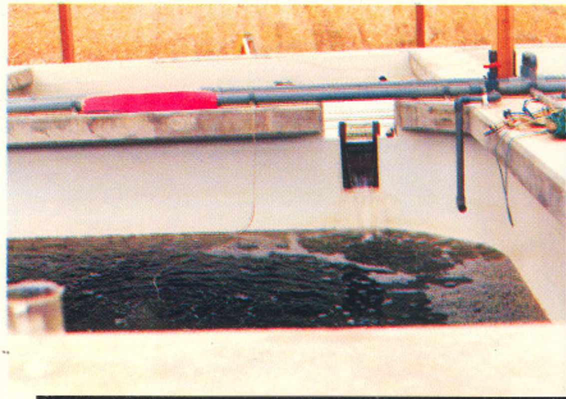

Syarahan
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THE EVOLUTION OF AN ENVIRONMENTALLY FRIENDLY HATCHERY TECHNOLOGY FOR UDANG GALAH, THE KING OF FRESHWATER PRAWNS AND A GLIMPSE INTO

The Future of Aquaculture in the 21st Century

Professor Ang Kok-Jee

Background Information

This lecture consists of two parts. Part one summarises the research on *Macrobrachium rosenbergii* conducted in Universiti Pertanian Malaysia since 1977 highligting its seed production technology. The second part contains some thoughts/ perceptions on the direction/trend of aquaculture development in the 21st century.

The giant freshwater prawn, *Macrobrachium rosenbergii* (de Man) known as udang galah is distributed in the Indo-West Pacific region extending from north-west India to Vietnam, Malaysia, Philippines, Papua New Guinea and Northern Australia. It is the biggest freshwater prawn. The male grows to a size of 320 mm and weighs over 200 g (Ling, 1969).

New (1995) reviewed the status of the culture of this species world wide. In 1992 the world production of this prawn was 31,325 tonnes. It comes from the continents of Asia, Africa, Latin and Central Americas, North America, Oceania and the Pacific region. This indicates the wide interest shown in the commercialization of this species. Ninety two percent of this production comes from the Asian region.

The current farm-gate price in Malaysia is RM21/kg (30 pieces/kg). In Brussels, Belgium the retail price of this prawn was RM133/kg headless as compared to marine prawns which was RM155/kg (Ang, personal observation, 1992). In Europe due to the natural depletion of *Crangon* spp. fishery which are marketed as "Scampi", udang galah has been found to be an acceptable substitute for *Crangon* spp. since its tail has a resemblance to *Crangon.*

The main supply of udang galah comes from capture fishery of natural water bodies such as rivers and lakes. However, production from these sources has been declining due to overfishing, and aquatic pollution. This decline has been pointed out by Kloke and Potaros (1975).

Although the pioneering work in the larval rearing of this species was done by Ling and Merican (1961) and Ling (1962) in Malaysia, there is still no large scale commercial production of this prawn in this country when compared to marine tiger prawn.

According to fisheries statistics (Anon. 1987 - 1991) the production has increased from a mere 5.04 tonnes in 1987 to 131.07 tonnes in 1991. This constitutes to less than 2% of the total freshwater fish production in the country. Perak, Selangor and Negeri Sembilan are the main producers of udang galah. The average size per holding is 0.27 ha and an average pond size is 0.16 ha (Anon. 1991). However, the culture of freshwater prawn has attracted many people because of its high price and great demand.

Several reasons were attributed to the slow growth in freshwater prawn farming in this country. Many of the existing ponds are found to be unsuitable for freshwater prawn culture due to poor site selection, inadequate water supply, and poor design. Ang (1991 unpublished) found that small-scale aquaculturists had to face several problems. Some of these problems were high feed cost, poor growth rate, delay in getting seed, flooding in ponds during rain, high mortality due to diseases, pollution, poor water quality and predators.

New (1985) discusses the progress in the culture and R & D of this species. In Malaysia research agencies such as the universities are involved in the study of this species with respect to its larval rearing technology, nutritional requirements at larval and on-growing phases as well as its farming systems. The results from some of these studies have been reported in various publications (Singh, 1980; Arnielo and Singh, 1982; Lee, 1982; Ang and Cheah, 1986; Ang *et al.,* 1989; Nik Razali *et al.*, 1989; Othman Mohamed, 1989; Law *et al.,* 1990; Ang and Law, 1991; Ang, 1993; Law *et al.* 1994; Alam, *et al.* 1993a and 1993b; Maclean, *et al.* 1994)

Macrobrachium rosenbergii research in Universiti Pertanian Malaysia can be broadly divided into five components. These are (1) seed production (Cheah and Ang 1979; Alam, Ang and Cheah 1986; Alam *et al.* 1991, 1992, 1993a; 1993b; Ang, Cheah and Yamazaki 1990; Eui 1993; Cheah, Ang and Arshad 1987; Chow 1992; Tan 1995; Rafig 1985; Yap 1992; Ng 1995; Ang, Raffig and Cheah 1990; Ang and Law 1991, Daud 1988; ; Cheah *et al.* 1989; (2) nursery production (Chin 1985; Abu Bakar 1990; Ang and Law 1992); (3) nutrition (Chin 1987, Poh 1985; Law *et al.* 1990, 1994; Ang *et al.* 1992; Lee 1992; Das 1995), (4) on-growing (Ang *et al.* 1989, 1992a, 1992b, Ang 1989a, 1989b, Komilus 1991), Maclean 1992; Maclean *et al.* 1994a, 1994b, 1994c, Ang and Law 1992, 1993; Yong 1986; and (5) water quality (Chan 1991, Ng 1992; Yeo 1991; Law 1993; Piyan 1984; Soh 1985; Sufian 1986, Azizan 1986).

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Seed supply and cost

Prawn seeds constitute about 24.6% to 39.2% of production cost in an udang galah farming (Ang 1990) depending on the stocking densities. Another constraint facing the udang galah industry in Malaysia is the shortage of high quality seed supply in spite of the early success in the larval rearing method developed by Ling (1969).

Udang galah hatchery system

Essentially there are two hatchery systems for seed production of udang galah namely the clear water system (Ling, 1969) and the green water system (Fujimura, 1966). Both these systems have their merits and demerits. Some of the demerits of these two systems are labour intensive, and the requirement of large quantity of water for exchange purposes after each feeding. Under poor management conditions it is often infected with diseases and resulted in high mortality, usually after the third or fourth cycles. Traditionally udang galah hatcheries have to be located near the sea since it requires a large amount of seawater for its operation. From these two systems evolved other systems such as recirculation clear water system (AQUACOP, 1977; Ong, 1983).

Concept of an ecological natural ecosystem for larval rearing of udang galah

Under natural condition udang galah larvae grow in estuaries where the environmental conditions are very dynamics with the frequent changes in salinity, organic and inorganic loadings which are regulated by tides and river flow. It is hypothesised that since the larvae thrive well under such dynamic conditions they must be hardy and adaptable to the constant fluctuations in several environmental factors.

Introduction of the modified static green water system for larval rearing of udang galah

The larval rearing methods of udang galah have been documented by several workers (clear water method by Ling 1969; Ling and Costello 1976; green water method by Fujimura 1966). These methods involve intensive hatchery management such as frequent water exchange and cleaning of larval tanks to ensure good sanitation. Such a method would involve wastage of water and is labour intensive. To overcome and simplify the above mentioned problems a study was conducted at the hatchery of the Faculty of Fisheries and Marine Science, UPM Serdang to produce udang galah juveniles without water change and using "green water" at salinities of 6-8 p.p.t. and 12-14 p.p.t. "Green water" has been shown to be an efficient system to remove toxic metabolites such as ammonia from the culture medium (Cohen *et al.* 1976). The "green water" which mainly consists of unicellular algae such as *Chlorella* act as a biological filter in the culture tank and is produced by exposing water of salinity 6 p.p.t. which contained *Tialpia mossambicus* to sunlight (Fujimura 1966). Such a system will simplify and reduce labour and managment. It will also enable the hatchery to be set up away from the sea.

Several studies using the "modified green water" system were carried out initially using only 100 L larval rearing tanks and then increased to 1,000 L, 2,000 L and finally 10,000 L tanks. The results from this study are given in table 1.

Table 1. Production of udang galah post-larvae (PL) under different culture systems in Malaysia

Culture Systems	Salinity (ppt)	Stocking Rate per	Rearing Period Litre	Survival Rate (Days)	PL per (%)	References Litre
Static Green Water	12 - 14	40	25 - 51	-	8 - 10	Lee (1982)
Static Clear Water	12	42	37 - 40	66 - 97	30 - 39	Ong (1983)
Recircu- lated Clear water	12	29 - 47	33 - 35	58 - 92	25 - 38	Ong (1983)
	12 - 14	40 - 48	32 - 63	-	9 - 17	Lee (1982)
	6 - 12	-	-	48.6	54	Zainoddin & Yaakob (1989)
	6	32	35	23.9	7.2	Julia Overton (1993)
Modified Static Green Water	12	25	42 - 53	36 - 77	8.3 - 19.3	Ang & Cheah (1986)
	6	25	47 - 79	39 - 40	8.9 - 10.3	Ang & Cheah (1986)
	11 - 12	30	31 - 35	30 - 73	9 - 21	Alam *et al.* (1991)
	12	-	35	50 - 66	30 - 40	Ang (unpub lished)
	6	32	28	32.7	9.8	Julia Overton (1993)

The results show that a production of 8.3 to 40 post-larvae per litre can be achieved with a variable survival rates of between 30% to 77%. These results are comparable to other production systems.

The following basic criteria must be observed in operating the "modified static green water" system in order to achieve optimum production.

1. The salinity of the culture medium is in the range of 6 to 12 p.p.t.

2. The culture medium has to be seeded with "green-water".

3. The larval tank has to receive a diffused light of at least 6000 to 18,000 lux for 10 hours per day.

4. The larval tank has to be equipped with uninterrupted 24 hours aeration.

5. The depth of the tank should not exceed 80 cm.

6. The culture water need not be replaced throughout the length of the culture period but need only to be topped up to maintain the original volume.

7. The larvae may be fed with egg custard but the last feeding should be given live feed such as *Artemia* or *Moina* (table 2). If *Artemia* is used, do not deencapsulate the cysts to hatch but just hatch them and feed the larvae with the hatched *Artemia* nauplii together with the egg cases and the unhatched cysts.

8. The bottom and the sides of the larval rearing tank should not be dis turbed to ensure the growth of the algal mat (lab-lab).

Table 2a. Composition of egg custard

Ingredients	Quantity
Hen egg	1.0
Skim milk powder	20.0 g
Cockle homogenate	20.0 ml
Vitamin premix	0.5 g
Cod liver oil	1%

Source: Modified from Kabir Ahmad Raffiq (1985)

Table 2b. Feeding Schedule and particle size of the egg custard for udang galah larvae.

Time	Age in days			
	1-5	6-10	11-20	More thna 20
Egg custard feed size (mm)	< 0.23	>	< 0.35 >	< 0.60 >
0830	E.C.	E.C	E.C.	E.C.
1130	E.C.	E.C.	E.C.	E.C.
1430	E.C.	E.C.	E.C.	E.C.
1615	E.C. + Ar.	E.C. + Ar.	E.C. + Ar.	E.C. + Ar.

Source: Ang and Cheah (1986)
E.C. + Ar. - Egg custard plus *Artemia*

The evolution of the biostream hatchery system

The study on the larval rearing of *Macrobrachium rosenbergii* (de Man) in a 16-ton recirculated biostream began in 1987 at Universiti Pertanian Malaysia, Serdang, Malaysia. The function of this system has been described by Yamazaki *et al.* (1988). Basically the bio-stream system consists of the main larval rearing tank which is connected to the biostream component and water in the tank is recirculated via the biostream component by air-lift pump (fig. 4).

Subsequently several experiments were conducted to improve larval production using the biostream. Some of the basic criteria for this method to succeed are 24 hour uninterrupted air supply ; depth of larval rearing tank should be about 80 cm; biostream and larval rearing tank should be located under transparent roof to receive at least a light intensity of 6000 lux during day time.

A week before the larval rearing starts, brackishwater of 6 to 12 p.p.t. salinity is allowed to circulate in the biostream. Thus the introduction of the "green water" as in the case with the "modified green water system" is not needed. During operation the required number of berried female prawns having eggs of the same developmental stages are stocked in the biostream component of the hatchery system which serves as automatic incubation chamber. By using table 3, one can calculate the number of berried females (all orange eggs or all grey eggs) that can be stocked in the biostream for larval rearing. Upon hatching, the larvae automatically flow into the larval rearing tank by gravity. The power supply to operate the air pump can also be linked to solar powered cells. The feed and feeding schedule is similar as in the "static modified green water system".

Table 3. Relationship between body weight and egg number in *Macrobrachium rosenbergii.*

TL	OL	BW	EW	
(cm)	*(cm)*	*(g)*	*(g)*	*Egg No.*
8.0	6.2	4.29	0.132	1044
8.5	6.6	5.31	0.189	1535
9.0	6.9	6.48	0.265	2209
9.5	7.2	7.82	0.364	3115
10.0	7.6	9.36	0.493	4317
10.5	7.9	11.10	0.657	5889
11.0	8.2	13.06	0.864	7917
11.5	8.6	15.25	1.122	10505
12.0	8.9	17.69	1.442	13771
12.5	9.3	20.40	1.834	17855
13.0	9.6	23.40	2.310	22915
13.5	9.9	26.70	2.885	29134
14.0	10.3	30.31	3.574	36719
14.5	10.6	34.26	4.394	45903
15.0	10.9	38.57	5.364	56952
15.5	11.3	43.25	6.508	70163
16.0	11.6	48.32	7.846	85867
16.5	11.9	53.81	9.405	104436
17.0	12.3	59.72	11.212	126279
17.5	12.6	66.08	13.299	151853
18.0	12.9	72.91	15.699	181660
18.5	13.3	80.24	18.447	216253
19.0	13.6	88.07	21.584	256239
19.5	13.9	96.43	25.151	302283
20.0	14.3	105.35	29.195	355112

Source : Ang K.J. and Law, Y.K. 1991
TL : Total Length; OL : Orbital Length;
BW: Body Weight; EW : Egg Weight.

The high cost of larval production is also attributed to the wide use of *Artemia* as live feed for the larvae. Studies at UPM on the larval rearing of *M. rosenebrgii* have indicated the viability of complete replacement of *Artemia* with _*Moina* as live feed from stage VI-VII without any reduction in post-larval yield. Thus this offers new opportunities for the culture of this species in regions where the cost of live feed such as *Artemia* is high and sometimes it is unavailable.

Our studies have also shown that 50% of sea water can be replaced by sea salt in culturing the giant freshwater prawn larvae, without affecting production.

With proper management, a larval production of between 17.4 to 40 post-larvae per litre can be consistently obtained. The larvae produced by this method are very healthy and vigorous. Its simplicity of operation and management, low production cost and environmentally friendly device are some of the merits of this system. The water quality at the end of the production cycle is still in good conditions (table 4).

Table 4. *Some of the water quality parameters in the new Bio-Physico-Chemical Hatchery System used for Macrobrachium rosenbergii larval rearing*

TRIAL No./ PARAMETERS	I Tanks		II Tanks
	1	2	3
pH	7.00-7.59	7.77-8.07	7.36-8.60
Water temperature (o^c	27.0-28.0	27.2-28.0	25.6-28.0
Ammonium-Nitrogen (p.p.m.)	ND-0.02	-	ND-0.04
Culture volume (tons)	10.0		8.64

A proposal for the transfer of udang galah farming technology from laboratory to farm level

Although udang galah culture in Malaysia began in 1960's but to date its development is very slow due to several reasons. These are highlighted in the earlier part of this paper.

It is estimated that Malaysia has about 4,000 ha of freshwater fish ponds. Assuming that only 10% of these existing ponds are suitable for udang galah culture, an annual production of about 2,400 tonnes valued at RM50.4 millions of udang galah can be obtained. The annual seed requirement will be about 120 millions valued at RM4.8 millions.

The udang galah culture technology developed at UPM can be transferred to selected rural areas where the participants can be trained to adopt this new technology. The selected area can become a model centre to other regions. Networking can be established between UPM/Rural Ministry/State and Federal agencies.

Selection of a model centre should be based on - (a) interest of the participants, (b) suitability of the existing ponds and, (c) already the existence of basic infrastructure. With the establishment of such a centre, it is anticipated that udang galah culture can be developed fast in this country to supply the local and export markets.

A GLIMPSE INTO THE FUTURE OF AQUACULTURE

The recent report (COFI/95/9) of the high-level panel of external experts in fisheries to the Director-General of FAO stated that upto the year 2010 the problem of maintaining per capita consumption of fish is theoretically tractable provided the resources are properly managed but beyond that time the possibilities are uncertain especially by the year 2050 it is anticipated that the population will rise to 10 billion. In 1990 per capita fish consumption was 13.4 kg as compared to 10.3 kg in 1970 (Westland, 1995). However, many studies have indicated that the world food fish resources are limited.

In the case of aquaculture, it has been growing steadily, in both quantity and value, during the last 20 years. It contributes about 20% of the world fish production today. Many of the current harvest comes from low-priced fish produced by small-scale farmers, and over 80% comes from the Asian region (COFI/95/9). There is, however, a global trend toward high-priced species and using more intensive and technologically advanced farming systems. Thus when we adopt an intensive or super-intensive farming systems, the habitats for the culturing environments should be of high quality. The effluents from the aquaculture activities will also contribute to pollution.

Current status of the economy of fishery

The seas and the inland waters are being subjected to an ever increasing pollution. Many coastal areas, and rivers are already biologically almost dead or highly endangered due to steadily increasing harmful substances in the water. It requires the will and the cooperation of all nations of the world to clean and reverse the process.

It is known that the neritic zones on earth are the breeding places for many aquatic organisms. The ecological destruction of these breeding regions has long-ranged consequences for our future fish supply. Competitive use of water for various human activities (consumption, recreational, industrial and agriculture) are very intense.

Besides, the fish meat may also contain very high concentrations of heavy metals and pesticides therefore, the fish is not suitable for human consumption. Even if mankind is able to reduce this further burdening of our waters with harmful susbstances, the already sedimented heavy metals and poisons retain dangerous and life destructing impacts.

Therefore, it is imperative that solutions to the above-mentioned problems should be available. One solution to these problems is to produce fish under stringent environmental control using a closed recirculating filtration system. The technology for am efficient recirculating water filtration system for small aquariums is available for some times already.

However, the technology using this system for large-scale commercial fish production is of recent development and it is not available in Malaysia at present. Though some countries in Europe claim to be able to produce eels to the tune of 200 tonnes/ year in a 1500 m^2 of surface area via the recirculating super-intensive system.

Traditionally aquaculture in Malaysia has been practised under the extensive and semi-intensive pond systems using polyculture method introduced by the early Chinese immigrants. During the 1970's and 1980's marine prawn pond farming was introduced usually using whole scale adoption of methods used elsewhere mainly Taiwanese method.

Cage culture of freshwater and marine species was introduced in 1960's and became popular in 1980's and 1990's. Intensive culture of tilapia in cages and flow-through tanks have also become popular.

The recent development of open pond/tank super-intensive culture of prawn has also experienced losses due to diseases. The collapse of that industry in Taiwan in mid-1980 was due to disease and pollution. The same fate has met the Thai intensive catfish pond culture in 1970's and 1980's.

Therefore, there are limitations for all the present methods of aquaculture production in open or flow-through water systems. These primary limitations are pollution of water by fish excrements and uneaten feeds (Woodward, 1990). The most important detrimental effects associated with fish farming are the increase in particulate organic matter entering the sediment and the increase in nitrogen and phosphorous entering the water column. Chemicals used in the treatment and control of diseases in ponds and tanks also degrade our environemnt. The present method of culture are also being subjected or exposed to uncontrollable external environments such as pollution (Law, 1994) and climatic changes.

Possible radical changes in aquaculture practice in the 21st Century

As Malaysia rapidly progresses into the next century and the Government's policy of making the country into an industrialised developed economy by year 2020, aquaculture industry in Malaysia has also to adopt itself to fit into the long term strategic planning of the country or face extinction.

The scenario for 21st century will be the doubling or even tribling of its population. The demand for aquatic products such as fish and shrimps will increase as population increases. However, the supply of fish from capture fishery will not be able to meet this demand. From world fishery statistics of the last 20 years, it clearly indicates that the total annual world production of fish from natural waters will not exceed 100 millions metric tons. Thus there will be a shortage of fish supply. Hence, it is imperative that this demand should be met by aquaculture production method.

In order to fulfill this demand radical changes in the production system have to be evolved and introduced. The economic scenario of the country will change from an agricultural based economy to an industrial based economy. There will be tremendous pressure and changes imposed upon the country resources -such as land, water, human and other natural resources. All these resources will be subjected to alternative and competitive uses.

As far as aquaculture industry is concerned three important mitigating factors will influence its future viability as an industry in Malaysia. These factors are water, land and manpower.

In a recent report the Environmental International Agency (EIA) stressed that "There can be no stronger indicator of marine ecosystem dysfunction than the mass die-offs of whales, dolphins, and porpoises around the coast of the United States and Europe in recent years." The agency says that lethal viruses associated with pollution have been blamed. Besides large amounts of higly toxic man-made chemicals and industrial wastes of all kinds, the latest and most potentially lethal is nuclear waste. Oil pollution is another serious contribution to aquatic environment degradation especially in the Straits of Malacca (Law 1994).

Our rivers too have not been spared with pollution. In a recent report by the Department of Environment, Ministry of Science, Technology and Environment Malaysia, over 32 of our rivers have been classified as badly polluted.

The importance of water in Malaysia has been emphasised by the Department of Irrigation. According to report the country will face a water crisis in 30 years time unless Malaysians act now to protect and conserve our water resources. "Like oil, water is a strategic resource for which nations will compete fiercely as it becomes more scarce."

The current breakdown of water usage in Malaysia is: irrigation 78%. domestic and industrial 20%, and non-consumptive uses such as hydropower generation, navigation, aquaculture, recreation and mining 2%. By year 2020 the total water demand and a further rise is likely from the present 9 billion cubic meters to 13.2 billion cubic meters. As the country gears up towards an industrial based economy, more water resources will be allocated and used by this sector. As the country becomes more affluent, more land and water areas will be used for recreational purposes. Correspondingly there will be less land and water available for aquaculture needs. There will be also shortage of manpower in all economic sectors.

Therefore, the current aquaculture practices of using floating net-cages in lakes or seas or flow-through or water replacement in ponds to the tune of 3-6 times of its volume per day may not be any longer viable in the near future due to comptetive use of water and land. These practices utilize a large volume of water, land for ponds and water areas for cages.

Hence, new production systems to increase efficiency and environmentally friendly have to be found. A new direction in aquaculture is to utilize a biologically balanced recirculating water system for intensive and super-intensive culture of aquatic organisms. Producing aquatic organisms in this manner can economise water, labour and land. The production system can be environmentally controlled. Surely the production cost will increase but in the next century people will enjoy a much higher standard of living and higher purchasing power.

Therefore, I propose that aquaculture activities should be moved from sea/water based to land based using the biological recirculation filteration system. In such a production system, the product quality that are offered to consumers can be guaranteed. In order to adapt the aquatic organisms to such a system, more intensified research are needed in the areas of eco-physiology, nutrition, genetics and diseases. Hardy species/varieties have to be developed through genetic selection/engineering to adapt high density stocking, fast growth, etc. Basic information on the basal metabolism, oxygen consumption rates and patterns at different age and sizes by the species considered for such a system are necessary.

Conclusion:

In conclusion, I propose the establishment of a networking between UPM/ State/Government agencies to bring udang galah farming technology to the rural area through the creation of a model centre for the dissemination and promotion of the technology.

I also suggest that Malaysia should look seriously into an alternative method of farming systems for aquatic orgnanisms so as to be in line with our country's developemnt in the 21st century. One alternative is the adoption of a biological recirculation filteration system for intensive and super-intensive culture of aquatic organisms.

Although the technology for intensive and super-intensive culture of fin-fish is already available for some species in some countries, the wholesale transfer of technology of this system to Malaysia will not be successful because of several generic variations due to different species and environmental conditions. Thus adaptive research has to be done at the local levels and conditions.

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