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Larviculture of Seabass (*Lates calcarifer*) and Grouper (*Epinephelus malabaricus*) in Thailand.

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Abstract. — Artificial propagation of seabass was first achieved in Thailand in 1971 by stripping the ripe spawners collected from natural spawning grounds. The duration of embryonic development is approximately 17 hours at 27°C. The larvae are fed on rotifer first after which *Artemia* and minced fishes are given at 10 days old and 25 days old, respectively. The fingerlings can be transferred to nursery or culture at enclosures at 35-40 days age.

At present, natural spawning of grouper can be obtained in captivity by environmental management. The larvae at age of 3-11 days are fed with rotifer and *Artemia*, respectively. Then, *Artemia* mixed with minced fishes are given. At the age of 45 days, the fingerlings were fed only with minced fishes. Survival rate of fry was very low. The hatchery techniques have to be improved.

INTRODUCTION

The culture of seabass (*Lates calcarifer*) and grouper (*Epinephelus malabaricus*) are widely developed in South East Asia. They are more popular marine food fish of high market value in the region. In the past, seabass fry were collected from the wild for stocking in ponds and cages. The artificial propagation of sea bass was first achieved in Thailand in 1971 by stripping the ripe and running spawners collected from natural spawning grounds (Ruangpanit, 1986). After that, effective hatchery techniques were largely developed allowing commercial culture of sea bass to expand rapidly along the coastal provinces of Thailand.

The induced breeding trials for grouper have been conducted in Singapore since 1977 (Chen et al., 1977). Induced spawning by hormone injection has been reported successful in Singapore, Kuwait and Thailand. However, the larvae rearing techniques are still under study. Therefore, the grouper fry are still mostly collected from the wild.

INDUCTION OF SPAWNING

Seabass

Seabass broodstock would be ready to start spawning at the end of their third year when they reach 3.5 kg (Maneewongsa, 1986). The best milt is obtained from 2-4 years old, and the best eggs would be from female fish more than 3 years old. The parent fish should be moved to spawning tank about 1 month before spawning season. The spawning tank would be around 80-100 tons and at least 2 m in depth. It can be rectangular or round. About 24 spawners can be kept in each tank with a ratio of male : female 1 :3.

The broodstock can be raised directly from the juvenile stage in net cages. The fingerlings would be collected from the wild or from fry spawned in the hatchery. In the past, the wild-caught adults were kept and reconditioned in the hatchery (Kungvankij, 1986).

Two major techniques of mass production of seabass fry are practiced in Thailand, induced spawning and artificial fertilization (Chen et al., 1977; Kungvankij, 1986; Maneewongsa, 1986). Induced spawning techniques is mostly employed. Two methods are normally used for inducing seabass to spawn in captivity; hormonal injection and environmental manipulation. Both methods induce the fish to spawn naturally in the tank. The popular techniques for induced spawning is environmental manipulation. This is the best method for commercial scale seabass spawning because much more fish seed can be produced (Ruanganit, 1986). The techniques are controlling the feeding at 1-2 percent of total body weight. The feeding is done once a day in the afternoon. Thirty to fifty % of tank water is changed daily.

Natural spawning in captivity takes place at the same time as natural spawning in open water (Maneewongsa, 1986). Spawning activity always occurs during spring tide 2-3 days before the new or full moon, and up to 5-6 days after the new moon at about 1800-2300 hours; (Chen F.Y. et al., 1977; Ruanganit, 1986). The ripe males and females swim together, often turning laterally and hitting the surface of the water before spawning. They spawn continuously 3-5 days/month and spawn every month during rainy season or year round (Table 1).

Grouper

Grouper broodstock are ready to spawn at an age of approximately 3 years and 3.0-4.0 in body weight (Ruanganit et al., 1988). The spawning techniques are similar to the techniques of seabass spawning. Induced spawning by environmental manipulation is mostly employed at present. In the past, induced spawning by hormonal injection and artificial fertilization were done.

For broodstock development, male groupers were obtained by accelerating the process of sex reversal of 3 years old females through oral application of methyltestosterone at the dosage of 1 mg/kg for a period of about 2 months (Ruanganit et al., 1988; Ratanachot et al., 1986). This

is due to a protogynous hermaphrodite characteristic of *Epinephelus malabaricus*.

The parent fish can spawn naturally in captivity for several days during both lunar phases, (full moon and new moon) once a month and also every month between November and April of the following year (Table 2).

Table 1. Monthly fish egg production and hatching rate of seabass by environmental manipulation at Satul Fisheries Station in 1981 (Kungvankij, 1986).

		Tank No.	No. of egg ('000)	No. of yolk fish ('000)	Hatching rate (%)
April	25-28	5	5200	4200	80.7
May	23-27	5	6120	4710	76.9
June	22-25	5	7860	6150	78.2
July	20-24	5	11240	9450	84.1
July	23-25	4	1350	550	40.7
August	22-26	5	13510	10900	80.1
August	24-27	4	2540	1750	68.8
September	22-23	4	1730	1000	57.8
October	20-22	4	2520	1917	76.7
November	19-21	4	390	272	69.7
December	18-21	4	1700	1215	71.5
January	16-17	4	200	86	43.0
February	12-20	4	1438	1140	79.3
March	15-18	4	3770	2960	78.5
April	14-17	5	6640	4849	73.6
May	13-15	5	14000	11950	85.4
Total			80208	63140	78.72

Table 2. Monthly egg production and hatching rate of grouper by environmental manipulation at National Institute of Coastal Aquaculture (NICA). From Ruangpanit et al., 1988.

		No. of eggs ('000)	No. of yolk fish ('000)	Hatching rate (%)
January	20, 24, 26, 27, 28, 29, 31	9 290	3 760	40.47
February	1, 3, 5, 6, 7, 8, 9, 12, 14, 16, 17, 18, 19, 22	12 7507	7 627	59.82
March	3, 4, 5, 6, 17, 18, 19, 21	11 350	7 481	65.91
April	15-21	4 900	1 149	23.07
Total		38 370	20 017	57.16

NATURE OF EGGS AND EMBRYONIC DEVELOPMENT

Seabass

The mature egg is round with its shell membrane fully distended (no spaces nor distortions), measuring about 0.8 mm in diameter. They tend

to stick together and while in groups, the eggs give a golden hue. It has one oil globule inside which measures about 0.2 mm in diameter (Tattanong *et al.*, 1988).

The milt will flow freely from a mature male spawner. It should be of good amount preferably about 10 ml and not very sticky so that it flows freely if poured from container. If the milt is examined under the microscope, the sperm can be observed to move very rapidly.

Table 3. Duration of embryonic development in seabass at 27°C. (From Tattanong and Maneewongsa, 1988)

Embryonic stage	Period	
	Hours	Minutes
(a) Fertilized egg	0	0
(b) One-cell	0	35
(c) Two-cell	0	38
(d) Four-cell	0	44
(e) Eight-cell	1	03
(f) 32-cell	2	12
(g) 64-cell	2	43
(h) 128-cell	2	55
(i) Pre-blastula	3	11
(j) Blastula	5	32
(k) Gastrula	6	30
(l) Neurula	8	32
(m) Embryo develops head, optic lobes and tail buds	11	20
(n) Heart starts functioning, tail free, body starts to move	15	50
(o) Hatching	17	30

Table 4. Rate of absorption of yolk as shown by decreasing diameter of yolk inside the sac in seabass (Tattanong and Maneewongsa, 1988)

Diameter* of yolk in yolk sac (mm)	Time (days)
0.8800	0
0.3525	1
0.2752	2
0.1530	3**
0.0050	4
0.00	5***

* As the sac is actually elongated, this is a measurement across the longer axis from anterior to posterior

** Mouth opens

*** Yolk completely absorbed

When the milt and eggs are mixed by the dry method, fertilization takes place. There appears to be no significant changes on the egg from outside observations during the early stages. It was observed that it takes about 35 minutes after the mixing of the eggs and milt for embryonic development to begin. The approximate time and duration of various embryonic stages of seabass are enumerated in Table 3.

The period from fertilization to egg hatching can be affected by temperature. At 27°C, the eggs hatch in about 17 hours (Table 3) while at 30-32°C, the eggs hatch in 12-14 hours (Tattanong *et al.*, 1988). The newly hatched larvae is 1.5 mm in length with a big yolk sac. The yolk sac has one big oil globule at its anterior. This makes the larvae to stay in the water with head raised up at 45° to 90° angle of the water surface (Tattanong *et al.*, 1988). The body is slender and pale in colour with a loose distribution of pigments. The eyes, digestive tract, anus and caudal fins are distinctly seen but the mouth remains closed for a period of about three days. Table 4 presents the rate of absorption of the yolk as been observed under usual conditions.

Grouper

There have been no specific studies on the development of gonad in grouper in Thailand. However, induced spawning made in recent years was successful. Larval rearing has only been studied in laboratory.

When the milt and eggs are mixed by the dry method, fertilization takes place. The fertilized eggs are about 0.82 mm in diameter. It was observed that it took about 40 minutes after fertilization for embryonic development (Ratanachot *et al.*, 1986).

The approximate duration of the various embryonic stages of grouper were 19 hours at water temperature, 25-32°C and water salinity 31-33 ppt. (Table 5).

The mechanism of hatching of the grouper embryo has not been studied in detail. The newly hatched larva is about 2.50 mm in length with a yolk sac. They have a free tail fin and can move freely (Ruangpanit *et al.*, 1988; Ratanachot *et al.*, 1986).

DEVELOPMENT OF LARVAE, FRY AND JUVENILES

Seabass

The newly hatched larvae have a free tail fin and can move very freely. The larvae tend to confine at about 0.5 m below the water surface, often near areas of water that has aeration or slight movement (Ruangpanit, 1986).

The mouth opens when the larvae are about 3 days old and the yolk has almost completely absorbed. This is a sign that the fry can start feeding. Up to seven days old, the larvae are pale in colour. From seven days to metamorphosis, at 18-20 days, they appear dark with distinct vertical stripes on parts of the body. After 18-20 days, the larvae again assume a pale brownish colour. This time the vertical stripes can be more clearly distinguished. There are three stripes, one at the caudal peduncle, another at the level between the spinous dorsal fin and the soft dorsal fin, and a third over the head, all of which are particularly distinct.

In one month, the larvae metamorphose into the fry stage which has the appearance very close to the parent fish. The fry measures 1.5-2.0 cm.

These further grow and develop into juveniles after the third to fifth month when they attain 8-15 cm (Ruangpanit, 1988).

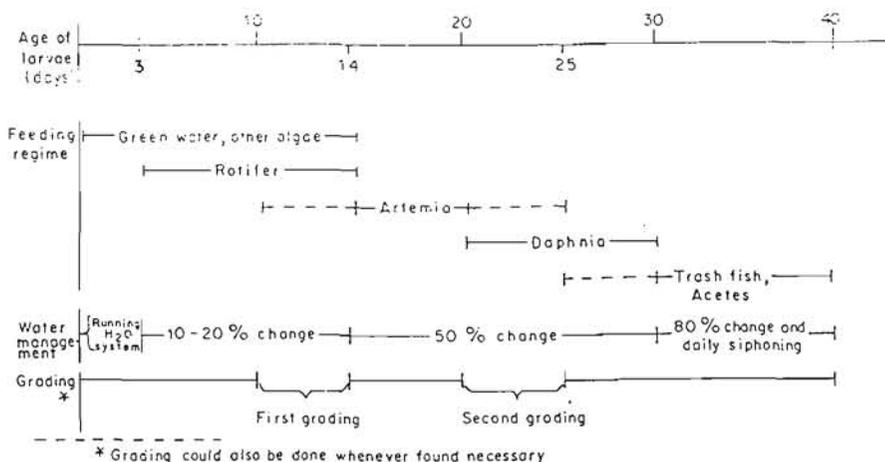


Fig. 1. — Chart showing management method for seabass nursery tank within the first 40 days period.

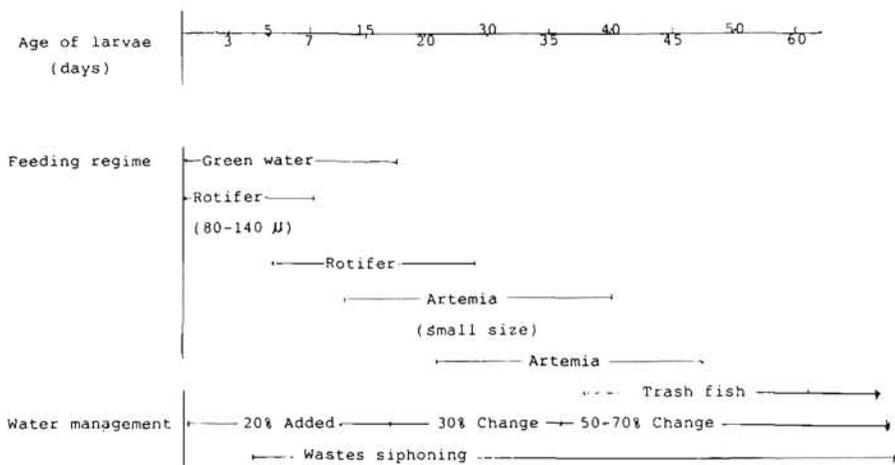


Fig. 2. — Chart showing management method for grouper nursery tank within the first 60 days period.

Grouper

As mentioned previously, the hatching mechanics, embryonic and larvae development have not been studied in details in Thailand. However, some details of larvae and fry development were observed. The larvae start to feed at the age of 3 days. The spines of the larvae were formed at the age of 10 days or length of 3.72 mm (Ratanachot *et al.*, 1986). The fry looks like the parent fish at the age of 40 days, length of 35 mm. (Table 6).

Table 5. Duration of embryonic development in grouper at 25-32°C and salinity, 31-33 ppt (from Ratanachot and Pakdee, 1986).

Stage	Duration		Size (mm)
	hours	minutes	
Fertilized egg	—	—	0.82
2-cell	—	40	—
4-cell	—	50	—
8-cell	1	03	—
16-cell	1	12	—
32-cell	1	27	—
64-cell	1	52	—
128-cell	3	06	—
Morula	4	06	—
Blastula	5	06	—
Gastrula	7	47	—
Form Notochord	9	13	—
Form mouth	15	27	—
Form fin	16	22	—
Heart beat visible	17	09	—
Newly hatched larva	19	45	1.756

Table 6. Duration of larval development in grouper at 25-32°C, and salinity 31-33ppt (From Ratanachot and Pakdee, 1986).

Stage	Duration day	Size mm	Remarks
Larvae	2	2.50	
—	3	2.62	Start to feed
—	5	2.86	Black colour on abdomen
—	7	3.10	
—	10	3.72	Dorsal spines formed
—	15	4.98	
—	20	17.20	Dorsal spines developed to the tail and colour spot appeared on the body
—	25	19.80	Mucous tissue cover on dorsal spine
—	30	23.00	Appearance of dark stripes
—	40	35.00	Metamorphosis completed (appearance similar to sarent fish)

LARVAE REARING AND MANAGEMENT

Seabass

As described previously, natural spawning in controlled tanks takes place at the same time as natural spawning in open water which is from the beginning of April to the end of September. The spawning in other periods must be induced by hormone injection. After spawning, fertilized eggs float to the surface and unfertilized eggs sink.

Egg collection and incubation. Eggs in spawning tanks can be collected and transferred to incubation tanks by either of the two following procedures (Maneewongsa, 1986; Ruangpanit, 1988) :

- the spawning tanks are supplied with continuous flow of sea

water after spawning. The overflowing water should carry the eggs into a small tank containing a plankton net (200 microns mesh size). Eggs are collected and transferred to incubation tanks the following morning.

- the eggs are collected from spawning tanks using a fine mesh (200 microns) seine net the morning after spawning.

Table 7. The amount of rotifer fed to seabass larvae/day (stocking 40 larvae/litre in 30-litre containers).

Rep. No.	Age of larvae (days)							
	2	3	4	5	6	7	8	9
1	369	164	410	820	820	1 066	984	984
2	278	556	648	648	1 204	1 019	1 019	833
3	369	553	560	560	876	1 107	1 245	1 199
4	478	318	398	398	955	955	1 115	1 035

Table 8. The average growth (T.L. mm) of seabass reared at different densities (From Maneewongsa and Ruangpanit, 1984).

Age (days)	No. larvae/litre			
	50	80	110	140
1	1.24	1.24	1.24	1.24
5	2.99	2.91	2.71	2.93
8	3.31	3.24	3.16	3.29
11	4.58	3.93	4.10	3.91
13	5.16	4.51	4.27	4.19

Table 9. Survival rate of grouper larvae rearing at NICA (1988). (From Rungpanit *et al.*, 1988).

Date	Newly hatched larvae No.	Fingerlings at 50 days old No.	Length (cm)	Survival rate (%)
20-1-88	630,000	7,644	3.3-5.0	1.2
24-1-88	250,000	6,691	3.7-5.1	2.6
26-1-88	200,000	6,274	3.7-5.2	3.1
28-1-88	540,000	23,869	3.5-5.0	4.4
9-2-88	320,000	2,869	3.7-5.1	0.9
16-2-88	350,000	3,183		
Total	2,290,000	50,530	3.5-5.2	2.2

Eggs are collected with fine mesh net and placed in incubation tanks at 100-200 eggs/l passing the eggs through 1 mm mesh screen in order to remove floating algae and other debris that have adhered to the egg. The optimum salinity for hatching appears to be between 20 and 30 ppt.

Larvae rearing. The rearing tanks commonly used in Thailand are made of concrete, either outdoors and indoors (Ruangpanit, 1986). Volume ranges from 5 to 25 tonnes. The process of larvae rearing is divided into two steps (Maneewongsa, 1986; Ruangpanit, 1988). The first step or primary rearing extends from hatching to a larval size of 4-6 mm in total length or 10-15 days after hatching; second step or secondary rearing covers the period of 6-15 mm length size or age 16-35 days after hatching.

In the primary rearing, the stocking density for newly hatched larvae in rearing tanks is 50-100 larvae/l. The bottom of the larval rearing tanks should be cleaned every day. The sea water should be changed and replaced every day at the rate of 30-50 percent in the morning. Good quality sea water with a salinity 30-31 ppt (Maneewongsa, 1986; Ruangpanit, 1988), is required for larvae rearing. If possible, a running water system should be used in the rearing tank for 2 days before feeding.

Feeding with rotifer, *Brachionus plicatilis* starts on the second day after hatching, corresponding with the formation of mouth opening which has been generally observed in the afternoon of the second day. The rotifer density of 10-20 pieces/ml was required as shown in Table 7. Rotifers should be given in adequate amounts up to the age of 15 days.

Green algae, either from *Tetraselmis* or *Chlorella* sp. should be added daily to maintain a density $8-10 \times 10^3$ or $3-4 \times 10^4$ cells/ml, respectively. The algae serve a dual purpose as a direct food to rotifer and a water conditioner in the rearing tank. Brine shrimp (*Artemia* sp.) nauplii were used to feed larvae together with rotifers from age 8 days. The survival rate was between 60 and 85 percent at densities from 50 to 140 fish/l. The growth rate is 4.19-5.16 mm in total length. (Table 8)

For the secondary rearing, when the fish larvae reached 15 days old they are transferred to another tank. The brine shrimp nauplii can be used for feeding. The stocking density would be reduced to about 10-30 larvae/l. Addition ground fish meat can be fed with *Artemia* nauplii when the fry reach 11-15 mm, or about 25-30 days old. The sea water in the nursing tank must be changed daily at approximately 50 percent. The survival rate of larvae are 77.7, 87.7 and 90 percent at stocking densities of 10, 20 and 30 larvae/l.

Grading techniques. Cannibalistic behaviour of seabass fry can be observed after the fry completes metamorphosis, when they are about 15 days old (15 mm in total length). To maintain a uniform size and minimize the mortality of the fry, grading of fry to size groups at regular and frequent intervals must be done. After the first size grading at around 12-15 days old, size grading should be done every 3-5 days (Maneewongsa, 1986; Ruangpanit, 1988). The material usually used for grading consists of plastic containers punched at the bottom with holes of 2, 3.5, 5, 6 and 7 mm in diameter. Fish are placed in the plastic containers which are floated in the newly prepared larvae nursing tank. The small fish can pass through the hole to the new tank. The remaining fish in the plastic containers are transferred into another tank and likewise graded with the use of a plastic container with larger holes.

Growth. By nursing seabass with enough food and appropriate techniques as described previously, they should attain a length of 1.2 cm in 30 days (Maneewongsa, 1986; Ruangpanit, 1986). The normal growth within the first 30 days is shown in table 9.

Grouper

Natural spawning in controlled takes place from November to the end of April in the following year. As described previously, the techniques of larval rearing of grouper fry have not been studied. The larval rearing techniques of sea bass fry are applied. However, the techniques have to be improved to obtain better survival rates of fry. At present, the hatchery techniques are employed as follows :

Egg collection and incubation. After spawning, fertilized eggs, also float to the pond water surface while unfertilized eggs tend to sink. The eggs can be collected by similar method for sea bass egg collection. At present, eggs are mostly collected and transferred to incubation tanks the following morning by using a fine mesh (200 microns) seine net (Ratanachot et al., 1986; Ruangpanit, 1988).

The eggs are washed of floating algae by passing through 1 mm mesh screen. Fertilized eggs are then dipped in 1 ppm of acriflavine solution for 1-2 minutes to get rid of bacteria and other microscopic organisms. Unfertilized eggs and waste materials are also removed by siphoning from the bottom of the nursing tank. The water salinity for hatching appears to be about 30 ppt.

Larvae rearing. As mentioned previously, the tanks, food and feeding and other techniques are similar to those employed in sea bass fry rearing. The process can be divided into two steps : primary rearing, which extends from hatching to a larval size of 5.0 mm or 15-20 days after hatching; and secondary rearing which covers the period up to 3.5-5.0 cms size or 20-50 days after hatching.

— At primary rearing the stocking density for newly hatched larvae in rearing tank is 10-60 larvae/l (Ruangpanit et al., 1988). The air supply should be provided very slowly keeping about 4-5 air stones in the tank of 26 tonnes. The live food organisms must be fed for the first 30 days after hatching. Three days after hatching, the fry are fed with small size rotifers (80-140 microns). At this point the completion of mouth opening has been observed. The normal sized rotifer would be used for feeding at 5-7 days, after hatching. The stocking density of rotifers in the rearing tank can be approximately 10-50 /ml. Rotifers should be given in adequate amounts up to 20 days age. Green algae *Tetraselmis* or *Chlorella* sp. should be added daily to serve as a direct food to rotifer and as water conditioner. Small size shrimp nauplii are fed to larvae together with rotifers from age 12-15 days (Ruangpanit, 1988).

Filtered sea water is stocked at a depth of 60 cm in 26 tonnes tank. Then, 20 percent sea water volume is replaced daily. The waste material is siphoned out daily from the bottom of the rearing tank after 7 days.

— At secondary rearing, brine shrimp nauplii are fed up to age 45 days. The small size brine shrimp nauplii are fed during age 12-30 days, while the normal size nauplii were fed from age 30 days to 45-50 days. Approximately 30 percent of filtered sea water is changed daily. P.V.C. pipe (1.5-2') for hiring particle were fixed in the rearing tank at level 30 cm above the bottom. Filtered sea water would be daily changed and supplied as previously.

Juvenile rearing. When the fry are 50 days old or 3.5-50 cms length they are transferred to another tank (Ruangpanit et al., 1988). The ground fish meat can be fed at age 45 days with *Artemia nauplii*. Filtered sea water is totally changed and supplied every day. The semi moist compound diet is given three times a day.

Growth. Growth of grouper fry which survived in hatcheries are shown in Table 6. The fry attain a length of 6.25 cm in 60 days.

As mentioned previously, the rearing techniques are still under study in Thailand. At present, grouper fingerlings collected from the wild are the only source. Only one crop of fry survived from NICA hatcheries in 1988. The average survival rate of 50 days old grouper fry was 2.2 percent (Table 10).

LIFE FOOD ORGANISM CULTURE

The culture of aquatic micro-organisms as food for larvae of fish is very important. The success of the production of fish fry depends on a constant supply of food.

Phytoplankton culture

Algae species used in seabass hatcheries in Thailand are *Chlorella* sp. and *Tetraselmis* sp. The first stage of the phytoplankton culture is conducted in the algal room, except for large-scale culture which is done outdoors. It is necessary to maintain pure stocks of algae throughout the year.

Mass production of phytoplankton started at a 1-1 scale. The scale of culture is then gradually increased to a volume ratio of 1:10. The average culture cycle in unicellular algal mass production is 3-5 days. Cell density is 1-2 million cells/ml for *Chlorella* sp. and 80,000-120,000/ml for *Tetraselmis* sp. (Maneswong, 1986). The measurement of cell density by means of a blood cell counter is used only at the first stage culture. For the estimation of cell density in the large-scale culture, the measurement of transparency of green water is employed by using a white disc 15 cm in diameter. The culture of *Tetraselmis* sp. in Thailand is more successful than with *Chlorella* sp. which is usually contaminated with a blue-green algae.

Tetraselmis sp. can be cultured in natural sea water between 15 and 36 ppt and grown at temperatures between 15 and 33°C under natural light conditions. Because the temperature of the outdoor tank for culturing phytoplankton was between 26 and 33°C, *Tetraselmis* was suitable for culturing for feeding rotifer in Thailand. The culture media for these algae are as follows : ammonium sulfate 100 g/tank; superphosphate 15 g/tank; urea 8 g/tank.

Rotifer culture

There are many species belonging to Rotifera, but the most suitable for mass culture appears to be *Brachionus plicatilis*. It is an important and

indispensable food for marine finfish larvae. It is rich in nutrients and small enough in size for the larvae to consume.

Table 10. Normal growth rate of seabass larvae in 30 days. (From Tattanong and Manee-wongsa, 1988).

Age (days)	Total length (mm)	Remarks
Fertilized egg	0.870	Diameter of fertilized egg
0	1.51	Beginning to hatch *
—	2.18	
7	3.59	
14	4.36	
20	8.10	
30	12.05	

* Hatching is at 12th to 17th hour depending on temperature.

Table 11. Disease of Seabass and Grouper Culture in Thailand.

Size	Disease	Cause of	Mortality (%)	Treatment
3-8 days (0.5 cm)	Gas-bubbles disease	—	90-100	Formalin 25-30 ppm 24 hours
10-20 days (0.5-1.5 cm)	Blackbody	—	50	Formalin 100-200 ppm 15-20 minutes and tetracycline 25 ppm 24 hours
2.5-8 cm	Marine white-spot disease	<i>Cryptocarium</i> sp.	10-100	Formalin 30 ppm 30 minutes
1.5 inches	Kidney disease	<i>Vibrio</i> sp;	5-100	Ampicillin 50-100 ppm 5-7 days
3 inches	Columnaris disease	<i>Flizibacter columnaris</i>	60	Acriflavin 3 ppm 3 days or NaCl 3-5 %
3 inches	Fin rot and tail rot	<i>Aeromonas hydrophillia A. punctata</i>	5	Tetracycline 25 mg/kg fish or inject 6 mg/kg fish
4-7 inches	Lymphocystis	DNA Virus	—	—

Rotifer are usually reared in concrete or fibreglass tanks. The size of the culture tank ranges from 1 to 50 tonnes. The tanks are initially filled with *Chlorella* sp. or *Tetraselmis* sp. cultured at a density of 10×10^6 and 10×10^4 cells/ml respectively. Rotifers are added at a density 10-20/ml, reaching 80-100/ml in 5 days. There are then ready for harvesting by siphoning the water from the rotifer culture tanks through 63 microns mesh bags, leaving half of the original column to serve as a starter for the next batch. Then phytoplankton (100,000 cells/ml) are added to the rotifer culture tank to the same level in order to grow the next batch of rotifer. Dry baker's yeast is added as a supplementary food at the rate of 0.5 g/million rotifer when water in the rotifer culture tanks became clear. Each rotifer culture tank was used for culturing for 7-10 days, then cleaned and reused.

DISEASE AND PREVENTION

Many diseases have been identified in nursing of seabass and grouper fry in Thailand. The parasites found in grouper fry included protozoa and trematodes (Table 11). Diseases caused by *Cryptocaryon* sp., *Vibrio* sp. and *Flexbaxter columnaris* were also found in sea bass fry. Among these, white spot is most commonly observed during hatchery operations. Some treatment methods have been studied. The preventive measure is to grow strong fry, which can withstand pathogenic agents, through proper control of water quality, provision of clean rearing tanks, provision of fresh, high-quality feed in proper quantity, and appropriated stocking density of fry.

Table 12. The economics of seabass hatchery in Thailand (Kungvankij et al., 1987).

Item	Value
A. Income	
Newly hatched larvae (1 day old)	10 M. (1,000/2 US\$) 20,000
0.5 cm larvae (15 days old)	2 M. (1,000/6 US\$) 12,000
2.5 cm larvae (40-50 days old)	2 M. (1,000/100 US\$) 200,000
Sub-total A	232,000
B. Fixed Cost	
Land cost (10,000 18 % interest)	1,800 (1.2 %)
Hatchery construction (50,000 10 % depreciation)	5,000 (3.5 %)
Equipment (20,000 20 % depreciation)	5,000 (2.6 %)
Interest (200,000 16 %)	36,000 (23.7 %)
Property tax (1.5 %)	150 (0.1 %)
Sales tax (1 %)	2,320 (1.5 %)
Sub-total B	49,270
C. Operating Cost	
Broodstock	2,500 (1.6 %)
Broodstock feed	2,000 (1.3 %)
Artemia cyst	40,000 (26.3 %)
Hormone	2,000 (1.3 %)
Chemical/fertilizer	2,000 (1.3 %)
Larval feed	5,000 (3.3 %)
Electricity (12,000/tonth)	14,400 (9.5 %)
Fuel and oil	1,000 (0.7 %)
Labor chief technician	400 x 12 = 4,800
technician 3 x 300 x 12 = 10,800	
workers 2 x 100 x 12 = 7,200	22,800 (15 %)
Materials and supply	5,000 (3.3 %)
Maintenance	4,000 (2.6 %)
Sundry	2,000 (1.3 %)
Sub-total C	102,700
D. Total Cost (B + C)	151,390
Net operation cost (A-C)	127,300
E. Net income (A-B-C)	78,030
F. Income over total cost	51.34 %

Table 13. The following hatchery facilities used in Thailand.

Stage	facility	Stocking density	Unit volume (t)	Size, Shape construction material
Adults	spawning tank	1 fish/5 ton	50-150	square 5 x 5 x 2 m circular 2 m depth concrete with aeration
Eggs	incubation tank	100-200 e./l.	0.5-2	conical, circular, fibre-glass, concrete
Larvae	larvae rearing tank	20-50 l./l.	5-25	circular, rectangular concrete
Natural food	starter tank	0.5-1	circular, fibre-glass	
Phytoplankton	algal culture tank	10-50	rectangular concrete	
Zooplankton	rotifer culture tank	10-50	rectangular concrete	

THE ECONOMICS OF SEABASS SEED PRODUCTION

Seabass seed production and culture have been developed over the past 15 years. The technology has helped to expand and to develop the industry into a promising enterprise.

The spawners can be collected from the culture area. Spawning is induced by hormone injection and water ambient manipulation. Larval rearing techniques developed in Thailand have been successful and the technology can be and has been transferred to private hatcheries and fishfarmers (Tookwinas, 1988).

The financial analysis of seabass hatchery is shown in Table 13. A hatchery in Thailand producing larvae in excess can dispose of newly hatched larvae to farmers or to other hatcheries (Kungvankij *et al.*, 1987). The farmers can operate their own backyard hatchery to rear seabass fry to nursery stage. Therefore, it becomes convenient and economical to operate a seabass hatchery. Table 12 shows that income from seabass hatchery is 51.34 percent over total cost.

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