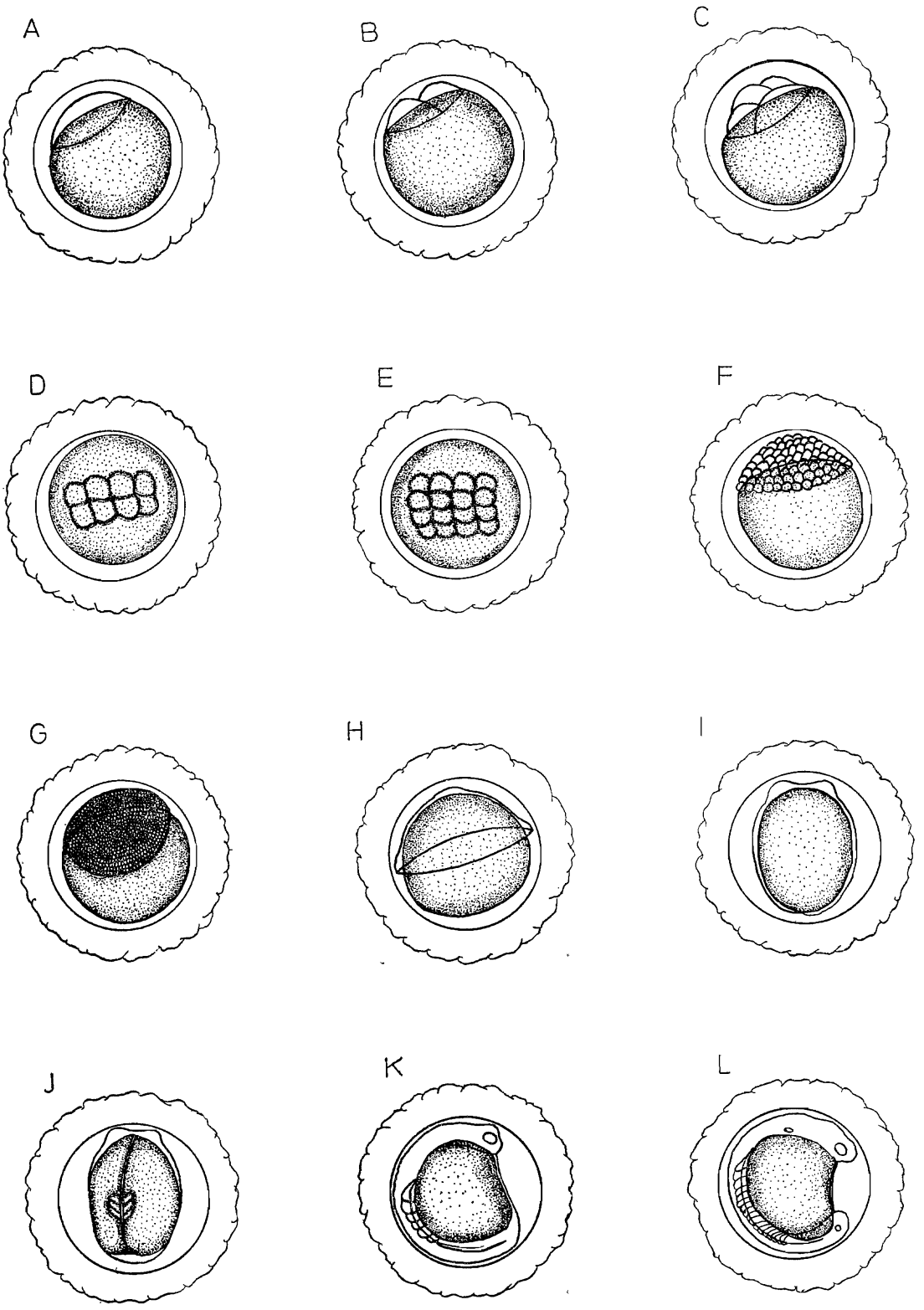
茲將水溫與卵化所須時間之關係及卵發生之概要列示於 Table 2，Table 3 及 Fig. 3。

Table 2. Time needed for hatching at different water temperatures

Water temperature (°C)		Time needed for hatching (hr)	
Range	Average	Beginning	Completion
19.5—20.7	19.8	54	65
23.3—26.4	25.3	34	44
28.9—30.6	30.0	28	35

Table 3. Development of eggs of *Parasilurus asotus*

Water temperature (°C)	Time required	Progress of development
	After fertilization	
19.5	10′-30′	blastoderm formation
	1hr 15′	2-cell stage
	1hr 25′	4-cell stage
	1hr 50′	8-cell stage
	2hr 15′	16-cell stage
20.0	7hr	morula stage
19.7	11hr-13hr	blastula stage
19.7	15hr-18hr	gastrula stage
19.7	19hr	embryonal fomation
	21hr	3-myotome stage
	22hr 30′	optic vesicle formation
		7-myotome stage
19.5	28hr	appearance of Kupffer's vesicle
		18-myotome stage
19.5	32hr 30′	auditory vesicle formation
		24-myotome stage
20.0	36hr	eye ball formation
		otolith formation
		brain differentiation
	39hr	rudiment of pectoral fin
		clearly seen
		alimentary canal formation
20.7	45hr	heart beating
20.4	54hr	hatching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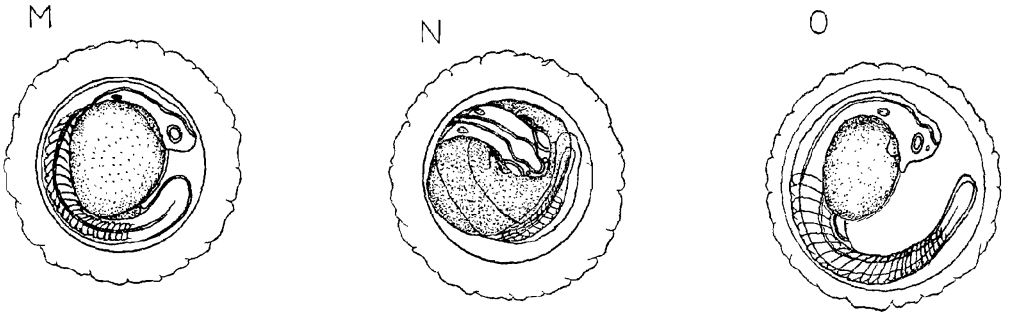
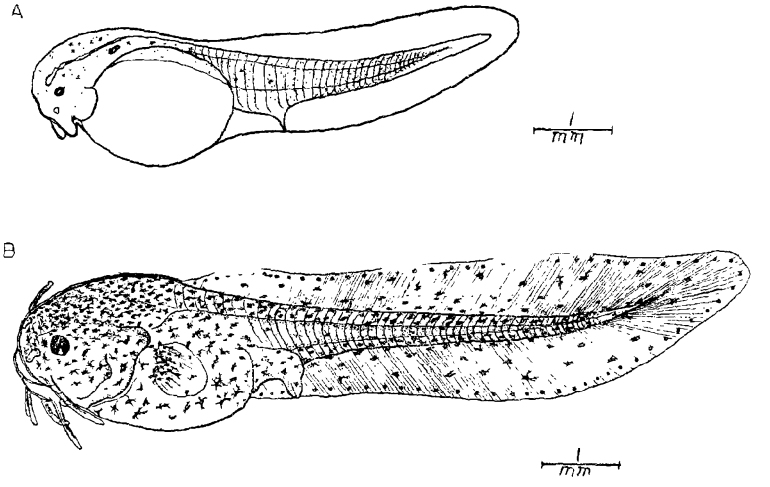


Fig. 3. Development of eggs of *P. asotus*.

A. Blastoderm formation: 50-60 min after fertilization.
B. 2-cell stage: 1 hr 15 min.
C. 4-cell sage: 1 hr 25 min.
D. 8-cell stage: 1 hr 50 min.
E. 16-cell stage: 2 hr 15 min.
F. Morula stage: 7 hr.
G. Blastula stage: 11-13 hr.
H. Gastrula stage: 15-18 hr.
I. Embryonal formation: 19 hr.
J. 3-myotome stage: 21hr.
K. Optic vesicle formation, 7-myotome stage: 22 hr 30 min.
L. Appearance of Kupffer's vesicle auditory vesicle formation: 28 hr to 32 hr 30 min.
M. Eye ball formation, otolith formation, brain differentiation: 36 hr.
N. Heart beating: 45 hr.
O. Immediately before hatching. 53 hr.

5. 孵化仔魚

茲將剛孵化到 450 小時的仔魚形態之變化以 Fig. 4 表示之。



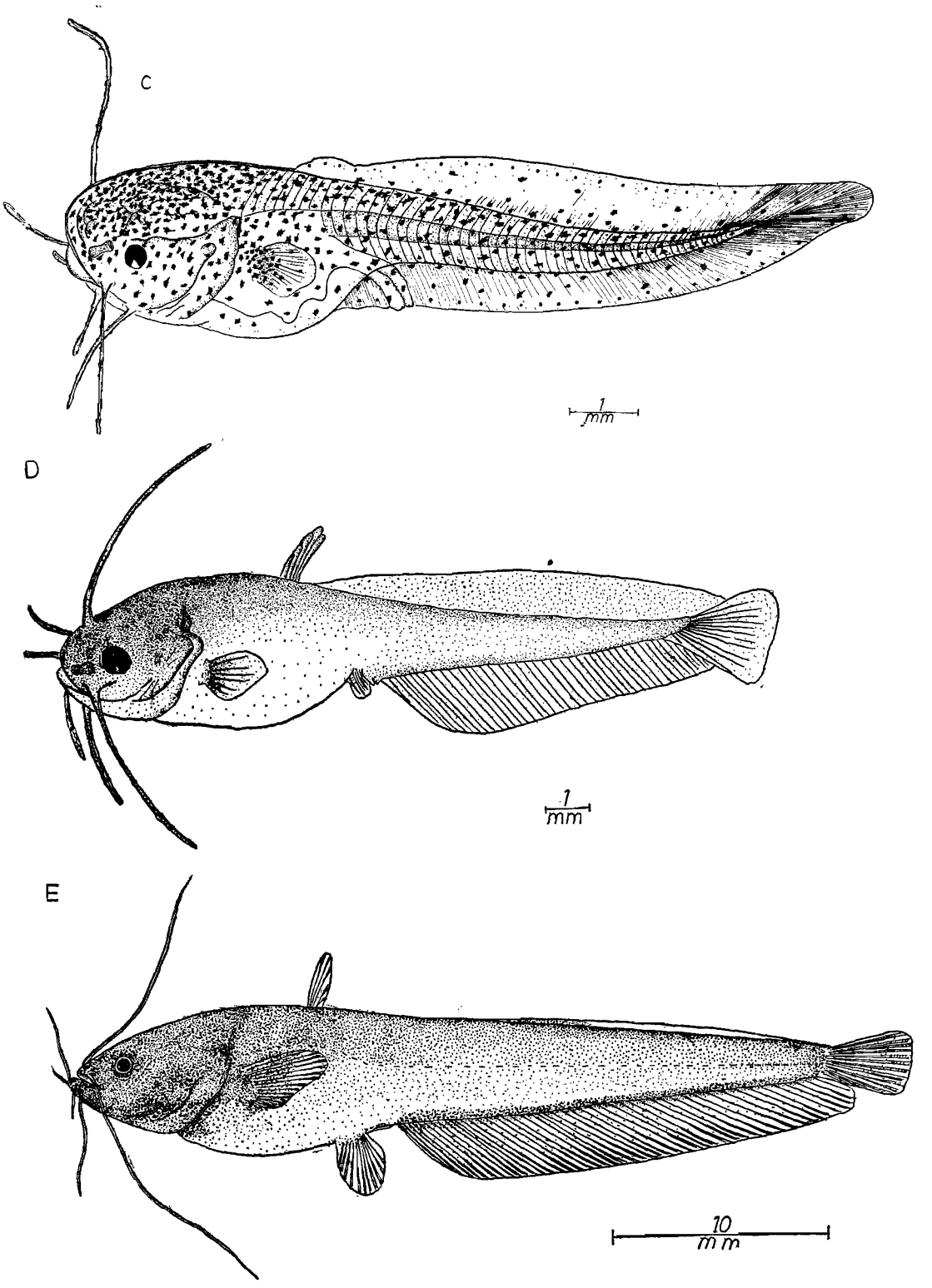


Fig. 4. Larvae of *P. asotus*.

A. Newly hatched larva: 6.24 mm in average total length.
B. 45 hr after hatching: 8.32 mm in average total length.
C. 68 hr after hatching: 10.5 mm in average total length.
D. 160 hr after hatching: 16.94 mm in average total length.
E. 450 hr after hatching: 38.79 mm in average total length.

剛孵出之仔魚 (Fig. 4-A) 其體長平均爲 6.24mm，卵黃向後延長成橢圓型，其長徑平均爲 2.07mm，肛門位於魚體中央部，未有游泳力，側臥於水槽底，不時將尾部擺動，眼球無黃色素，口未開，但已具有胸鰭原基與 3 對鬚之原基，仔魚膜除卵黃外幾乎包於魚體全部，膜上有規則的放射條紋，黑色色素在頭及體前半部，但因黃色色素佈滿體全部，致使黑色色素不明顯。

孵化45小時的仔魚 (Fig. 4-B) 體長平均 8.32mm，已能以正常姿勢游泳，眼已有黑色素沈澱，而且黑色色素佈滿魚體全部，包括仔魚膜、卵黃、肛門附近及胸鰭等。黃色色素消失。此時尾鰭及臀鰭原基已出現，3 對鬚已清晰可見，尾部延長，致於肛門位置偏向體前，卵黃將被吸收完畢，口部形成，已能攝食 180～570μ 的輪蟲及小型橈脚類，其一次的飽食量爲 3～7 個體。仔魚具有背光性，喜羣集於池底角落及側壁隅角。

孵化68小時的仔魚 (Fig. 4-C) 體長平均 10.50mm，筋節數64，卵黃已被吸收完畢，在解剖顯微鏡下可清楚地看到消化管及內臟，黑色色素大而濃，特別是頭及體背部，距背部仔魚膜起緣約 1mm 處形成缺刻，3 對鬚已延長。此時的仔魚已能攝食 700～1,500μ 的 *Daphnia*，一次的飽食量爲6～15 個體，晝間可在池壁觀察到其攝食。

孵化 160 小時的仔魚 (Fig. 4-D) 體長平均 16.94mm。此時的仔魚除腹鰭還未完全形成外，已具胸鰭、背鰭、臀鰭及尾鰭，而各鰭具有軟條 (fin ray)，背鰭後方的仔魚膜變成厚而黑，外觀酷似第 2 背鰭，但無任何其他構造。

孵化 450 小時的仔魚 (Fig. 4-E) 體長平均 38.79mm，其形狀與成魚大致相同，側線明瞭呈黃綠色，各鰭之軟條已分岐 (segment)，仔魚膜除少數仔魚外皆已消失，但此時下顎還具有 2 對鬚，此鬚之 1 對在孵化約 1 個月，體長 60.0 mm 時才消失。

6. 成長度與生存率

人工繁殖的成果，往往視其飼育仔魚的成功與否而定。茲將上述室內及室外飼育的結果即生長率及生存率列於 Table 4 及 Fig. 5。

室內飼育者最初之體長平均爲7.3mm，經15日才達16.0mm，生存尾數196尾，生存率32.70%；30日後才爲 36.53mm，生存尾數94尾，生存率15.67%；2 個月才達 71.20mm，體重 2.80g，生存尾數87尾，生存率 14.50%。

室外飼育者最初之體長平均爲 10.50mm，較前者僅大 2.8mm，而15日後已過 29.75mm；30日後爲 61.20mm，生存尾數 3,682 尾，生存率 81.81%；2 個月後爲 96.50mm，生存尾數 3,021 尾，生存率67.13%。由計算推算；室外飼育之仔魚，要達到體長 71.00mm 只須37日，較室內飼育者快 23日左右。此爲室內飼育期間，時值冬季，在飼育開始 2 天，水溫突變寒冷，在室外魚池無法撈取適當的天然餌料以飼餵仔魚，因此大量死亡，後以切細之絲蚯蚓餵之，情況略見好轉，以後便很少在飼育水槽中發見死魚。故推測其後仔魚尾數減少之原因可能爲仔魚互相殘食之故。

由室外飼育之經驗而論，仔魚於孵化後15日起即能攝食鰻餌或魚漿，37日後其體力已增加，很少見其死亡，因此體長約 70.0mm，體重約 2.5g 之仔魚已充分能供爲種苗。

Table 4. Relation between total length (mm) and days after hatching

Condition of culture		Indoors							Outdoors					
Time after hatching (days)		7	10	15	20	30	50	60	7	10	15	20	30	60
Total length (mm)	M	11.21 ±0.50	15.02 ±0.45	18.24 ±0.70	25.10 ±1.50	38.56 ±1.16	61.02 ±1.12	71.00 ±1.82	17.05 ±0.21	29.75 ±0.50	40.57 ±0.72	61.03 ±0.60	88.32 ±0.44	98.01 ±0.53
	S	2.25 ±0.36	2.00 ±0.32	3.11 ±0.49	5.43 ±1.06	4.88 ±0.78	5.02 ±0.79	5.25 ±0.83	2.01 ±0.43	3.53 ±0.53	4.50 ±1.02	6.55 ±1.35	5.50 ±1.47	7.55 ±1.50
Number of survival				196		94		87					3682	3021
Survival (%)				32.70		15.67		14.50					81.81	67.13

Note: M, mean; S, standard deviation.

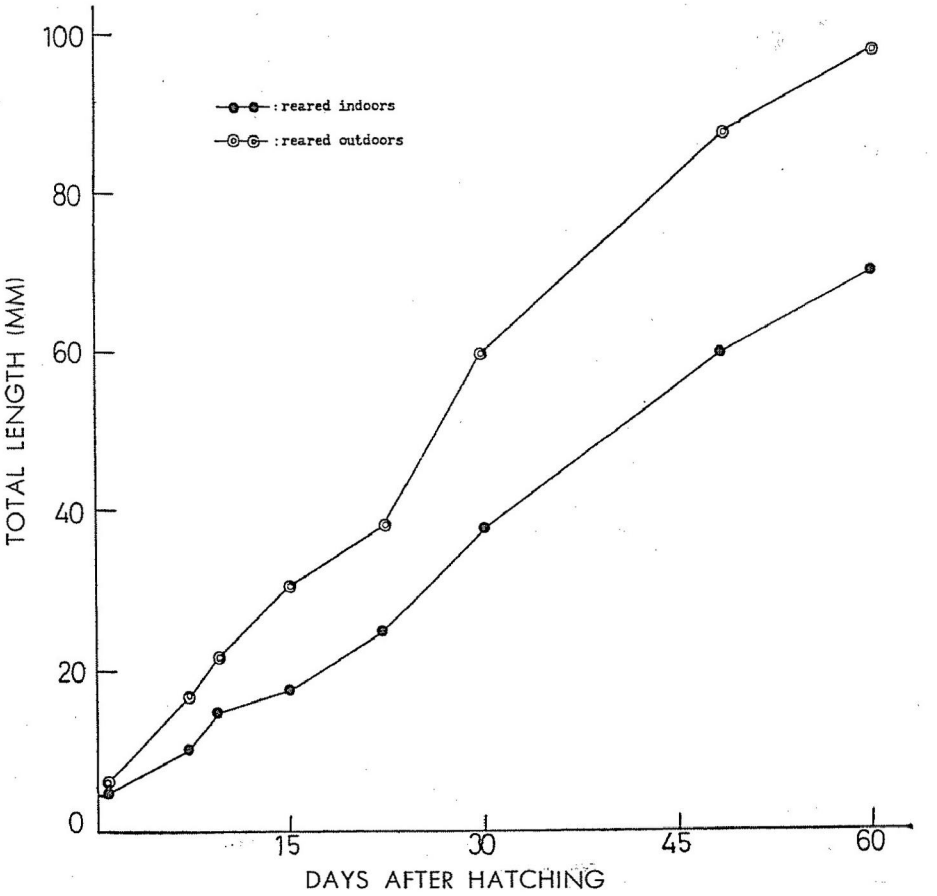


Fig. 5 Growth of *P. asotus* larvae.

摘　　要

於1971年10月20日、28日同年11月5日及1972年3月13日、4月17日、5月8日，對於池中養殖之鯰魚施行人工採卵試驗，得下列結果。

(1)體長 225.5～295.2 mm 之鯰魚，每尾只須注射鯉魚的腦下垂體 $^1/_2$～1 個（或鯰魚腦下垂體 1～2 個）加以食鹽水溶液的 $^1/_{10}$ 量之 0.5%單寧酸，即能促進卵巢成熟。

(2)注射次數只須 1 次即可，於注射後12～20小時內採卵便可得相當滿意的結果。

(3)雄魚不必注射促進精子成熟，而且 1 尾雄魚之精液可使用於雌魚 2～3 尾。

(4)卵在 pH 4.7～10.3 範圍內可受精孵化，但在 pH 6.7～7.5 之範圍內其孵化率最高。

(5)水溫與孵化時間如下：水溫 20°C 須54小時，25°C 須34小時，30°C 須28小時。孵化開始到全卵孵化完畢須10～12小時。

(6)孵化仔魚須經過30日，其形態才能完全與成魚相同。

(7)孵化仔魚經 2～3 日、卵黃將被吸收完畢時即開始攝食。仔魚期的餌料以輪蟲及 *Daphnia* 最佳。

(8)室內飼育和室外飼育的成長及生存率有極大的差異，室內飼育者，2 個月才達 71.0mm，而室外飼育者只須37日。2 個月後的生存率室內爲 14.50%而室外爲 67.13%。

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鯉魚腦下腺賀爾蒙之精製

Preparation of Sex Stimulating Hormone from Pituitary Glands of Common Carp

林　宏　德

Hon-der Lin

Abstract

In the artificial propagation of fish, a mixture of pituitary glands and L. H. hormone has been used to stimulate maturation and ovulation. There are present in the mixture large amounts of protein residues together with a small amount of the effective matter. After the pituitary gland mixture is injected into the body of the fish, there are always physiological ill effects caused by the function of rejection. The most commonly found symptoms are allergy, scale-dropping, etc. Before the pituitary hormone becomes effective, the body is subject to rejection of protein other than its own, resulting in the failure of artificial ovulation.

This experiment made it possible to extract sex stimulating hormone from pituitary glands of common carp (*Cyprinus carpio* Linnaeus) and also to prevent the decomposition of effective matter (hormone) if pH reduced water was used as a solvent. The effectiveness of the extract can be maintained for a long time if it is kept in a dry state. The injection of the hormone into common carp (*Cyprinus carpio* Linnaeus), silver carp (*Hypophthalmichthys molitrix* Cuvier and Valenciennes), grass carp (*Ctenopharyngodon idellus* Cuvier and Valenciennes), ayu (*Plecoglossus altivelis* Temminck and Schlegel), freshwater catfish (*Clarias fuscus* Lacépède) and snakehead (*Ophiocephalus tadianus* Lacépède) was found to be effective in bringing about ovulation.

摘　要

在魚類的人工孵化過程中，大多數使用同科魚的腦下腺與胎盤賀爾蒙作爲催熟與排卵之用。但腦下腺中除了極少量的有效成份之外，尙含有多量的蛋白質，此等殘留的蛋白質被注射入魚體之後，因排斥作用常常引起生理障碍，最常見者爲急性皮膚過敏及魚鱗脫落等現象，亦卽受注射之魚在腦下腺賀爾蒙未發生作用之前，先受到排斥異體蛋白質之害，以致未能順利排卵，造成種魚與時間之浪費，且腦下腺之臨時摘取常需人力與時間，實不勝其煩。

爲了除却腦下腺中之殘留蛋白質並防止其有效成份之分解，本實驗以醋酸溶液爲溶劑從鯉魚腦下腺提取賀爾蒙，經凍結眞空乾燥後製成針劑，並經應用於鯉、鰱、草魚、香魚、鯇、塘虱魚等魚類之催熟排卵，證明確實有效且使用方便。

材料與方法

從成熟的鯉魚摘下腦下腺後，以無水酒精或丙酮脫水數回。若放置於暗冷處，可保存二年而效力不消失。將其研磨成細粉之後，置於 Soxlet Extractor 中以丙酮抽取其中之脂類，然後以醋酸

溶液作爲溶劑，在 pH 4 之下抽取其中之賀爾蒙。此時須用超遠心分離機將溶液中之蛋白質完全分離。含賀爾蒙之酸液則分裝於小玻璃瓶中，每瓶裝入一公斤鯉魚的腦下腺，經凍結眞空乾燥後熔封之，卽成爲每瓶一公斤鯉魚單位，其效力在常溫之下經久不變。

腦下腺之乾量：

將同一批成熟度相若之鯉魚就其體型分爲大中小型三組，分別摘取其腦下腺，經脫水脫脂，再於眞空下乾燥之後稱其重量，結果如下：

日　期	鯉魚之體型	重　量 (kg)	尾　數	平均重量 kg/尾	腦下腺之量 (mg)	腦下腺之平均重量 mg/kg
1970,3.13	大	26.2	44	0.588	72.7	2.78
〃	中	25.2	72	0.350	72.0	2.97
〃	小	18.6	90	0.207	59.6	3.21
1971,4.21	大	12.7	21	0.605	34.1	2.71
〃	小	9.7	43	0.225	35.6	3.70
1971,4.13	大	62.3	89	0.700	144.0	2.30
〃	小	23.2	96	0.241	85.5	3.70

註：小型：250克以下者，中型：250～500克者，大型：500克以上者。據上列結果，鯉腦下腺之重量與體重之比，體型小的較大型的爲高，亦卽用於摘取腦下腺的鯉魚，採用成熟而體型小的較爲有利。

抽出液之 pH：

新鮮的腦下腺被摘出後，若有水份存在，則因自家消化，其有效成份(賀爾蒙)漸被分解消失。此種分解作用却因 pH 值之降低而被抑制。下表指出各種 pH 值之抽出液對於被抽出物(賀爾蒙)之影響：

日　期	抽出液之 pH	實際應用對象	尾　數	排卵尾數
1969年5月2日	7.0	白　鰱	2	無
〃	6.3	〃	2	無
1969年6月2日	5.5	〃	2	1
〃	〃	草　魚	2	1
1970年6月15日	4.2	〃	4	3
〃	4.2	白　鰱	4	2

注射賀爾蒙之時間：下午六時。
注射賀爾蒙之水溫：27°C。
注射賀爾蒙之量：1.2公斤鯉魚單位/公斤種魚，分爲二次注射每六小時注射一次。
第一針至排卵之時間：12～14小時，超過14小時未排卵者放棄。
上表指出抽出液之 pH 調整在4左右時，賀爾蒙之分解已被抑制。

實際使用：

在不同時期應用於各種魚類之催生所得結果如下：

日　期	種　魚	體　重 kg	鯉魚賀爾蒙（公斤鯉魚單位）	他種賀爾蒙	第一針至排卵之時間 hr	孵化情形
1968,11.15	鯉	0.40	0.3	—	9	良
〃	〃	0.31	0.3	—	9	良
〃	〃	0.61	0.4	—	9	良
1971,2.9	〃	0.72	1.0	—	10	良
1970,6.5	鱒	1.20	1.0	—	13	良
〃	〃	1.05	1.0	—	12	良
〃	〃	1.15	1.0	—	—	—
〃	〃	1.38	1.5	—	—	—
〃	〃	1.61	1.5	—	14	良
〃	草魚	2.00	2.0	—	—	—
〃	〃	2.50	2.5	—	14	良
〃	〃	2.20	2.5	—	13	良
〃	〃	3.10	3.0	—	—	—

水溫：27°C. 賀爾蒙分爲兩回每六小時注射一次。

上表示精製之鯉腦下腺賀爾蒙對鯉科魚類具有催熟排卵作用。其他魚類如鯉科之鯁及大頭，塘虱魚科之塘虱，鱚科之香魚，及鱘科之鱘魚等亦經試驗有效。

討　論

每回催生試驗都單獨使用鯉魚腦下腺賀爾蒙以證明其效力，至於與他種賀爾蒙製劑混合使用時，是否有相乘作用，尚未明瞭。

用於摘取腦下腺的鯉魚，選擇小型而成熟者較爲有利。

一公斤鯉魚單位之賀爾蒙在玻璃瓶中只呈一個痕跡，但因恐帶進不良因素，未添加任何增量劑。似應添加少量的 peptone 使製劑呈海棉狀以利乾燥與再溶解。

鯉魚腦下腺賀爾蒙對於烏魚、鰻等魚是否有催生作用未經試驗。

用於降低 pH 之酸應採用揮發性酸，使其在眞空乾燥時能揮發出去。

本試驗以醋酸溶液（pH 4 左右），從鯉魚腦下腺中提取賀爾蒙，以克難粗製方式研製成針劑，並經應用於鱒，草、鯁、香魚、塘虱魚等魚類之催生，證明有效，且使用方便。爲使此一研究工作能獲得更大成效起見，應計劃利用多種魚類之腦下腺以凍結眞空乾燥法精製成針劑賀爾蒙，分別應用在各種不同魚類催生上，以比較其效果及經濟價值，並證明其有無共通性。

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