I. INTRODUCTION

The Prince of Songkhla is one of the major universities under the governing of the Ministry of University affairs in Thailand. It consists of two campuses : one in Haad Yai with emphasis on Science and Technology and the other in Pattani oriented toward Social Science and Humanities. It is the aim of the University to concentrate its research areas on the relevant problems concerning locally available resources.

One such area which awaits investigation is the utilization of natural resources in Lake Songkla, which is the largest lake in Thailand, with the area extending to three southern provinces. The lake is actually a Lagoonal reservoir which connects to the Gulf of Thailand. The lake can be divided into 3 parts according to the salinity of water, (1) the upper most part covering 70% of the lake surface is freshwater area, (2) the lowest part of the lake is seawater area covering about 25% of the lake surface and (3) the middle area, where freswater and seawater (brackish water area) meet, covers about 5% of the lake surface.

Thale Noi

Thale Noi, the upper most part of Lake Songkla is a fresh water lagoon of approx. 25 km sq. The lagoon is situated at the junction of Pattalung, Songkhla and Nakornsrithammaraj provinces. Aquatic weeds bloom all year round with abundance of a few species. Some of them such as *Hydrilla verticillata* and *Ceratophyllum demersum* are used as pig feed.

In 1979, the annual harvest for this purpose is estimated at 356 tons in Thale Noi and 1,457 tons from the whole Pattalung province, which covers 25% shore line of the upper part of Songkla Lake (Fisheries Section, Pattalung Governor Office).

During January-December 1982 the average standing crop of 12.197 kg/m^2 of aquatic plants in Thale Noi was observed (Purintavarakul, self communication, 1984). The sattelite and aerial photographs taken in 1975 and the recent estimation showed that these plants grew in 1/2 area (6.25 km. sq.) of Thale Noi, From these date, it is suggested that each harvest of the plants is approximately 23,437 tons. The turn over rate of these plants is about 2 months, bringing the maximum annual collection in the Thale Noi alone to 140,625 tons.

It was suggested that 2,000-3,000 tons of fish could likely be produced utilizing only the aquatic weeds of Thale Noi as feed. At an average price of 20 Baht per kg., extra income of 40-60 million baht could be realized by the surrounding villagers (Davy, self communication, 1981).

As indicated by the Project title, the objectives of the investigation is directed toward the utilization of aquatic plants in Lake Songkla. As a result of recent expansion of exclusive economic zone by neighbouring countries and the increased fishing activities in the Gulf of Thailand, such investigation has become increasingly important and responsive to the present econopolitical pressure in Thailand.

During the first phase study of this project (1981-1984), it was found that Thale Noi covered with aquatic weeds and showed a heavy siltation resulting to a shallower reservoir. Fisheries product will be less than the past. It was also found that nile tilapia *(Oreochromis niloticus)* can be cultured in the lake both in cage and pond. It was also found that there was a potential to make fish feed pellet from aquatic plants.

The second phase of this project is undertaken to study the utilization of aquatic plants in Lake Sonkla as fish food.

Project Title : Aquatic Weeds (Thailand) II

Subtitle : Utilization of Aquatic Plants in Lake Songkla (Thailand) Phase II

Official Recipient : Faculty of Science and Faculty of Natural Resources, Prince of Songkla University, Haad Yai, Songkla, Thailand

Cooperative Institutes :
1. National Institute of Coastal Aquaculture (formerly Songkla Fishery Station), Songkla, Thailand
2. Fisheries Section, Governor's Office, Pattalung province, Pattalung, Thailand

Research period : 22nd September 1986 - 31st July 1991

Research location :

Field studies : Thale Noi (upper part of Songkla Lake) Pattalung, Thailand

Laboratory studies :
1. Department of Biology, Faculty of Science (FS) Prince of Songkla University (PSU)
2. Department of Aquatic Science Faculty of National Resources (FNR) PSU

II. PROJECT STAFF

Project Leader : Reungchai TANSAKUL, Ph.D

Department of Biology

Faculty of Science

Prince of Songkla University (PSU)

Coordinator for the National Institute of Coastal Aquaculture

(NICA) : Pairoj SIRIMONTRAPORN

Head, Division of Songkhla Lake Ecology

Coordinator for the Pattalung Fisheries Station :

Paiboon WATTANAKIJ

Head of the Station

Coordinator for the PSU :

Niti RITTIBHONBHUN

Dept. of Aquatic Science,

Faculty of Natural Resource, PSU

Research investigators :

Name		Institute
Ms. Pimpan	Tansakul	Bi PSU Phycologist
Ms. Yaowaluk	Dissara	Bi PSU Microbiologist
Dr. Charoen	Nitithamyong	AQ PSU Fish Biologist
Mr. Chorraman	Wongwit	AQ PSU Aquatic Biologist
[e]Dr. Anne	Cronin	AQ PSU Aquatic Biologist
Dr. Aoawapa	Angsupanich	AQ PSU Aquatic Biologist
Ms. Supaporn	Rakkeaw	AQ PSU Aquatic Biologist
Mr. Chalong	Maneekul	AD PSU Ag. Economist
Ms. Sutonya	Thongrak	AD PSU Ag. Economist
Mr. Jaruiy	Petchrat	AD PSU Ag.Exonomist
Mr. Kanit	Chaiyakum	NICA Fish. Biologist
Dr. Somsak	Boromthanarat	AQ PSU Fish. Biologist
[b]Mr. Kijkarn	Soopamas	AQ PSU Fish. Biologist
[b]Mr. Vutiporn	Promkuntong	AQ PSU Nutritionist
[a]Ms. Chutima	Tuntikitti	AQ PSU Fish Biologist
[c]Mr. Sommai	Chiayvareesajja	AQ PSU Aquaculturist
[d]Mrs. Jarunee	Chiayvareesajja	AQ PSU Aquaculturist
Mr. Kongkaew	Tepachai	Project site manager
Mr. Amporn	Tongnuakaw	Project site technician
Mr. Piya	Jantin	Project site care taker
Mr. Boonrat	Taweesuk	Project site care taker
Mr. Boonrit	Taweesuk	Project site care taker

NICA : National Institute of Coastal Aquaculture, Songkhla

AQ PSU : Dept. of Aquatic Science, Prince of Songkhla University

AD PSU : Dept of Agricultural Development, Faculty of Natural Resources, Prince of Songkhla University

Bi PSU : Dept. of Biology, Faculty of Science, Prince of Songkhla University

BiC PSU : Dept. of Biochemistry, Faculty of Science, Prince of Songkhla University

[a]Ph.D.Study at the University of British Columbia, Canada

[b]Ph.D.Study at the University of Munich, Germany

[c]Ph.D.Study at the Auburn University, USA

[d]Ph.D.Study at the University of Oslo, Norway

[e]British VSO at Dept. of Aquatic Science, PSU

III. PROJECT IMPLEMENTAION

Date	Details of operation
1st September 1986	The project grant memorandum was signed by the Rector of Prince of Songkla University.
22nd September 1986	The first grant payment of Cdn $ 44,000 (Baht 821,753.88) was sent from IDRC to the Rector of PSU.
September 1986	the University appointed Ms.Rattana Suthawiroj to be the financial officer for the project. Also Dr.Reungchai Tansakul was appointed to be a project leader and the project scientists were also named.
October 1986-February 1987	Selection of the project's scientific methods of investigation. At the same time, the project working plan was drawn up and tested following the previous first phase project.
3rd March 1987	The second grant payment of Cdn $ 27,000 (Baht 520,946.92) was sent from IDRC Singapore Office to the Rector of PSU.

1987 - 1989	The third grant payment (14 Sept. 1987) to the sixth grant payment (23 May 1989) were sent to the PSU Rector office (see details in financial report).
1st September 1987	Dued to flood and storm damage of the project, the additional grant payment of Cdn $ 12,000 was sent to the project as the project extension
1989-1990	Two more grant payments were sent to the project in Dec. 1989 and Feb. 1990.
30 April 1991	Termination of the project experiment, after that scientific datas were analised and final report were written.

Training

M.Sc. study (Prince of Songkla University)

During this phase II project, 3 M.Sc. students of the PSU graduate school were chosen for M.Sc. scholarships and 3 thesises were completed under the project support as following :

1. Kruasri Wisessuwannaphoomee, 1988.

"Changes in haematological properties and ionic concentrations of Nile tilapia (Sarotherodon niloticus) in low pH water."

2. Vichai Vattanakul, 1990

"Biochemical activity of sperm in the fertilization of tilapia (Oreochromis niloticus)."

3. Jerawon Boonsri, 1991

"Potential of some aquatic weeds as composition for the compounded diet of the Black tiger prawn (Penaeus monodon Fabricius)."

Ph.D. study (University of British Columbia, Canada)

Our Ph.D. project student, Ms. Chutima Tantikitti went to Canada for her UBC Ph.D. studentship in December 1987. She is under supervised of Prof. M. March of the Department of Animal Science. At the moment, she is doing her Ph.D. programme. Her study shown to be satisfied and she will complete her thesis very soon.

*Remark she got a fixed term scholarship (Bht 461,456.33) from the project.

Consultant visits

Dr. Kok Leong Wee from Division of Agricultural and Food Enginerring, AIT, Bangkok, visited Thale Noi the project site and PSU during 3-5 July 1988. Recommendations on fish nutrition and aquaculture system for furthur experiment were given and his written report was sent to Dr. Brian Davy.

During the IDRC Fish Nutrition Workshop at AIT, Bangkok, 6-10 June 1988; Dr. Reungchai Tansakul discussed with Prof. Takeshi Watanabe (Fish Nutrition Laboratory, Tokyo University of Fisheries, Japan) and Prof. C. Young Cho (Fish Nutrition Laboratory, Univ. of Guelph, Ontario, Canada) on Furthur experiments on fish nutrition study of our basic aquatic weed pellets (aquatic weed : rice bran : fish meal = 4:3:1).

Dr.Sena S. De Silva visited the Prince of Songkla University and Thale Noi the project site during 13-19 December 1988 after the big flood and stories in that raining season. His recommendations to solve the problem after the flood were reported to IDRC office.

Dr.G. Spendijian visited the project site and the Prince of Songkla University during 6-8 December 1989 to have an over view the nature of the project. This suggestions was consided and included in the project experimental design.

Workshop and Conference

1. Ms.Chutima Tantikitti attended "A Short Course on Economics for Fisheries and Aquaculture Scientist", 14 May - 15 June 1984, at the Universities Pertanian, Malaysia.

2. Ms. Chutima Tantikitti presented a paper (poster session) in the First Asian Fisheries Forum, during 26-31 May 1986 in Manila, the Philippines.

3. Dr. Reungchai Tansakul, Sommai Chiayvareesajja and Chutima Tantikitti presented 3 papers in the Second International symposium on Tilapia In Aquaculture, during 16-20 March 1987, in Bangkok.

4. Dr.Reungchai Tansakul attended the IDRC Agricultural Communication Workshop, Chiangmai during 28 March - 2 April, 1988.

5. Dr.Reungchai Tansakul and Sommai Chiayvareesajja presented 2 scientific papers in the IDRC Fish Nutrition Workshop at AIT, Bangkok, 6-10 June 1988. Mr. Vutiporn Promkuntong also attended the same workshop. (see details in Publication).

6. Mr.Santichai Rungsiyapirom from the Pattalung Fisheries Station attended a training course "9th Integrated Fish Farming', 18 April - 18 August 1988 at Wuxi, P.R. China.

7. Dr. Reungchai Tansakul, Sommai Chiayvareesajja and Chorraman Wongwit presented 3 papers in the second Asin Fisheries Forum, during 17-22 April 1988, in Tokyo, Japan.

8. Dr. Reungchai Tansakul attended a Research Management Workshop at the University of Philippines Los Banos (UPLB), The Philippine during 30 April - 26 May 1990.

9. Dr. Charoen Nittithamyong presented 2 papers at the Fourth Asian Fish Nutrition Workshop, 3-8 September 1990, in Vijayawada, India.

10. Dr. Reungchai Tansakul presented 2 scientific papers in the Second Asian Reservoir Fisheries Workshop, during 15-19 October 1990, in Hangzhou, poeple Republic of China.

Publications

1. Chaiyvareesajja, S. and Tansakul, R. 1989. Culture of Banana Prawn (*Penaeus merguiensis)* and Tilapia *(Oreochromis mossambicus)* by using aquatic weed mixture pellet. in "Proceedings of the Third Asian Fish Nutrition Network Meeting" (edited by De Silva, S.S.). Asian Fisheries Society Special Publication No.4, Asian Fisheries Society, Manila, Philippines, pp.153-156.

2. Chiayvareesajja, S., Wongwit, C. and Tansakul, R. 1990. Cage culture of Tilapia *(Oreochromis niloticus)* using aquatic weed-based pellets in "Proceedings the Second Asian Fisheries Forum" (edited by Hirano, R. and Hanyu, I.) Asian Fisheries Society, Manila, Philippines, pp. 287-290.

3. Chiayvareesajja, S., Wongwit, C., Cronin, A., Supamataya, K., Tantikitti, C. and Tansakul, R. 1989. Utilization of aquatic weed mixture pellet as Feed for Nile Tilapia *(Oreochromis niloticus* and pig. in "Proceedings of the Third Asian Fish Nutrition Network Meeting" (edited by De Silva, S.S.). Asian Fisheries Society Special Publication No.4, Asian Fisheries Society, Manila, Philippines, pp. 143-147.

4. Chaiyvareesajja, S., S. Taweesak, P. Tansakul, S. Angsupanich and S. Rakkeaw. 1988. Site selection for aquaculture in Thale Noi Lake, Thailand. Thai J. Agric. Sci.,21 (July 1988):245-252.

5. Chiayvareesajja, S. et al. 1988. Comparison between natural feeding alone and supplemental feeding with pellets containing locally available ingredients for cage culture of *Oreochromis niloticus* in Thale Noi, Thailand. in "Proceedings The Second International Symposium On Tilapia In Aquaculture (edited by Pullin, R.S.V. et al.)". International Centre For Living Aquatic Resources Management, Manila, pp. 323-327.

6. Keowsurat, P., A. Jantasilp and P. Tansakul. 1988. Growth of isolated algae from Thale Noi Lake cultured in laboratory. Thai J. Agric. Sci.,21 (July 1988):253-262.

7. Keowsurat, P. and P. Tansakul. 1987. Isolation of unialgal culture. in "Proceedings of 13th Conference on Science and Technology of Thailand (edited by The Science Society of Thailand, Bangkok, pp. 456-457.

8. Klinnavee, S., Tansakul, R. and Promkunton, W. 1990. Growth of Nile Tilapia *(Orochromis niloticus)* fed with aquatic plant mixtures. in "Proceedings the Second Asian Fisheries Forum" (edited by Hirano, R. and Hanyu, I.). Asian Fisheries Society, Manila, Philippines, pp. 283-286.

9. Nitithamyong, C., J. Chiayvareesajja., S. Chiayvareesajja, C. Wongwit and R. Tansakul. Growth and production of Nile Tilapia *(Oreochromis niloticus)* and in integrated culture with pig and snakehed. in "Proceedings the Fourth Asian Fish Nutrition Workshop, 3-8 September 1990, Vijayawada, India. in press.

10. Nitithamyong, C., J. Chiayvareesajja, S. Chiyvareesajja, C. Wongwit and R. tansakul. Production of Nile Tilapia *(Oreochromis niloticus)* in different culture and harvesting systems. in "Proceedings the Fourth Asian Fish Nutrition Workshop, 3-8 September 1990, Vijayawada, India. in press.

11. Promkunthong, W. and C. Chawpaknum. 1988. Substitution of basal diet with *Ceratophyllum demersum* in *Sarotherodon niloticus* feed (in Thai). Songklanakarin J. Sci. and Technol. 10(2):195-203.

12. Promkunthong, W. and P. Sriploy. 1988. Substitution of layer manure for basal diet in *Sarotherodon niloticus* feed (in Thai). Songklanakarin J. Sci. and Technol., 10(2):185-194.

13. Tansakul, R. 1985. Utilization of aquatic plants in Thale Noi : Fish culture. in "Proceedings of the First Tropical Weed Science Conference Vol. I (edited by Weed Science Society of Thailand). Weed Science Society of Thailand, Bangkok, pp. 162-165.

14. Tansakul, R. 1987. Ecology of Songkhla Lake (in Thai). J.Sci. (Sci. Soc. Thailand), 4(12):690-701.

15. Tansakul, R. Utilization of aquatic plants in Songkhla Lake (Thailand). in "Proceedings Second Asian Reservoir Fisheries Workshop", 15-19 October 1990, Hangzhou, in press.

16. Tansakul, R. et al. 1987. Utilization of herbivorous fish in the Thale Noi ecosystem to control aquatic weed. in "Proceedings of the Regional Seminar on the Utilization of Urban and Rural Wastes (edited by Somboon, W. et al.)." Chulalongkorn University Press, Bangkok, pp. 311-329.

17. Tansakul, R., P. Sirimontraporn, C. Wongwit, C. Nitithamyong, S. Angsupanich and N. Rittibornbhun. Fisheries of Thale Noi (Thailand) during 1982 and 1989. in "Proceedings Second Asian Reservoir Fisheries Workshop", 15-19 October 1990, Hangzhou, in press.

18. Tantikitti, C., N, Rittibhonbhun, K, Chaiyakum and R. Tansakul. 1988. Economics of tilapia pen culture using various feeds in Thale Noi, Songkhla Lake, Thailand. in "Proceedings The Second International Symposium On Tilapia In Aquaculture (edited by Pullin, R.S.V. et al.)." International Centre For Living Aquatic Resources Management, Manila, pp. 569-574.

19. Wangead, C., A, Geater and R, Tansakul. 1988. Effects of acidic water on survival and growth rate of Nile tilapia *(Oreochromis niloticus)*. in "Proceedings The Second International Symposium On Tilapia In Aquaculture (edited by Pullin, R.S.V. et al.)". International Centre For Living Aquatic Resources Management, Manila, pp. 433-437.

20. Wongwit, C., Chiayvareesajja, S. and Tansakul R. 1990. Carcass quality of Tilapia *(Oreochromis niloticus)* in different culture systems in "Proceedings the Second Asian Fisheries Forum" (edited by Hirano, R. and Hanyu, I.). Asian Fisheries Society, Manila, Philippines, pp. 299-301.

21. Wongwit, J. and S. Taweesak. 1987. Fluctuation of pH in Thale Noi (Songkhla Lake) (in Thai). in "Proceedings of 13th Conference on Science and Technology of Thailand (edited by The Science Society of Thailand). The Science Society of Thailand, Bangkok, pp. 724-725.

Project dissemination and public relation

1. The Thale Noi Project was reported nation wide on "Thai's Today" (after 8 o'clock news) on TV7 in 1989.

2. The Thale Noi project was reported and televised nation wide on TV5 (8 o'clock news) on 24 April 1991.

3. The Thale Noi project will be reported in the TV 5 (Pacific Communication Co.) miniseries "Songkhla Lake", televised nation wide very soon.

4. Dr.Reungchai Tansakul was chosen by the ministry cabinet council to be a member in the Thai UNESCO committee on Man and Biosphere (MA B) since 1989.

5. Dr.Reungchai Tansakul and Assist. Prof.Niti Rittibhonbhun were invited as a guest lecturer in a Training course "Integrated Environment Planning Management", 3-12 July 1991, Songkhla; which organised by The National Environment Board and Griffith University, Brisbane.

6. Dr.Reungchai Tansakul was invited as a guest lecturer in a Seminar on Songkhla Study, 17-19 August 1991, Songkhla.

7. Dr.Reungchai Tansakul was invited by The dean of the Faculty of Science and The Science Club, Prince of Songkhla University to present the results of the Thale Noi project to the PSU staff.

8. Dr.Reungchai Tansakul and Assist.Prof.Niti Rittibhonbhun were invited as a guest lecturer in Seminar on Rehabilitation of Samrong Canal (Songkhla) basin, 20 July 1991, Songkhla; which was organized by the Songkhla Environment Protection Association.

Technical report

GROWTH OF NILE TILAPIA (OREOCHROMIS NILOTICUS) FED WITH AQUATIC PLANT MIXTURES

Abstract

Growth of Nile tilapia (Orechromis niloticus) fed with hornwort (Ceratophyllum demersum Linn.), water hyacinth (Eichhornia crassipes Solms.) and chuut-nuu (Eleocharis ochrostachys Steud.) pellet was studied. Fish of 7.00 ± 1.92 g were maintained in 1,000-liter fiberglass tanks. Ten dietary formulae were tested. The control diet was chicken pellet containing 16.81% crude protein. The 9 other dietary formulae were the combination of 3 crude protein levels (16,25 and 35%) and 3 levels of dried aquatic plants (20, 30 and 40%). After a period of 11 weeks feeding, fish fed with diets containing different kinds of aquatic plants but the same percentage of protein showed no significantly different rates of survival, growth or feed conversion. Fish fed with the same kind of aquatic plant but higher percentage of protein showed higher growth rates and better feed conversion rates. The diet of chuut-nuu with 35% crude protein (formula No. 10) gave the highest growth rate and a low production cost per kg fish. Diet No. 4, which consisted of hornwort with 35% crude protein gave a high growth rate and the lowest cost per kg fish produced.

In conclusion, this study supports the potential of using aquatic plants as a partial replacement for fish meal or animal protein source as was found in the animal protein replacement by bacterial S.C.P. "Pruteen" (Viola and Zohar 1984) and Eurolysine Fodder Protein (Davies and Wareham 1988). This preliminary experiment may be extended by adding some amino acids or minerals to enhance growth rate (reducing production cost) of tilapia, such as adding bone phosphorus and plant phosphorus (Viola et al. 1988).

In developing countries, natural aquatic plants, which are often abundant and free, will be an important source for fish feed as found in Thale Noi, Thailand. If these techniques are established, they may be usefully applied in freshwater reservoirs in Thailand and elesewhere in the region.

Complete results of this study were in the publication No.8.

Table 1 Proximate composition of experimental ingredients (all values are expressed as percertage on dry weight basis).

Ingredients	Moisture content %	Crude protein %	Crude fat %	Ash fibre %	Crude extract %	N-free %
Fish meal	8.33	53.14+0.14	4.52+0.20	29.96+0.34	0.91+0.06	3.14
Rice bran	9.27	10.93+0.06	20.19+0.06	7.93+0.03	7.93+1.09	43.78
Ceratophyllum demersum	9.74	11.59+0.16	1.19+0.08	20.96+0.55	12.30+0.04	41.22
Eichhornia crassipes	9.79	8.05+0.09	0.90+0.04	15.59+0.33	20.75+0.10	44.92
Eleochoris ochrostachys	10.63	4.47+0.18	0.89+0.06	10.66+0.25	26.07+0.68	47.28
Cassava starch	11.71	0.00	0.17+0.05	0.66+0.32	0.04+0.02	87.44

Table 2 Composition of experimental diets in this study.

Composition	Dietary treatments								
%	2	3	4	5	6	7	8	9	10
Fish meal	14.63	34.11	58.00	18.51	36.97	59.96	22.25	39.81	62.81
Ceratophyllum demersum	40.00	30.00	20.00	-	-	-	-	-	-
Eichhornia crassipes	-	-	-	40.00	30.00	20.00	-	-	-
Eleocharis ochrostachys	-	-	-	-	-	-	40.00	30.00	20.00
Rice bran	40.22	31.09	17.00	34.34	26.83	13.94	29.25	22.89	11.48
Cassava starch	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Beef wax	4.15	3.80	4.00	6.15	5.20	5.10	7.59	6.40	5.70

Table 3 Proximate analyses (mean+ SE) of the experimental diets (% dry weight).

Dietary treatments	Moisture content %	Crude Protein %	Crude fat %	Ash %	Crude fibre %	N-free extract	Gross* energy
1	10.21	16.81+0.27	3.21+0.08	6.65+0.02	4.09+0.29	59.03	363.69
2	5.80	17.09+0.08	13.92+0.58	17.40+0.09	8.18+0.02	37.82	378.53
3	6.24	24.47+0.12	11.79+0.07	19.50+0.22	6.47+0.06	31.58	371.20
4	4.42	34.40	10.61+0.11	23.49+0.34	4.17+0.03	22.91	379.68
5	7.72	17.06+0.02	14.02+0.44	14.46+0.19	11.65+0.00	35.09	365.28
6	6.68	24.37+0.08	12.42+0.00	17.76+0.21	8.53+0.18	30.24	371.04
7	7.29	34.58+0.19	10.69+0.14	23.14+0.40	5.84+0.71	18.46	363.16
8	5.75	17.00+0.10	13.77+0.06	13.54+0.24	12.91+0.78	37.03	370.63
9	8.30	24.40+0.16	11.94+0.59	16.41+0.28	10.53+0.00	28.42	359.37
10	6.74	34.78+0.14	11.04+0.68	23.70+0.35	6.71+0.27	16.7	363.38

* Kcal/100 g.

Table 4 Growth, survival and food conversion rate of S. niloticus after 11 weeks of experimental diets feeding.

	Experimental diets (mean + SE) *									
	1 (control)	2	3	4	5	6	7	8	9	10
Initial weight (g)	a 7.73 +1.59	a 7.24 +1.45	a 7.64 +1.71	a 7.52 +1.92	a 7.65 +1.47	a 7.87 +1.72	a 7.65 +1.55	a 7.45 +1.58	a 7.35 +1.69	a 7.13 +1.86
Final weight (g)	bc 26.18 +7.01	a 16.79 +4.72	bc 25.44 +8.00	cd 27.88 +7.58	a 16.16 +3.71	bc 24.51 +7.52	cd 29.22 +8.80	a 16.42 +5.06	b 21.97 +6.98	d 31.70 +10.95
Mean weight gain (%)	bcd 238.36 +4.39	a 132.02 +1.84	bcd 23274 +5.85	cd 266.96 +1088	a 117.07 +2.19	bc 212.67 +3643	d 281.94 +2.99	a 122.08 +1665	b 198.63 +1599	e 346.46 +4341
Specific Growth rate (%/fish/day)	bc 1.583 +0.02	a 1.093 +0.01	bc 1.561 +0.02	bc 1.688 +0.04	a 1.006 +0.01	b 1.472 +0.15	cd 1.740 +0.01	a 1.033 +0.10	b 1.469 +0.14	d 1.937 +0.13
Mean food conversion rate	bc 2.564 +0.15	a 3.691 +0.09	bc 2.484 +0.15	cd 2.049 +0.40	a 4.277 +0.32	b 2.689 +0.27	cd 2.069 +0.29	a 3.890 +0.19	b 2.719 +0.21	d 1.897 +0.17
Survival (%)	a 97.77	a 100	a 100	a 95.56	a 98.89	a 97.77	a 98.89	a 100	a 98.89	a 100

* Values with the same superscripts a, b, c, d are not significantly different ($P < 0.01$)

Table 5 Production cost of the experimental diets and fish production cost fed with experimental diets.

Diets	Diets production cost (Baht/kg)	Fish production cost * (Baht/kg)
1	7.00	17.95
2	5.04	18.60
3	6.67	16.57
4	8.07	16.54
5	5.43	22.95
6	6.96	18.72
7	8.86	18.33
8	5.77	22.45
9	7.22	19.63
10	9.03	17.13

* calculated from feed cost only

CAGE CULTURE OF TILAPIA (*OREOCHROMIS NILOTICUS*) USING AQUATIC WEED-BASED PELLETS

Abstract

Aquatic weed (*Ceratophyllum demersum*) based pellets were formulated and used as feed for tilapia (*O. niloticus*) reared in bamboo cages of immersed volume 1 x 1 x 1 m^3 in order to determine the appropriate stocking density and appropriate aquatic weed mixture pellet for tilapia in Thale Noi, the uppermost part of Songkla Lake. The study comprised 2 experiments. The first compared 4 experimental diets, viz. no feeding, fed on a commercial fish pellet, and fed on aquatic weed-based pellets containing dry weed, rice bran and fish meal in ratios of 4:3:1 and 4:2:2 by weight. The second experiment compared 4 stocking densities, viz. 30, 100, 300 and 500 fish per cage. During a 3-month experiment, parameters of fish growth and water quality were monitored at monthly intervals. Five handred fish per cage was the best stocking density and the most appropriate feed was the aquatic weed -based pellet in the ratio of 4:3:1.

Aquatic weed mixture pellet formulation

The study consited of 4 experimental diets, viz. no feeding, fed on commercial fish pellet, and aquatic weed-based pellets containing dry weed, rice bran and fish meal in ratios of 4:3:1 and 4:2:2 by weight. Dry weed, rice bran and fish meal were mixed and 1 g of vitamin premix (Ovimin, International Pharmaceutical Co. Ltd. Tel-Aviv, Israel) was added for every 4 kg feed. In order to formulate semimoist diets, water was added at 20% by weight of feed. Aquatic weed-based pellets were prepared daily using and electric meat mincer.

Stocking density of tilapia

The study consisted of 4 stocking densities, viz. 30, 100, 300 and 500 fish/cage and all fish were fed on 4:3:1 aquatic weed-based pellet. Tilapia (>15 cm long) using in the two studies were fed twice daily at a rate of 5% body weight per day, and the amount of feeding was adjusted after each sampling.

During a 3-month experiment, fish wet weight, survival and water quality (pH, temperature, dissolved oxygen, turbidity and condutivity) were monitored at monthly intervals. The water quality parameters during the trial period were as follows: the concentration of dissolved oxygen ranged from 4.1 to 6.9 mg./l; pH ranged from 5.2 to 7.3; conductivity ranged from 0.1 to 0.8 ms/cm; water temperature ranged from 30.4 to 34.2 ^{0}C and turbidity ranged from 1.8 to 7.7 NTU. Values of each parameter were similar at each site. Proximate chemical composition of the experimental diets was determined according to the methods recommended by A.O.A.C. (1975) and gross energy measured with a ballistic bomb calorimeter (Gallenkamp).

Results

Aquatic weed-based pellet formulation

Chemical composition of the experimental diets is presented in Table 1. The crude protein and crude lipid contents of aquatic weed mixture pellets, both 4:3:1 and 4:2:2, were higher than the commercial pellet (respectively 23.4, and 30.1 compared with 20.7% crude protein; and respectively 12.3 and 10.6 compared with 4.7% crude lipid). The gross energy of the commercial pellet was higher than that the two formulated diets (4071, compared with 3,895 and 3,644 kcal/kg, respectively).

Growth performance of tilapia fed on various feeds is shown in Table 2. On the basis of percentage weight gain, food conversion rate (FCR) and fish production, the best growth performance was obtained from the fish fed on the commercial pellet, followed by those fed on 4:2:2 and 4:3:1 aquatic weed-based pelet.

Economic analysis for the feeding experiment is shown in Table 3. The most appropriate feed for cage culture of tilapia was the aquatic weed-based pellet in the ratio of 4:3:1, giving the cheapest feed (3.15 Baht/kg) and the highest profit (13.02 Baht/cage, excluding cost of cage and labor).

Stocking density of tilapia

Growth performance of tilapia at various stocking densities (SD) is shown in Table 4. the best growth performance of tilapia on the basis of percentage weight gain and FCR was obtained from the fish at stocking density of 100 fish/cage followed by those at 30, 500 and 300 fish/cage. However, 500 fish/cage was the best SD on the basis of fish production (19.8 kg/cage) and profit(47.48 Baht/cage, excluding cost of cage and labor)as shown in Table 5.

Complete results of this study were in the publication No.2.

Table 1. Proximate analysis of the formulated feeds, as fed basis

PARAMETER	COMMERCIAL PELLET	4:3:1 FEED‡	4:2:2 FEED‡
Mositure(%)	8.9	42.9	33.2
Crude lipid(%)	4.7	12.3	10.6
Crude protein(%)	20.7	23.4	30.1
Crude fibre(%)	10.7	9.3	8.7
Ash(%)	6.3	17.5	20.6
Gross energy(kcal/kg)	4071	3895	3644

‡ Composition of dry weed, rice bran and fish meal.

Table 5. Economic analysis for the study on stocking densities

COST(Bahi/cage)[†]	STOCKING DENSITY (fish/cage)			
	30	100	300	500
Cage & labor	500.00	500.00	500.00	500.00
Fish stock[††]	53.01	154.89	479.41	689.49
Feed	42.07	139.67	378.90	598.16
Total cost	595.08	794.56	1358.31	1787.65
Total incomme[†††]	108.10	334.19	892.30	1335.13
Profit	-486.98	-460.37	-466.01	-452.52
Excluded cage & labor	13.02	39.63	33.99	47.48

* US$ 1 = Baht 25, ** 18 Bath/kg, *** 23 Baht/kg

Table 3. Economic analysis for the study on stocking densities

COST(Bahi/cage)*	No FEED	COMMERCIAL PELLET	4:3:1 FEED	4:2:2
Cage & labor	500.00	500.00	500.00	500.00
Fish stock**	49.02	60.06	53.01	47.49
Feed	0.00	166.78	42.07	68.05
Total cost	549.02	726.84	595.08	615.54
Total incomme***	54.74	164.14	108.10	123.56
Profit	-494.28	-562.70	-486.98	-491.98
Excluded cage & labor	5.72	-62.7	13.02	8.02

* US$ 1 = Baht 25, ** 18 Bath/kg, *** 23 Baht/kg

Table 4. Growth performance of tilapia at various stocking densities in 1.5 m^3 bamboo cages from 23 December 1987 to 20 March 1988 (mean±standard error). Mean values of 3 replications. Mean values in the same row with a common supperscipt are not significantly different ($p>0.05$).

PARAMETER	STOCKING DENSITY (fish/cage)			
	30	100	300	500
Average initial weight (g/fish)	98.2 ± 1.0^{AC}	86.1 ± 3.7^{BC}	88.8 ± 4.5^{C}	76.6 ± 3.9^{B}
Average final weight (g/fish)	156.6 ± 4.2^{P}	145.8 ± 2.8^{P}	129.9 ± 4.7^{Q}	117.8 ± 4.3^{Q}
Average weight gain (%)	59.6 ± 3.2^{DE}	69.7 ± 4.1^{D}	46.6 ± 5.0^{F}	54.0 ± 2.6^{EF}
Survival (%)	100.0 ± 0.0^{A}	99.7 ± 0.3^{AB}	99.6 ± 0.4^{AB}	98.5 ± 0.6^{B}
Fish production (kg/cage)	1.7 ± 0.2^{K}	5.9 ± 0.2^{L}	12.2 ± 1.1^{M}	19.8 ± 0.5^{N}
FCR (g feed/g fish)	$7.80.6^{WZ}$	7.5 ± 0.4^{W}	9.9 ± 1.0^{XZ}	9.6 ± 0.2^{Y}

Table 2. Growth performance of tilapia fed on various feeds in 1.5 m^3 bamboo cages from 23 December 1987 to 20 March 1988 (mean±standard error). Me values of 3 replications. Mean values in the same row with a common superscri are not significantly different (P>0.05).

PRAMETER	NO FEED	COMMERCIAL PELLET	4:3:1 FEED	4:2:2 FEED
Average initial weight (g/fish)	90.8 ± 4.9^{A}	111.2 ± 2.9^{B}	98.2 ± 1.0^{A}	88.0 ± 3.3^{A}
Average final weight (g/fish)	79.3 ± 5.3^{P}	237.9 ± 8.7^{Q}	156.7 ± 4.2^{Q}	179.1 ± 10.4^{RS}
Average weight gain (%)	-12.7 ± 2.0^{D}	114.2 ± 10.3^{E}	59.6 ± 3.2^{F}	105.0 ± 19.1^{GR}
Survival (%)	100	100	100	100
Fish production (kg/cage)	-0.3 ± 0.1^{K}	3.8 ± 0.3^{L}	1.7 ± 0.2^{M}	2.7 ± 0.5^{N}
FCR (g feed/g fish)	---	5.3 ± 0.3^{W}	7.8 ± 0.6^{X}	5.3 ± 0.9^{W}

UTILIZATION OF AQUATIC WEED MIXTURE PELLET AS FEED FOR NILE TILAPIA (OREOCHROMIS NILOTICUS) AND PIG

Abstract

Dry aquatic weed *(Ceratophyllum demersum)*, rice bran and fish meal were mixed in a ratio of 4:3:1 in order to produce aquatic weed mixture pellet for the rearing of Nile tilapia *(Oreochromis niloticus)* and pig. Two culture systems; tilapia culture in ponds with fomulated feed at a feeding rate of 10% body weight per day; and an integration of pit-tilapia using the same formulated feed as pig feed at a feeding rate of 10% body weight per day were carried out in triplicate. During the six-month culture period, pig and tilapia growth, water quality parameters pH, temperature, DO, conductivity and turbidity were monitored at monthly intervals. Tilapia production in the integrated system was slightly higher than in the monoculture system; production from the monoculture system and the integrated system being 4467 and 5499 kg/ha respectively. The pig grew well on the formulated feed and a good quality carcass was obtained. The results suggest that the integration of pig tilapia using aquatic weed mixture pellet as pig feed is practical and useful.

This study was undertaken in order to evaluate the utilization of this aquatic weed incorporated into pellet form as feed for the rearing of Nile tilapia, *Oreochromis niloticus* (L.) and pig. Furthermore, in order to maximize the limited resources, tilapia production using pig manure was also studied.

The production of tilapia in the integrated system was slightly higher than in the monoculture system. This may be due to big difference of nutrient loading into each system. The average value of daily loading of pig faeces was 6.42 kg/compartment, which was equal to 0.81 kg crude protein/compartment/day while

in the monoculture system it was it was 1.46 kg of feed/compartment/day which was equal to 0.35 kg crude protein/compartment/day.

These results suggest that the integration of pig tilapia using aquatic weed mixture pellet as pig feed is practical and useful on the basis of maxin\mizing the limited resources and reducing the fish production costs. The cost of supplemental fish feed is the largest operating cost in fish culture, usually 50% of the total operating costs. Polyculture of common carps and Chinese carps (Woynarovich 1980) and/or Indian carps and Chinese carps (Jhingran and Sharma 1980) are known to utilize all available food types resulting in a higher production. The introduction of a new fish species instead of tilapia in the integration of pig-fish farming is also feasible. Fang et al. (1986) reported that pig manure is suitable for the growth of Carassius cuvieri. In order to avoid oxygen depletion and to maintain an adequate supply of nutrient loading into fish ponds the amount of piggery waste loading should be adjusted. In manure loaded ponds which produced high fish yields, manure (dry organic matter) was added daily at a rate of about 2 to 4% of fish biomass (Schroeder 1980). Woynarovich (1980) reported that the total manure loading per ha of pond surface is between 40 to 80 pigs/ha which is similar to that reported by Cruz and Shehadeh (1980) with 60 pigs/ha, and Jhingran and Sharma (1980), with 35 40 pigs/ha. Chen and Li (1980) reported that waste loading can be as high as 250 pigs/ha. Moreover, some carnivorus species such *Ophicephalus striatus* (Cruz and Shehadeh 1980) and *Lateolabrax japonicus* (Chen and Li 1980) are stocked in the ponds in order to control overcrowding of tilapia. Cruz and Shehadeh (1980) reported that the highest net yields were obtained with 60 pigs/20,000 fish (85% *Sarotherodon niloticus*, 14% *Cyprinus carpio* and 1% *Ophicephalus striatus*)/ha.

Complet results were in the publication No.3.

Table 1. The range in water quality parameters in the two system from 30 May to 22 November 1987.

Culture System	pH	Temperature (^{0} C)	DO (mg/l)	Conductivity mS/cm	Turbidity (NTU)
Monoculture	6.30-6.55	30.2-30.8	3.48-6.12	0.07-0.48	17.50->100
Integrated	6.11-6.60	30.0-30.8	2.82-8.67	0.13-0.57	0.76-50.0

Table 2. Proximate composition of formulated feed and pig faeces (mean $\pm$ SE), air dry basis.

Item	Formulated Feed	Pig Faeces
Moisture (%)	42.97 + 2.13	79.40 + 1.27
Crude protein (%)	24.25 + 4.06	12.69 + 0.12
Lipid	14.15 + 5.44	5.66 + 1.86
Crude fibre (%)	9.75 + 0.29	14.86 + 0.76
Ash (%)	19.24 + 0.76	26.09 + 1.01
Ca (%)	2.29 + 0.53	3.62 + 1.29
P (%)	3.30 + 0.79	4.62 + 0.54
Gross energy (Kcal/kg)	4660.72 + 130	4457.18 + 275

Table 3. Growth performance of tilapia and pig (mean ± SE) during 30 May to 22 November 1987.

Item	Tilapia		Integration
	Tilapia	Pig	
Initial number (No/compartment)	640	640	3
Final catch (No/compartment)	1155±185	2360±450	3±0
% by number of final catch			
5 - 10 cm class	11.10±1.21	11.85±1.79	
10 - 15 cm class	42.93±1.27	72.08±1.60	
- > 15 cm class	45.97±1.24	16.08±2.47	
Average Initial weight[‡‡]	4.39±0.21[a]	5.60±0.13[b]	5.92±0.20
Average Final weight[‡‡]	62.39±1.73[c]	37.11±0.71[d]	69.44±0.44
Average % weight gained [‡‡]	1329.80±102.74[e]	563.82±26.88[f]	107.68±34.25
Total Production (kg/unit)[‡‡]	71.47±9.77[n]	87.99±17.75[n]	208.33±0.28
Food Conversion Rate	4.05±0.69	25.77±4.25	7.39±0.28

‡‡ unit of initial or final weight g/individual for tilapia and kg/individual for pig; for values along each horizontal line those with a common superscript was not significantly different at $p<0.05$.

CARCASS QUALITY OF TILAPIA (OREOCHROMIS NILOTICUS) IN DIFFERENT CULTURE SYSTEMS

Abstract

Tilapia (O. niloticus) reared in 3 systems, viz. integration of tilapia and chicken, monoculture of tilapia and integration of tilapia and pig, were sampled and analysed for carcass quality after 6 months rearing. Chicken and pig in intergrated systems and tilapia in monoculture were fed on an aquatic weed (Ceratophyllum demersum) mixture pellet. Levels of crude lipid and crude fibre of fish carcass were lowest (13.50% and 0.53%, respectively) and levels of crude protein and ash were highest (59.54% and 24.64%, respectively) in the integrated tilapia-chicken system. There were no significant differences in the ratios of dry flesh to dry body weight (FBdR) and dry bone to dry flesh weight to dry body weight (FBdR) and dry bone to dry flesh weight (BnFR) between the two integrated systems. The carcass of tilapia in monoculture was the best on the basis of the highest value of FBdR (83.23%) and the lowest value of BnFR (20.37%).

The carcass quality of fish from the manured ponds was worse than that from the feed-pellet pond on the basis of crude lipid content, while some composition of fish from the manured-ponds are better than those from the feed-pellet pond. Fish grown in manure fed ponds have a different taste and texture since they are much leaner, with only 6% fat, which is excellent compared to fish raised on high protein feed pellets with 15% fat, and fish raised on grain with 20% fat, which is just bearable (Wohlfarth 1978 cited by Edwards 1980.

Complete results of this study were in the publication No.20.

Table 2. Chemical composition of chicken manure, aquatic weed mixture pellet, pig faeces and carcass of fish reared under different systems (mean values, %), as fed basis. (1) Tilapia-chicken, (2) Monoculture of tilapia, (3) Tilapia-pig.

Materials	Moisture	Lipid	protein	Fibre	Ash
Chicken manure	41.21	3.39	27.65	14.02	27.42
Weed mixture pellet	42.86	12.29	23.43	9.33	17.46
Pig faeces	36.05	8.25	13.42	15.31	29.44
Fish carcass (1)	79.36	13.50	59.54	0.53	24.64
Fish carcass (2)	79.31	22.93	52.90	0.94	16.74
Fish carcass (3)	76.05	22.88	52.04	1.55	19.86

Table 3. Dry matter, dry flesh, dry bone and dry body weight relationship of fish in different systems (%, mean values ± standard error). Average values of 20 samples. Mean values in the same row with a common supperscript are not significantly different (P>0.05).

Parameters	Tilapia-Chicken	Monoculture	Tilapia-Pig
Dry body/Wet body weight	20.25 ± 0.29^{A}	22.71 ± 0.90^{B}	24.35 ± 0.48^{B}
Dry flesh/Dry body weight	78.86 ± 0.72^{P}	83.23 ± 0.90^{Q}	78.05 ± 1.34^{P}
Dry bone/Dry flesh weight	26.99 ± 1.16^{X}	20.37 ± 1.37^{Y}	27.24 ± 1.39^{X}

Table 1. Lay-out of the experiment.

Item/Culture System	Tilapia-Chicken	Tilapia	Tilapia-Pig
Stock of Tilapia (No./compartment)	640	640	640
Stock of Chicken (No./compartment)	36	0	0
Stock of pig (No./compartment)	0	0	0
Feed aquatic weed mixture pellet to	CHICKEN	TILAPIA	PIG
Feeding rate (% body weight per day	10	10	10
Average value of manure or feed to tilapia (kg/compartment/day)	1.84	1.64	6.42

Table 4. The most suitable models descrbing the relationship between different body qualities of O. niloticus in the different culture systems. bw, body weight. r^2 values are given in parenthesis.

System	Dry bw (X) to wet bw (Y)	Dry flesh (X_1) to dry bw (Y_1)	Dry bone (X_2) to dry flesh wt. (Y_2)
Tilapia-Chicken	$Y = -0.5723 + 0.2244X$ (0.9890)	$Y_1 = 0.3664 + 0.7272X_1$ (0.9913)	$Y_2 = 0.1523X^{1.3103}$ $(0/9808)^2$
Tilapia	$Y = 0.1417X^{1.11358}$ (0.9808)	$Y_1 = 0.8638X^{0.9819}$ $(0.9978)^1$	$Y_2 = 0.1621X^{1.0998}$ $(0.9444)^2$
Tilapia-Pig	$Y = 0.6225X^{0.7449}$ (0.9809)	$Y_1 = 0.1242 + 0.7685X_1$ (0.9857)	$Y_2 = 0.1794X^{1.1868}$ $(0.9808)^2$

PRODUCTION OF NILE TILAPIA (*Oreochromis niloticus*) IN DIFFERENT CULTURE AND HARVESTING SYSTEMS

Abstarct

Nile tilapia(*Oreochromis niloticus*) were reared in 2 systems, viz. monoculture and integration of tilapia and pig. Following a 3 month culture period, tilapia of marketable size were harvested monthly(multiple harvest) from one of the monoculture system and from the integrated system until the end of the experiment.. Total production of Nile tilapia from monoculture and integrated systems with multiple harvesting technique were 53.1 kg/unit and 100.0 kg/unit, respectively. Tilapia production from monoculture system with single harvest was 43.9 kg/unit. On an economical basis, integrated system with multiple harvest of tilapia gave a significantly lower return than monoculture of tilapia.

Discussion

Tilapia production

Raising pig alone with aquatic weed mixture pellet at the present socioeconomic status in Thailand gave a loss of 3400 baht/pond (Tables I and III) as found by Tansakul (unpublished data). This modified system tried to alleviate the loss by applying nultiple harvesting technique to the system as proposed by Hickling (1962) and Swingle (after Guerrero, 1982).

Comparing tilapia production in the 3 treatments, it was found that integrated system which produced the highest number of small fish gave the highest return (1813 baht/pond) (Table I). Multiple harvesting technique

significantly increased total number of fish harvested (Table I). Total tilapia production in weight was also higher for the integrated system than the monoculture ones as found by Chiayvareesajja and coworkers (1989). The discrepancy in total production of tilapia cultured under different system but with same harvesting technique may due to the higher nutrient load to the integrated system suggested by Chiayvareesajja and coworkers (1989). Total production of the multiple harvest in tilapi monoculture was not higher than that of single harvest which agreed with the results found by Edwards (1988).

The low production of small tilapia in the single harvest system where no large size tilapia was harvested during the experiment may be because of high density of spawners in the system. In the multiple harvesting regime, low proportion of large fish allows more space for medium and small tilapia to be produced in the system when large fish were harvested monthly. Low amount of large size fish would also allow them to breed freely compared to those in single harvest system. In addition, in the single harvest system due to high density of large size fish agonistic behavior might occur (Magnuson, 1962) and consequently hinder reproductive process (Allison et al., 1979). High rate of cannibalism might also occur in high density of large size fish (Pantastico et al., 1988) and thus reduce number of the young (Macintoch and De Silva, 1984).

In some areas like Thale Noi where small size tilapia can be sold as fish seed, a large proportion of small size fish could give a high return to the system.

Economic Analysis

When comparing the tilapia production cost in monoculture of tilapia (single and multiple harvesting regimes), there was no significant difference in benefit (Table IV) due to similar tilapia production in the system (Table I).

Tilapia production cost of integrated and monoculture multiple harvesting systems was not easily compared due to their different feeding regimes. If tilapia production is a by product from an integrated system, tilapia production cost would be about one sixth of the xost for monoculture ones (Table III). Raising pig alone with aquatic weed mixture pellet gave a loss as mentioned above.

Benefit from single harvest and multiple harvest of tilapia monoculture were 492 and 592 baht/pond (30,750 and 37,000 baht/ha) in 6 months or 61,500 and 74,000 baht/ha/yr, respectively, which could be considered good income for rural villagers in Thale Noi. Concerning tilapia production as a by product of the tilapia-pig integrated systems, raising tilapia in these systems could also provide a great benefit for pig farmers.

Feed for tilapia and pig in this experiment was a formulated aquatic weed mixture pellet which was developed for poor rural area where aquatic weeds are abundant such as Thale Noi (Tansakul, 1985). This experiment also showed optimistic figures for using these weeds as tilapia and animal feed. One problem facing the implementation of fish culture in Thale Noi is the capital for initial investment (land, equipments, etc.). If this obstacle is overcome, raising tilapia with aquatic weed mixture pellet may be another way to control aquatic weed and at the same time, provide an income to poor villagers in Thale Noi or anywhere in the region where a similar problem exist.

Details of this study was in the publication No. 10.

Table I. Production of Nile tilapia, pig and return (baht) of all production harvested in 3 different treatments (mean ± S.E.).

	Multiple hartvest + pig	Multiple harvest	Single harvest
Production			
Tilapia			
Small size (< 10 cm)			
Number	1889 ± 506[a*]	1548 ± 319[a]	3 ± 1[b]
Weight (kg)	34.9 ± 8.2[a]	18.0 ± 0.8[a]	0.0 ± 0.0[b]
Medium size (10-15 cm)			
Number	677 ± 172[a]	188 ± 9[b]	5 ± 3[c]
Weight (kg)	29.1 ± 1.3[a]	6.8 ± 0.7[b]	0.4 ± 0.2[c]
Large size (> 15 cm)			
Number	141 ± 2[a]	149 ± 27[a]	185 ± 15[a]
Weight (kg)	36.2 ± 3.1[a]	28.2 ± 5.7[a]	43.5 ± 2.8[a]
Total			
Number	2707 ± 658[a]	1999 ± 276[a]	193 ± 1[b]
Weight (kg)	100.0 ± 7.1[a]	53.1 ± 6.7[b]	43.9 ± 3.0[b]
Pig			
Weight(kg)	188.0 ± 10.1	-	-
Return**			
Tilapia	1813.2 ± 118.3[a]	1195.3 ± 226.1[a]	1093.4 ± 73.3[a]
Pig	4700.0 ± 275.4	-	-
Total	6513.2 ± 161.5[a]	1195.3 ± 226.1[b]	1093.4 ± 73.3[b]

* Values in the same row with different superscripts are significantly different from each other at $p < 0.01$.

** Price of tilapia: large size (> 15 cm TL) = 25 baht/kg,
medium size (10 to 15 cm TL)= 15 baht/kg, small size (< 10 cm TL)= 0.25 baht each
Price of pig = 25 baht/kg

Table II. Growth of cultured Nile tilapia, average weight and number of large tilapia harvested(± S.E.) using 3 different treatments.

	Multiple harvest + pig	Multiple harvest	Single harvest
Average initial weight of tilapia (g)	62.3 ± 0.9[a*]	66.3 ± 2.2[a]	65.7 ± 1.8[a]
Average final weight of tilapia (g)	41.5 ± 9.2[a]	26.6 ± 0.7[a]	228.5 ± 7.7[b]
Average final weight of large tilapia (g)	256.4 ± 19.1[a]	189.0 ± 3.2[b]	236.1 ± 6.9[a,b]
Total number of large tilapia harvested	141 ± 2[a]	149 ± 27[a]	185 ± 15[a]

* Values in the same row with different superscripts are significantly different from each other at $p < 0.01$

Table III. Production costs(baht ± S.E.) of Nile tilapia per pond cultured in single harvest and multiple harvest technique under monoculture and integreated system during 6 month experiment.

	Multiple hartvest + pig	Multiple harvest	Single harvest
Cost of tilapia for initial stocking*	93.5 ± 1.3	98.5 ± 2.8	98.5 ± 2.6
Cost of aquatic weed mixture feed**	6040.7 ± 290.6	504.4 ± 10.7	502.8 ± 18.6
Cost of pigs***	2100.0 ± 0.0	-	-
Total Cost	**8234.2 ± 291.4**	**602.9 ± 8.0**	**606.3 ± 16.0**

* Tilapia costs 15 baht per kilogram ; 25 baht = US $1
** Aquatic weed costs 4.42 baht per kilogram
*** Pig costs 2100 baht each

Table IV. Economic analysis of 3 different culture systems.

	Multiple harvest + pig	Multiple harvest	Single harvest
Return (baht)	6513 ± 162	1195 ± 226	1093 ± 73
Production cost (baht)	8234 ± 291	603 ± 8	606 ± 16
Benefit (baht)	-1721 ± 140[a*]	592 ± 219[b]	492 ± 83[b]

* Values in the same row with different superscripts are significantly different from each other at $p < 0.01$.

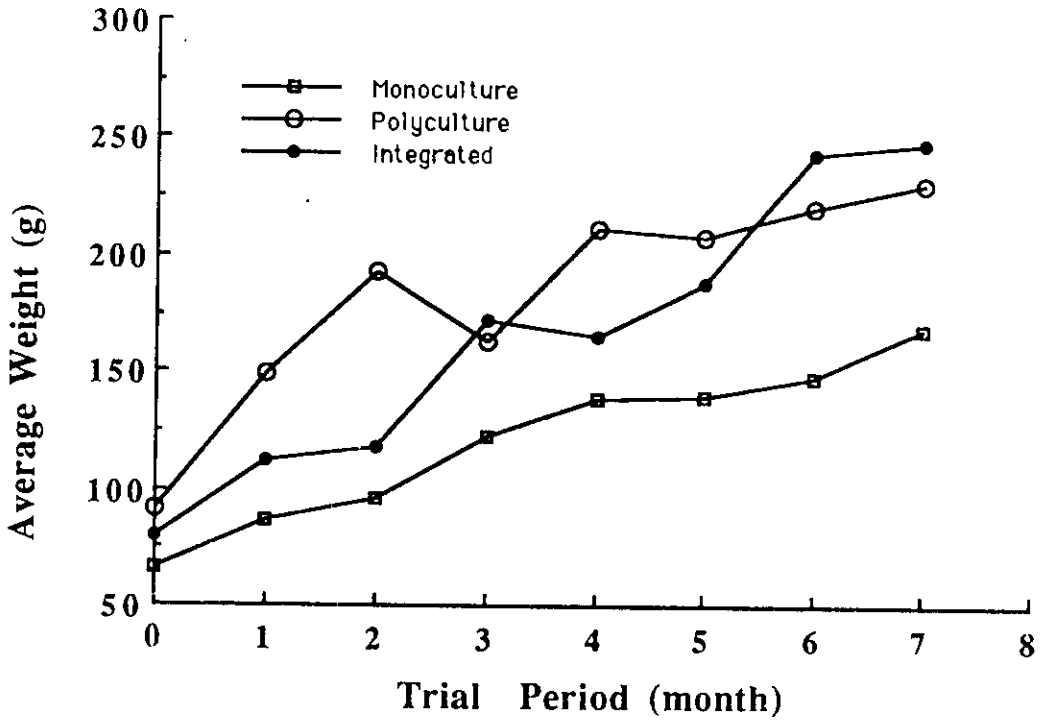

Figure 1. Average weight of tagged Nile tilapia during 7 month period of experiment.

GROWTH AND PRODUCTION OF NILE TILAPIA(Oreochromis niloticus) IN MONOCULTURE, IN POLYCULTURE WITH SNAKEHEAD(Channa striata)AND IN INTEGRATED CULTURE WITH PIG AND SNAKEHEAD

Abstract

Juvenile Nile tilapia(Oreochromis niloticus) of mean body weight 67 g were stocked in ponds of surface area 160 m^2 alone, with snakehead(Channa striata) or with snakehead and pig overculture in an integrated culture system. Three replicates of each treatment were used. Stocking density for tilapia was 90 fish/pond for all treatments and that of snakehead was 10 fish/pond. Three pigs were raised in the pen housed over each pond for the integrated system. After 7 months of experiment, tilapia grown in the integrated system had a significantly higher mean body weight($p<0.01$) than those in the other treatments. On an economical basis, tilapia raised in the integrated system gave a substantially lower return than those in polyculture and monoculture of tilapia.

Discussion

In general, stocking tilapia with its predator decreases tilapia production due to the reduced number of recruits but increases the average size of tilapia(Dunseth and Bayne, 1978 ; Ofori, 1988 ; Manzano, 1990). Contradictory result was also found (McGinty, 1985). In our study, stocking tilapia with snakehead did not affect tilapia production nor number of large size tilapia harvested and only in the integrated system that large size tilapia were significantly larger than those in the monoculture. Snakehead only put pressure on tilapia recruitment in integrated system but not in polyculture because the percentage composition of small size tilapia found in polyculture and monoculture was not significantly different(Fig. 2). The reason for the

difference in recruitment control of tilapia by snakehead in polyculture and integrated systems are not clearly understood but several explanations can be proposed. Snakehead probably preyed upon tilapia fry instead of inhibiting gonad recrudesence of tilapia because gonadosomatic indices of fish in 3 treatments were not substantially different. The average gonadosomatic index of tilapia in monoculture was 1.96 ± 0.27 (mean $\pm$ S.E.), in polyculture 3.16 ± 0.90 and in integrated system 2.79 ± 0.59. Nile tilapia in the integrated system did not directly receive feed but were fed on natural food produced by dropping of pig. Therefore, fish in this treatment received less energy intake than the ones in other treatments which were fed directly(Woynarovich, 1979) and consequently growth of tilapia fry was low comparing to other treatments. According to the optimum foraging theory, the smaller size tilapia in the integrated system would be more energeticlly beneficial for snakehead to prey upon resulting in reduced number of small fish in this particular system. Only when the number of tilapia fry was substantially reduced, would snakehead switch to larger size tilapia. This was confirmed by work done in our laboratory on prey selection of snakehead that normally would selectively prey on tilapia with total length less than 3 cm when tilapia of several size classes were offered(Nitithamyong, unpublished data). The selective foraging strategy of snakehead would then allow tilapia with total length more than 3 cm to grow to larger size. Moreover, the ratio of snakehead to tilapia, the original size of snakehead stocked and the time of stocking the predator in this study may not be optimum. Several studies have shown that the ratio of predator to prey stocked markedly affects the recruitment control of prey species. Generally, the higher the ratio of predator to prey, the higher the proportion of large size tilapia harvested(Dunseth and Bayne, 1978; Bedawi, 1985; Manzano, 1990) but Ofari(1988) found that stocking Lates niloticus with Nile tilapia at the ratio of 1:154 gave a significantly lower proportion of large size tilapia compared to those stocked at the ratios of 1:250 or 1:80. The stocking ratio of snakehead to tilapia in our study was 1:10 which was high

enough according to Pullin(1982). However, the stocking size of tilapia and the length of culture period(2 mo.) before stocking snakehead in this study might allow tilapia to produce too many fry for predator to cope with in the polyculture system. Therefore, it is advisable to conduct further research to evaluate the appropriate stocking strategy of snakehead and Nile tilapia. The size of snakehead(80 g) when it was stocked may be too small to elicit substantial effect because they might be too small to prey upon even small size tilapia due to its gape size.

On an economical basis, raising tilapia in the integrated system was not beneficial because larger amount of aquatic weed mixture pellet were needed for feeding the pigs compared to those needed by the fish(Table II). There was some profit in the other 2 treatments with no significant difference in profit between the 2 treatments demonstating no economic benefit of stocking tilapia with snakehead at this ratio and size. However, in the integrated system when the costs of pig feed and pig were excluded, there would be some profit as in the other treatments. This probably is the proper way to evaluate the profit because in the integrated system, one would have the swine manure for free. Further research is still needed before the feasibility of stocking tilapia with snakehaed can be confirmed.

Complete results were in publication number 9.

Table I. Growth and production of fishes (± S.E.) under 3 different culture systems

	Monoculture	Polyculture	Integrated
Average initial weight of tilapia (g)	84.1 ± 11.2[a*]	81.5 ± 1.6[a]	76.3 ± 2.9[a]
Average final weight of tilapia (g)	122.1 ± 21.2[a]	88.0 ± 7.0[a]	290.5 ± 3.5[b]
Average initial weight of snakehead (g)	-	80.5 ± 6.5[a]	80.0 ± 1.8[a]
Average final weight of snakehead (g)	-	283.3 ± 42.9[a]	246.0 ± 44.1[a]
Total initial weight of tilapia (kg)	7.6 ± 1.0[a]	7.3 ± 0.2[a]	6.9 ± 0.3[a]
Total final weight of tilapia (kg)	41.7 ± 16.9[a]	58.2 ± 2.6[a]	64.4 ± 3.9[a]
Average final weight of large size tilapia (g)	186.4 ± 9.6[a]	203.7 ± 7.7[a]	290.9 ± 3.3[b]
Number of large size tilapia(> 15 cm)	177 ± 65[a]	174 ± 23[a]	222 ± 15[a]
Total number of fish harvested	322 ± 92[a]	666 ± 39[b]	222 ± 15[a]

* Values in the same row with different superscripts are significantly different from each other at $p < 0.01$.

Table II. Economic analysis of 3 different culture systems.

	Monoculture	Polyculture	Integrated
Return (baht)*	968 ± 394	1337 ± 72	5384 ± 236
Production cost (baht)**	577 ± 23	877 ± 24	7311 ± 238
Benefit (baht)	391 ± 413[a]***	460 ± 79[a]	-1927 ± 184[b]

* Price of tilapia: large size (> 15 cm TL) = 25 baht/kg, ; 25 baht = US $1
medium size (10 to 15 cm TL)= 15 baht/kg, small size (< 10 cm TL)= 0.25 baht each
price of pig = 25 baht/kg

** Tilapia costs 15 baht/kg ,aquatic weed costs 4.42 baht/kg , pig costs 2100 baht each

*** Values in the same row with different superscripts are significantly different from each other at $p < 0.01$

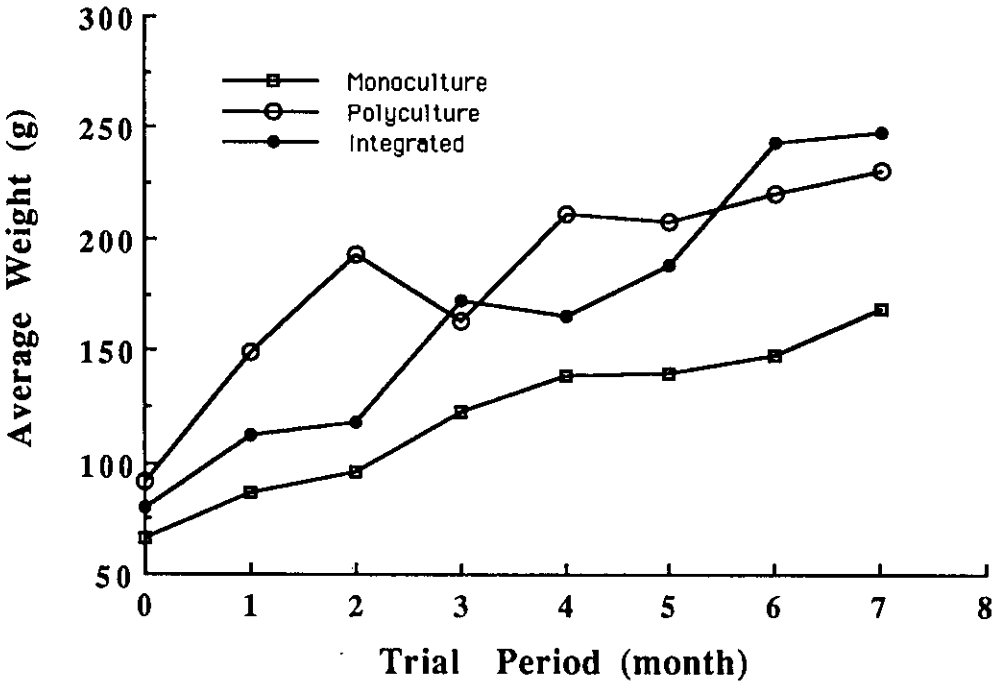

Figure 1. Average weight of tagged Nile tilapia during 7 month period of experiment.

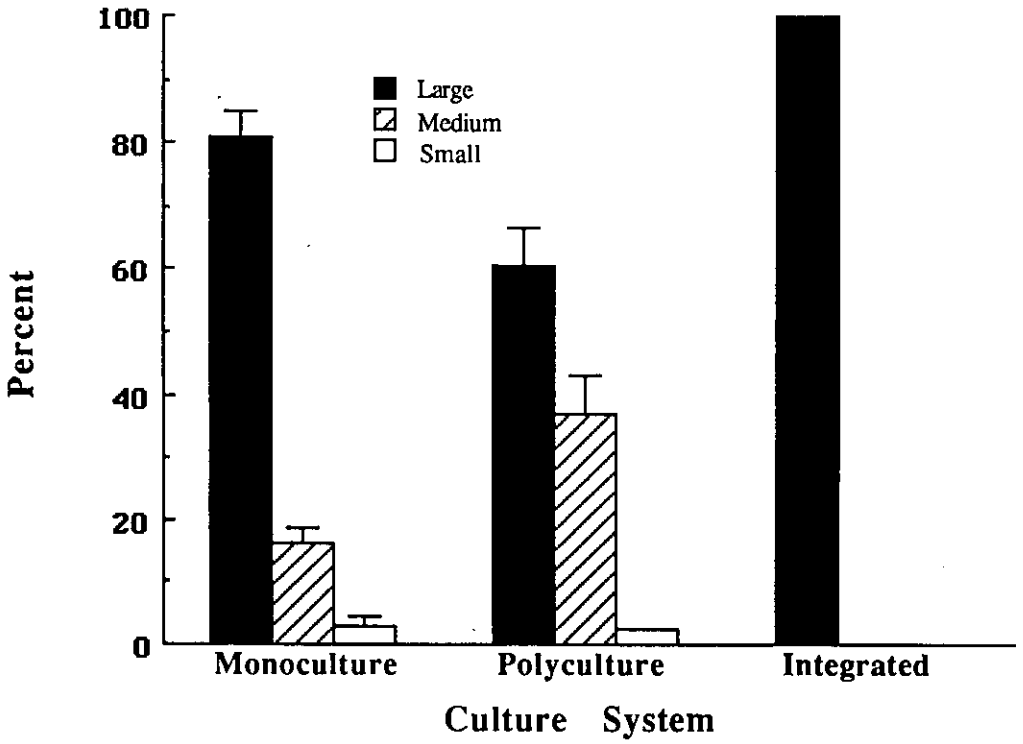

Figure 2. Percentage composition in weight of 3 size classes of Nile tilapia raised under 3 different culture systems (Mean $\pm$ 2 S.E.)

EFEECTS OF STOCKING DENSITY ON GROWTH PERFORMANCE OF HYBRID CATFISH

Introduction

Hybrid catfish, the cross between female indegenous catfish (Clarias macrocephalus) and male giant catfish(Clarias gariepinus) is presently a popular culture species in Thailand due to its fast growth rate and high resistance to disease. Commercial diet for this particular species is diet normally used for indegenous catfish. No special diet has been formulated for this species. Aquatic weed mixture pellet has been used for Nile tilapia with great success (Chiayvareesajja et al. 1988). This study was performed to evaluate the potential of aquatic mixture pellet as the hybrid catfish diet.

Materials and Methods

The study was performed in a small fish farm in Thale Noi. The experiment consisted of 3 treatments according to stocking density of fish which were 1600, 3200 and 4800 catfish per 160 m^2 earthen pond. Each treatment was done in triplicate. Fish were sampled once a month for determining theirs growth rate and amount of aquatic weed mixture pellet fed to fish daily. The experiment started on 24 April 1990 and lasted for 6 months. Hybrid catfish at an average weight of 2 g were used for initial stocking in all treatments. Fish were fed twice daily at the rate of 10% of their body weight. Procedure for aquatic weed pellet preparation were described by Chiayvareesajja and coworkers(1990).

During the 6 months period, water quality(pH, temperature, dissolved oxygen, conductivity and turbidity) were monitored at monthly interval.

Fish was also sampling monthly to assess its growth rate and for adjustment of ration fed. At the end of the experiment, all fish were harvested. Difference in average weight of fish in different treatments were subjected to analysis of variance each month. Duncan's multiple range test was used to verify the difference. Analysis of covariance was applied for the determining of final weight difference to filter the effect of growth rate difference after the first month.

Results and Discussion

During the 6 month period, hybrid catfish raised in the low stocking density grew faster than the fish raised in medium and high stocking density significantly($p = 0.0007$, Table 1) starting from the first month of culture period. No significant difference in growth rate was found between fish raised in medium and high stocking density. Due to the difference in growth during the first month, the difference in growth at the end of the experiment was subjected to analysis of covariance using the weight of fish at the first month as covariate variable. After the effect of first month weight was filtered out, the effect of stocking was still significantly apparent. Therefore, it suggests that higher density than $10/m^2$ would result in lower growth due to either competition and/or lower water quality in the pond.

Details of this study will be published in an international publication.

Table I. Average weight of hybrid catfish (X ± S.E.) during the 6 months experiment.

	Treatment		
	1600/pond	3200/pond	4800/pond
Initial	2.00 ± 0.00[a]	2.00 ± 0.00[a]	2.00 ± 0.00[a]
1 month	6.73 ± 0.56[a]*	3.02 ± 0.16[b]	3.26 ± 0.67[b]
2 month	12.46 ± 1.07[a]	5.25 ± 0.44[b]	6.11 ± 0.16[b]
3 month	24.77 ± 0.83[a]	9.66 ± 1.02[b]	9.48 ± 0.54[b]
4 month	56.00 ± 3.04[a]	23.44 ± 2.82[b]	26.62 ± 1.92[b]
5 month	93.01 ± 3.02[a]	33.82 ± 3.63[b]	45.65 ± 8.56[b]
final month	149.51 ± 12.72[a]	59.10 ± 6.34[b]	55.84 ± 4.53[b]

* Number with same superscipts are not significantly different at p = 0.05

EFFECTS OF NILE TILAPIA(Oreochromis niloticus) STOCKING DENSITY ON FISH PRODUCTION IN POLYCULTURE WITH HYBRID CATFISH

Introduction

Nile tilapia has been succesfully cultured togeteher with several species of fish. The present study was carried out to determine whether it can be cultured with hybrid catfish which is presently popular among fish farmers.

Materials and Methods

The experiment was carried in a small fish farm in Thale Noi. Each experimental unit was a 160 m^2 earthen pond. For initial stocking of each pond, juvenile Nile tilapia averaged 28 g were used. The experiment started in November 1990 and lasted for 3 months. The experimental design was completely randomized design with 3 replication. The difference among 3 treatments were stocking density of Nile tilapia:100, 200 and 500 per pond. In all treatments, 710 hybrid catfish were stocked together with Nile tilapia making all treatment polyculture system with vary stocking density of Nile tilapia. Fish were fed with aquatic weed mixture pellet which was used throughout experiments of this projects twice daily at 5% of fish body weight. Amount of food offered was adjusted monthly when tilapia and catfish in each pond were sampled. Nile tilapia were sorted into 3 size groups for weight determination in each size class. The 3 size classes were large(> 15 cm in total length); medium (10 to 15 cm) and small(<10 cm). For hybrid catfish only weight were recorded without sorting.

Water quality parameters; pH, temperature, dissolved oxygen, conductivity and turbidity, were monitored monthly also. Discrepancy among treatments in all aspects except the percentage composition of size classes were subjected to analysis of variance for their significant differences. Duncan's multiple range test was used to verify the difference between treatments. Difference in percentage composition of 3 size classes of tilapia among treatments was subjected to Chi-square test.

Results and Discussion

The results of this experiment could not be presented precisely because heavy mortality of Nile tilapia occred in all treatments after the experiment was carried for 2 months. The number of fish loss was present in Table I. The results hereby presented in Table II including average final weight, percentage of large size tilapia, number and average weight of large size tilapia were the corrected values.

For hybrid catfish, because the initial weight of the fish stocked is signicantly different(Table II), the analysis of covariance was used to test the difference in final weight of catfish using initial weights as covariates. The results indicated that culture hybrid catfish with high and low density of Nile tilapia did not affect the growth of hybrid catfish(Table II). However, it should be noted that growth of hybrid catfish in moderate density of Nile tilapia was significantly lower than those of low and high stocking density of Nile tilapia. The reason for this is not clearly understood.

The heavy mortality of Nile tilapia during the experiment which was highest at the highest stocking density and lowest at the low stocking density suggested that the capacity of the pond system could not tolerated high stocking density of these fishes because the system did

not allow for water exchange at all.

Details of this study will be published in an international publication.

Table I. Number of fish died during the second month of experiment.

	Treatments*		
	1	2	3
Number of fish	24 ± 17	73 ± 14	201 ± 74
Weight(kg)	3.3 ± 2.0	7.7 ± 1.7	16.9 ± 6.4

* Treatment 1 = 710 hybrid catfish stocked with 100 juvenile Nile tilapia

2 = 710 hybrid catfish stocked with 200 juvenile Nile tilapia

3 = 710 hybrid catfish stocked with 500 juvenile Nile tilapia

Table II. Initial and final weight of Nilt tilapia and hybrid catfish, and average weight and number of large size tilapia.

	Treatments*		
	1	2	3
Nile tilapia			
Initial weight(g)	29.3 ± 0.9[a]	28.2 ± 0.7[a]	26.5 ± 0.2[a]
Final weight(g)	30.5 ± 14.2[a,b]	8.7 ± 0.8[b]	39.9 ± 2.5[a]
Average weight of large size (g)	102.3 ± 2.3[a]	NA	97.2 ± 29.8[a]
Number of large size fish harvested**	8 ± 5[a]	0 ± 0[a]	160 ± 91[a]
% large size fish harvested**	15.9 ± 8.5[a,b]	0.0 ± 0.0[a]	30.2 ± 11.7[b]
Hybrid catfish			
Initial weight(g)	36.3 ± 0.6[a]	45.3 ± 1.4[b]	42.2 ± 1.7[b]
Final weight(g)	98.1 ± 3.9[a]	71.8 ± 3.4[b]	102.5 ± 1.48[a]

* Treatment 1 = 710 hybrid catfish stocked with 100 juvenile Nile tilapia
2 = 710 hybrid catfish stocked with 200 juvenile Nile tilapia
3 = 710 hybrid catfish stocked with 500 juvenile Nile tilapia

**The values were calculated from the final harvest without correction for the dead fish during the second month of experiment

EFFECTS OF DIFFERENT HARVESTING TECHNIQUES ON PRODUCTION OF NILE TILAPIA (Oreochromis niloticus)

Introduction

Harvesting techniques has been considered a method to increase production of tilapian fish(Edwards, 1982). This study was done to assess whether multi-harvesting technique would be beneficial for culturing of Nile tilapia(Oreochromis niloticus) fed with aquatic weed mixture pellet.

Materials and Methods

The experiment was carried in a small fish farm in Thale Noi. Each experimental unit was a 160 m^2 earthen pond. For initial stocking of each pond, 100 juvenile Nile tilapia averaged 28 g were used. Four different techniques for harvesting Nile tilapia was implemented: harvest of large and small size tilapia monthly, harvest monthly of large size fish only, harvest monthly of small size fish only and single harvest at the end of experiment. The experiment started at the end of October 1990 and stoped at the end of March 1991. For all multi-harvest treatments, the partial harvest was started in January 1991. The experimental design was completely randomized design with 2 replication. Fish were fed with aquatic weed mixture pellet which was used throughout experiments of this projects twice daily at 5% of fish body weight. Amount of food offered was adjusted monthly when fish in each pond were sampled and sorted into 3 size groups for weight determination in each size class. The 3 size classes were large(> 15 cm in total length); medium (10 to 15 cm) and small (<10 cm). At this time fish were harvested according to their treatments

and numbers of fish harvested in each size class were recorded and added to the numbers at the end of experiment for evaluation of percentage composition of different size class.

Water quality parameters; pH, temperature, dissolved oxygen, conductivity and turbidity, were monitored monthly also. The experiment was done for 5 months before all fish were harvested to determine production yield in each pond. Cost of feed and fish were compared to return from the final production of fish in order to assess benefit. Discrepancy among treatments in all aspects except the percentage composition of size classes were subjected to analysis of variance for their significant difference. Duncan's multiple range test was used to verify the difference between treatments. Difference in percentage composition of 3 size classes among treatments was subjected to Chi-square test.

Results and Discussion

Multi-harvesting technique has not shown to increase production in Nile tilapia. Average weight of fish in single harvest was statistically higher than multi-harvest treatments($p = 0.0001$, Table I) because most fish harvested were large(Fig. 1). The number of large size fish harvested in single-harvest was only significantly higher than that in multi-harvest of both large size and small size tilapia but not the multi-harvest of small size only or large size only(Table I). However, large size tilapia in single-harvest was substatantially larger than those in multi-harvest treatments(Table I).

Single-harvest gave lowest profit according to economic analysis while multi-harvest of small size tilapia gave the highest benefit(Table II).

For Nile tilapia selling tilapia seed seem to be a appropriate way to make profit because most fish harvested were small size(Fig. 1). Production gain from mult-harvest of small size tilapia was not different from other multi-harvest treatments even though it was significantly higher than that of single-harvest.

Details of this study will be published in an international publication.

Table I. Growth and production of Nile tilapia in 4 different treatments.

	Treatment*			
	1	2	3	
Average initial weight of fish(g)	27.8 ± 2.2[a]**	28.8 ± 0.0[a]	29.1 ± 0.3[a]	27.5 ± 0.4[a]
Average final weight of fish(g)	11.3 ± 0.8[a]	18.0 ± 2.2[a]	12.0 ± 1.3[a]	212.1 ±13.9[b]
Average weight of large size fish(g)	162.7 ± 3.5[a]	160.0 ±14.4[a]	153.8 ±10.7[a]	218.0 ±14.7[b]
Total number of fish yield	6918 ± 471[a]	4200 ± 375[b]	6299 ± 470[a]	237 ± 17[c]
Total number of large size fish	114 ± 2[a]	187 ± 10[b]	201 ± 21[b]	233 ± 17[c]
Production gain (kg)	73.6 ± 0.3[a]	70.0 ± 2.4[a]	70.6 ± 2.6[a]	45.5 ± 3.4[b]

* Treatment 1 = Harvest of large and small sizes tilapia monthly

2 = Harvest of large size tilapia monthly

3 = Harvest of small size tilapia monthly

4 = Single harvest of all size tilapia at the end of experiment

** Numbers with same superscripts are not significantly different at p = 0.05.

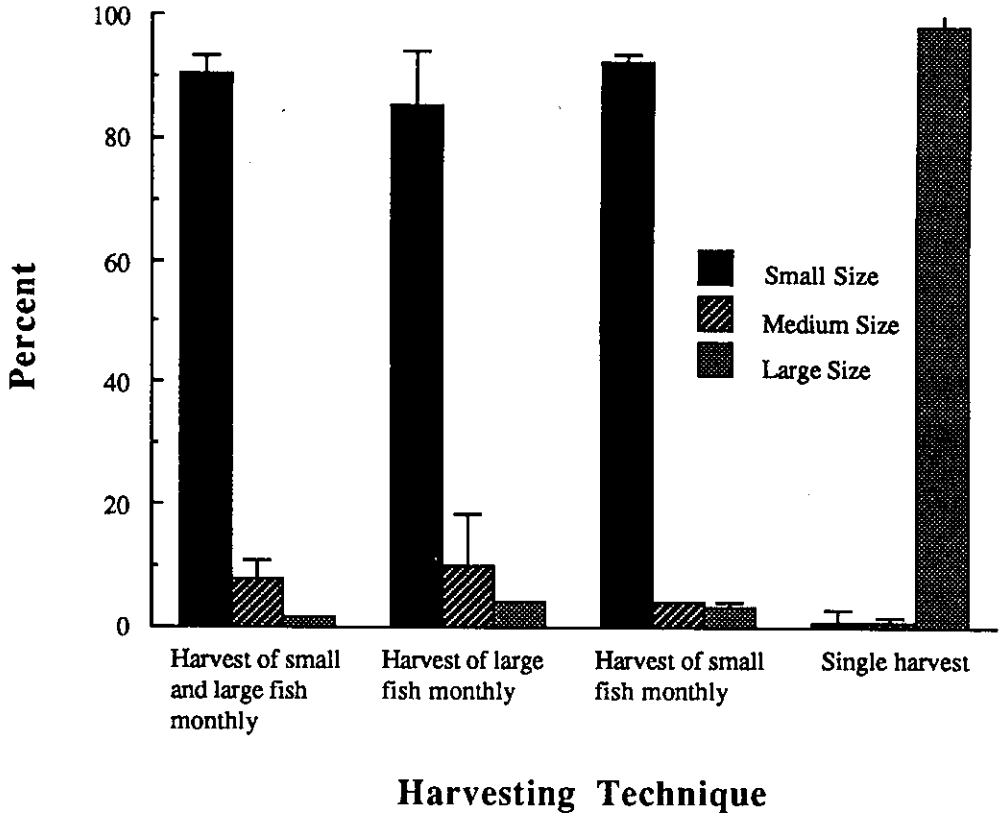

Figure 1. Percentage composition in number of 3 size classes Nile tilapia harvested under 3 different technique (Mean + 2 S.E.)

Table II. Economic analysis of 4 treatments.

	Treatment*			
	1	2	3	4
Cost(baht)**	1208 ± 11	1056 ± 170	889 ± 39	1077 ± 16
Return(baht)***	2277 ± 126	1878 ± 49	2395 ± 7	1247 ± 84
Profit(baht)****	1069 ± 115^{a,b}	821 ± 219^{b}	1506 ± 46^{a}	170 ± 95^{c}

* 1 = Harvest of large and small sizes tilapia monthly

2 = Harvest of large size tilapia monthly

3 = Harvest of small size tilapia monthly

4 = Single harvest of all size tilapia at the end of experiment

** Price of tilapia:

large size (> 15 cm TL) = 25 baht/kg; 26 baht = US $1

medium size(10 to 15 cm TL) = 15 baht/kg

small size (< 10 cm TL) = 0.25 baht each

*** Tilapia costs 15 baht/kg;

Aquatic weed mixture pellet cost 4.42 baht/kg.

**** Numbers with same superscripts are not significantly different at $p = 0.05$.

EFFECTS OF STOCKING DENSITY ON GROWTH OF NILE TILAPIA(Oreochromis niloticus)

Introduction

Aquatic weed mixture pellet has been found to be a suitable diet for Nile tilapia(Oreochromis niloticus)(Chiayvareesajja et al. 1988). Normally, stocking density used in the experiments was 160/160 m^2 as recommended for this species. In tilapia stunting phenomenon normally occures when stocking density is low resulting in small size of harvested fish at the end of growing season. At low density, tilapia apparently invests most energy in reproduction instead of growth due to low competition in food. It is also generally known that stocking density has a pronounced effect on growth of fish.

The present study was performed to evaluate the effects of stocking density on production of Nile tilapia fed with aquatic weed mixture diet.

Materials and Methods

This study was performed in a private fish farm in Thale Noi area. Juvenile Nile tilapia (O. niloticus) of average weight 38.9 g were stocked in nine 160 m^2 earthen ponds according to their stocking density which were 100, 200 and 500 fish per pond. The experimental design was completely randomized design with 3 replications. Fish were fed with aquatic feed mixture pellet which was used throughout experiments of this projects twice daily at 5% of fish body weight. Amount of food offered was adjusted monthly when fish in each pond were sampled and sorted into 3 size groups for weight determination in each size class. The 3 size classes were large(> 15 cm in total length);

medium (10 to 15 cm) and small(<10 cm). Water quality parameters; pH, temperature, dissolved oxygen, conductivity and turbidity, were monitored monthly also. The experiment was done for 6 months before all fish were harvested to determine production yield in each pond. Cost of feed and fish were compared to return from the final production of fish in order to assess benefit. Discrepancy among treatments in all aspects except the percentage composition of size classes were subjected to analysis of variance for their significant difference. Duncan's multiple range test was used to verify the difference between treatments. Difference in percentage composition of 3 size classes among treatments was subjected to Chi-square test.

Results and Discussion

During 6 month period, nile tilapia in the hishest stocking density (500/pond) produced, on the average, significantly larger fish than moderate(200/pond) and low(100/pond) stocking density(Table I). However, thses diffenece were merely the result of discrepancy in number of large size fish harvested at the curtail of experiment where higher number of large size tilapia was harvested in highest stocking density(Table I). When only large size tilapia was compared among these 3 treatments, no difference in weight was found. The total number of fish harvested under 3 different stocking density were not statistically different(Table I) reflecting the significant difference in size composition of tilapia in different stocking density. Fish in highest stocking density yielded the highest percentage of large size tilapia while in lowest stocking density yielded the least(Fig. 1).

The higher number of large size tilapia harvested in the highest

stocking density was just the artifact of higher number of fish input at the begining of experiment. Comparing the number of large size fish harvested per 100 of fish stocked revealed no difference among treatments (Table I). Moreover, considering weight gain per unit of weight stocked, the lowest stocking density gave the substantial higher relative weight gain than moderate and highest stocking density(Table I).

Based on the economic analysis, all treatments tolerated a considerable amount of losses and the highest stocking density made the highest loss because it had the highest production cost(Table II). It is therefore suggested that growing tilapia with moderate stocking density would be a sound strategy based on the economic analysis, number of large size produced per number of fish stocked and a tentatively larger size of large size tilapia(Table I and II).

Details of this study will be published in an international publication.

Table I. Growth and production of Nile tilapia(± S.E.) in 3 treatments.

	Stocking density		
	500/pond	200/pond	100/pond
Average initial weight of tilapia(g)	39.20 ± 3.03[a*]	37.67 ± 0.44[a]	40.67 ± 0.67[a]
Average final weight of tilapia(g)	37.39 ± 6.03[a]	23.78 ± 1.70[b]	13.81 ± 0.58[b]
Total weight gain(kg)	138.00 ± 10.71[a]	73.19 ± 12.58[b]	59.80 ± 2.37[b]
Average final weight of large size fish(g)	152.19 ± 8.35[a]	170.68 ± 27.82[a]	161.72 ± 10.65[a]
Average final weight of medium size fish(g)	41.22 ± 9.45	31.82 ± 2.88	27.24 ± 1.04
Average final weight of small size fish(g)	12.17 ± 0.33	10.53 ± 0.17	8.34 ± 0.32
Number of large size fish	464.67 ± 69.21[a]	171.33 ± 23.68[b]	77.33 ± 8.95[c]
Total number of fish harvested	4517 ± 968[a]	3386 ± 437[a]	4647 ± 309[a]

Table I. continued.

	Stocking density		
	500/pond	200/pond	100/pond
Weight gain per unit weight stocked	7.04 ± 0.04[a]	9.82 ± 1.73[a]	14.73 ± 0.79[b]
Number of large size fish per 100 fish stocked	92.93 ± 13.84[a]	85.67 ± 11.84[a]	77.33 ± 8.95[a]

* Numbers with same superscripts are not significantly different at p = 0.05.

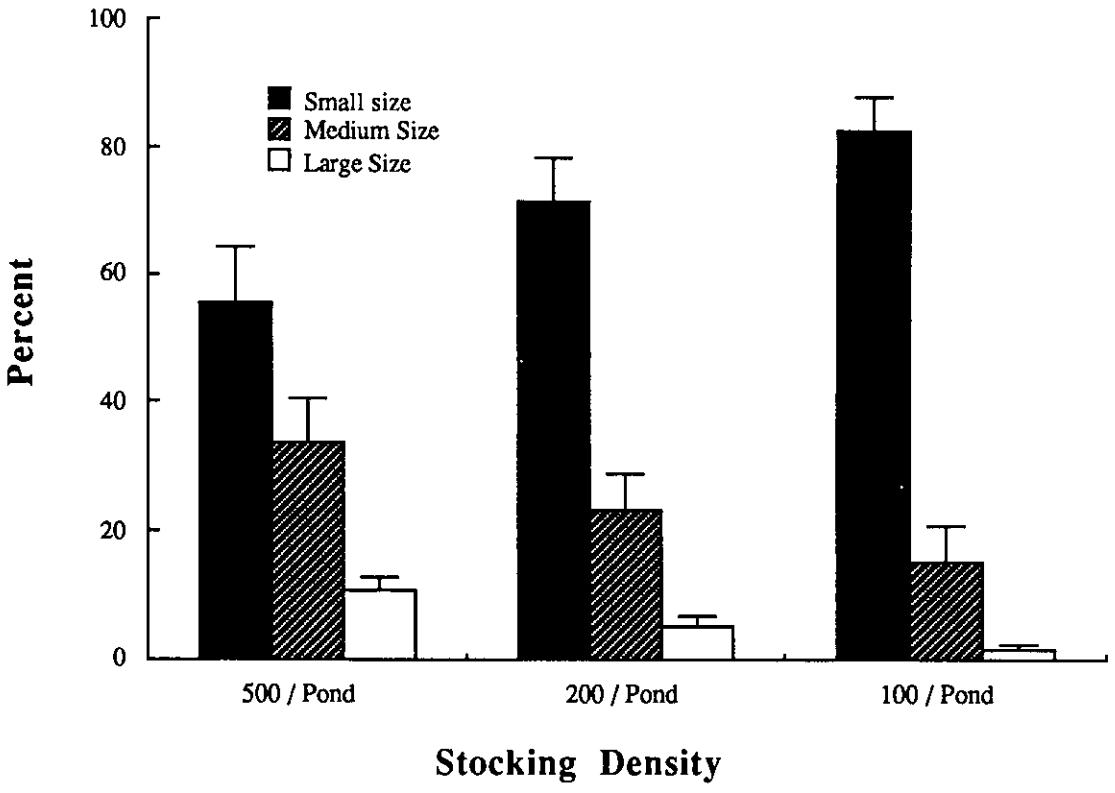

Figure 1. Percentage composition in number of 3 size classes of Nile tilapia raised under 3 different stocking density (mean + 2 S.E.)

Table II. Economic analysis of 3 treatments.

	Stocking density		
	500/pond	200/pond	100/pond
Return (baht)*	3241 ± 313	1739 ± 301	1563 ± 59
Production cost(baht)**	5182 ± 42	1921 ± 6	1199 ± 41
Loss(baht)	1941 ± 348[a***]	182 ± 307[b]	364 ± 18[b]

* Price of tilapia:

large size (> 15 cm TL) = 25 baht/kg; 26 baht = US $1

medium size(10 to 15 cm TL) = 15 baht/kg

small size (< 10 cm TL) = 0.25 baht each

** Tilapia costs 15 baht/kg;

aquatic weed mixture pellet cost 4.42 baht/kg.

*** Numbers with same superscripts are not significantly different at $p = 0.05$.

UTILIZATION OF AQUATIC PLANTS IN SONGKHLA LAKE (THAILAND)

Abstract

Songkhla Lake is the biggest natural lake in Thailand (98,600 ha). The lake is a lagoonal type which connects to the gulf of Thailand. Salinity in the lake varies from 0-30 ppt seasonally, and on the distance from the sea. Thale Noi is a freshwater part of the lake with a surface area of 25 km^2, It is slightly acidic and has 19 spp. of aquatic plants with a biomass ranging from 6-21 kgm^{-2}, depending on season.

This paper presents the resume of a four-year study in which an attempt is made to utilize this weed as a source of fish feed and to find an appropriate weed management technique. Four species of popular herbivorous species, *Oreochromis niloticus*, *Labeo rohita*, *Ctenopharyngodon idella* and *Puntius gonionotus*, were tested for culture under the reservoir condition for one year. Nile tilapia (*O. niloticus*) and Indian carp (*L. rohita*) performed better than the other two.

From a series of fish culture and nutrition studies *O.niloticus* was found to be the most suitable for culture. Mono and polyculture and integrated culture with pig and chicken with single and multiharvesting were tested with *O. niloticus* maintained on a weed based feed. Aquatic weed pellet was also used as animal feed to omnivorous fishes, pig and chicken.

INTRODUCTION

Songkhla Lake of 98,680 ha. is the biggest natural lake in Thailand. The lake is a lagoonal reservoir connected to the Gulf of Thailand. It is divided into three parts: 1) the uppermost - covering 70% of the lake surface, is freshwater, 2) the middle area, covering 5% of the lake surface, is brackish

water and 3) the lowest part of the lake, is seawater (Bhommanonta, 1989 and Davy, 1981).

Thale Noi is a freshwater lagoon of approximately 25 km^2. connected to the uppermost part of Lake Songkhla. Thale Noi and the uppermost of Lake Songkhla contain a large number of aquatic weeds *Ceratophyllum demersum, Hydrilla verticillata, Najas graminea, Utricularia minor, Blyxa japonica* (plate 1) which bloom all year round. It has been estimated that 140,625 mt of aquatic weeds are produced annually (Davy,1981). In 1979, 1,800 mt of aquatic weeds were harvested from the upper part of the lake for animal feed (Fisheries Office, Phattalung province, 1979 ; Tansakul *et al.*, 1987).

More than 200 fishermen work in Thale Noi, mostly with gill nets and encircling seines (John Taylor *et al.*,1985). Thale Noi is heavily fished and yields 500-600 t/yr of fresh water fish worth approximately 8 million bath or 36.0% of annual income of Thale Noi community (Institute of Science and Technology, 1982). Fisheries is still an important source of income to the villagers; Fish yield has decreased over the year and is not enough to support the people who are engaged in fisheris (Rittibhonbhun *et al.*,1984). Aquaculture in Thale Noi could provide a new source of protein food and income for the villagers. With particular regard to the Thale Noi situation, herbivorous fish culture may offer the most potential, in order to utilize the abundant aquatic macrophytes, the annual biomass of which has been estimated at 146 kg m^{-2} (Purintavaragul and Lheknim, 1984). There are several species of fish that are reported to feed on aquatic macrophytes; grass carp (*Ctenopharyngodon idella), Puntius gonionotus, Osphronemus gorami, Tilapia* spp, *Trichogaster pectoralis, Labeo rohita,* etc. (Edwards 1980). Herbivorous fish are very beneficial not only for local consumption but also as a means to control the population of aquatic macrophytes. However, there are several developmental constraints to

aquaculture in the area such as climate, water quality and appropriate sites (Chiayvareesajja *et al.*, 1988).

RESULTS AND DISCUSSION

Water quality

During 1982-1983 water quality parameters and plankton biomass were checked (Table 1 and Fig.1). There were no significant differences of water depth, water temperature, alkalinity and nitrate level among stations but there were significant differences of other parameters. The average water depth of Thale Noi ranged from 103.8 cm (station 3) to 126.5 cm (station 4). The water pH ranged from 5.6 (station 3) to 6.9 (station 4) with the lowest pH of 3 at station 3 during November and December 1982. Annual dissolved oxygen ranged from 3.9 ppm (station 5) to 6.4 ppm (station 4) with the highest concentration of 10 ppm recorded at station 4 in February 1982 and the lowest concentration of 1 ppm recorded at station 3 in September 1982. The levels of nitrate ranged from 0.024 ppm (station 4) to 0.036 ppm (station 1). The average levels of phosphate ranged from 0.005 ppm (station 4) to 0.022 ppm (station 1).

Phytoplankton biomass

The highest level of annual phytoplankton biomass was 940.5 mg/m^3 at station 1 and the lowest level was 196.8 mg/m^3 at station 3. There were no significant differences of phytoplankton biomass among station 2,3,4 and 5. Moreover, there were no significant differences of correlation coefficient between phytoplankton biomass and nitrate, phosphate and pH (Chiayvareesajja *et al.*, 1988).

Zooplankton

Six groups of zooplankton were recorded e.g. Ciliata, Rotifera, Copepoda, Nauplius larva and copepodite stage, Cladocera and Ostracoda. Rotifers were the most abundant at all stations observed throughout the year and nauplii and copepodite stages were next. The highest zooplankton densities were recorded at station 2 (Chiayvareesajja *et al.*, 1988).

Fish Culture

Thale Noi is very productive. Unfortunately the pH is low (Tansakul, 1985). The idea of using herbivorous fish culture for aquatic weed control was tested in the area between 1981 and 1984. A schemeatic representation of the different steps that were adopted in this study is given in Fig.2.

After a preliminary testing period of 12 months *Labeo rohita* and *Oreochromis niloticus* proved to be better candidates than *Ctenopharyngodon idella* and *Puntius gonionotus* for rearing in Thale Noi. Grass carp, which was mentioned as a promising species for controlling aquatic weeds by Bhatia (1970), Edwards (1980) and Fowler (1985), grew very well, reaching a size of 1-2 kg in Thale Noi fish pens. However, high mortality, cost and unavailability of fry did not favour further studies on it. *P. gonionotus* was eliminated because of its slow growth rate and low survival rate. *L. rohita* and *O. niloticus* showed better survival rates and fish production than grass carp and *P. gonionotus*. *L. rohita* and *O. niloticus* lived and grew well in the preliminary experiments, where the fish were not fed but had to depend on the weeds in the bamboo pens.

Production of *O. niloticus* in Thale Noi pens was high with a high SD when the fish were fed only with aquatic plants. The higher SD of 30 $fish m^{-2}$. was more productive than the lower SD (3 $fish m^{-2}$.) which is the standard number of

the Department of fisheries recommended for tilapia culture in earthen ponds. This productivity of 1.08 kgm^{-2}. was very much lower than that of tilapia cultured in cages in the Ivory coast (Coche,1982).

Productivity of *L. rohita* in the pens was similar to that of *O. noloticus* (0.5-1.02 kgm^{-2}.) in 14 months, and the higher SD (10 $fishm^{-2}$.) was more productive than the lower SD (3 and 1 $fishm^{-2}$.). These figures show that *L. rohita* may be used for weed control-fish culture as *O. niloticus*. Later *O. niloticus* was selected for feed trial studies after consideration of other secioeconomic factors.

Concerning *O. niloticus* culture with different kinds of feed, it was found that *O. niloticus* in the pens not given food and the ones that were fed with 5% body weight of fresh *C. demersum* gave similar results (Tansakul *et al.*, 1987). This may indicate that *O. niloticus* can grow well only on microplanktonic algae and benthic microorganisms as was found by Moriarty and Moriarty (1973) in Lake George, Uganda. Feeding *O. niloticus* with chicken pellets gave productivity figures three times higher than feeding with fresh C. demersum or without feeding. However, it gave a very high food conversion rate of 15.10, which would greatly increase production costs over the other two methods. When the overall production costs were taken into consideration *O. niloticus* fed on chicken pellets may not be suitable in a rural subsistance farm setting such an in Thale Noi.

A study on the evalution of the suitalibity of aquatic weed *C. demersum*, *Eleocharis ochrostachys* and *Eichhornia crassipes*, the three most abundant species in Thale Noi by tilapia (*O. niloticus)* was also conducted The weeds were used to prepare fish pellets with 16,25 and 35% crude protein content into which were incorporated 40,30 and 20% dry weeds (Table 2). The control pellet was chicken pellet (Centaco Co.,16.81% crude protein).

After 11 weeks fish showed 86-90% survival. During the first and second weeks treatments showed no difference in growth. However, during the 3rd-11th weeks, fish fed with pellets of higher protein level grew better (Table 4). Fish fed with different plants at the same protein level showed no statistical difference in growth (Table 4).

Fish fed with 35% crude protein level grew best, probably indicating *O. niloticus* required a minimum protein level more than 25% (De Silva & Perera, 1985, Klinnavee *et al.*, in press). Also fingerling *O. niloticus* of 6.5-35 g size required optimum protein of 30-35% (Juncey,1982, De Silva & Perera, 1985).

The pellets with low percentage of crude protein content showed higher FCR (Table 3). High fibre in fish feed caused low feed digestion, and low absorbtion (Appler and Jauncey, 1983). Also fish fed with low (16%) crude protein content may recieve insufficient vitamin and minerals, and affect FCR (Sritasit *et al.*, 1982; Jauncey and Ross, 1982).

Later another study was conducted with a simple dietary formula containing dry weed, rice bran and fish meal in a ratio of 4:3:1 and 4:2:2. It was found that the most appropriate feed was the aquatic weed mixture pellet in the ratio of 4:3:1, giving the cheapest feed (3.15 Baht/kg) and the highest profit (13.02 Baht/cage, excluding cost of cage and labor). However, further improvement of the aquatic weed mixture pellet is desirable since it resulted in poorer growth than commercial fish pellets. On the basis of crude protein, lipid and fibre contents, the nutritive value of the 4:3:1 feed meets the requirements of tilapia (Jauncey and Ross, 1982). However, rates of nutrient assimilation of feed given are unknown since there is no data on digestibility of each component. It was observed that the crude protein and lipid contents of the two aquatic weed mixture pellets were markedly higher than that of the commercial pellet but the gross energy contents of both feeds were lower than that of the

commercial pellet. Food energy is an important factor affecting fish growth since the amount of protein assimilated depends on the amount associated with assimilable food energy (Bowen, 1982). Increased food energy level is considered for improvement of the aquatic weed mixture pellet, and such an improvement is economically feasible since the cost of the aquatic weed mixture pellet is much lower than that of commercial fish pellets (Chayvareesajja *et al.*,in press).

Integrated systems

Tilapia was successfully reared in fish pens and cages in Thale Noi and fed with aquatic weed pellet as mentioned above. An integrated culture system with chicken, local strain (unpublished data), where the chicken was fed with aquatic weed pellet was also evaluated. There was another study to evaluate the utilization of aquatic weed pellet form as feed for the rearing of Nile tilapia, *O. niloticus* and pig. Furthermore, in order to maximize the limited resources, tilapia production using pig manure was also studied.

The nutritive value of formulated feed was much higher than that of pig faeces. The crude protein and lipid contents of the formulated feed and pig faeces were (on dry weight basis) 24.25% , 12.69%, 14.15% and 5.66%, respectively (Chiayvareesajja *et al.*,1989).

All the pigs grew well on the weed pellet and the percentage weight gain was high (1074%). The average loadings of pig faeces and urine were 6.42 kg/3 pigs/day and 6.24 kg/3 pigs/day, respectivelyb (Plate II).

Growth performance of tilapia in the two systems was not apparently different. However, although there was no significant difference between tilapia production in the two systems the production in the integrated system was slightly higher than in the monoculture system (87.99 and 1.47 kg/compartment,

respectively; Table 5). The percentage weight gain of tilapia in the monoculture system was much higher than in the other. The food conversion ratio (FCR) of tilapia, on the formulated feed (4.05) was much better than in tilapia fed on piggery waste (25.77). The FCR of 7.39 of pigs fed on aquatic weed mixture pellet was relatively high.

At the final harvesting, the number of tilapia in both systems were higher than the number stocked, and that in the integrated system was twice that in the monoculture system (2360 and 1155 fish/compartment, respectively). Furthermore, most tilapia in the integrated system (72.08%) were 10-15 cm, and in the other (45.97%) were of > 15 cm (Chiayvareesajja *et al.* 1989). The yield in this study was similar to that of Green et al. (1989).

It was also found that there were no significant differences in carcass qualities of tilapia reared in monoculture and integrated culture systems, but different in chemical compositions (Wongwit *et al.*, in press).

Tilapia (*O. niloticus*) reared in the 3 systems, viz. integration of tilapia and chicken, monoculture of tilapia and integration of tilapia and pig, were sampled and analysed for carcass quality after 6 months rearing. Chicken and pig in integrated systems and tilapia in monoculture were fed on aquatic weed (*Ceratophyllum demersum*) mixture pellet. Chemical composition of chicken manure, aquatic weed mixture pellet, pig faeces and carcass of fish in each system were analysed by proximate analysis. Levels of crude lipid and crude fibre of fish carcass were lowest (13.50% and 0.53%, respectively) and levels of crude protein and ash were highest (59.54% and 24.64%, respectively) in the integrated tilapia-chicken system. There were no significant differences in the ratios of dry flesh to dry body weight (FBdR) and dry bone to dry flesh weight (BnFR) between the two integrated systems. The carcass of tilapia in monoculture was the best on the basis of the highest value of FBdR (83.23%) and

the lowest value of BnFR (20.37%) (Wongwit *et al.*,in press).

Later, an aquaculture practical training for small holden famers to raise tilapia in 5x5 m bamboo cages with some subsidies from the project was studied. Unforfunately due to two monsoon storms and floods in 1987 and 1988, and the low profit income from fish culture, farmers stoped their fish raising (unpublished data).

Also in 1989, a one man operated fish feed centre was experimentally studied. The centre produced 20-30 kg. of aquatic weed pellet to supply a farmers of 10 small earthen fish ponds in Thale Noi for 6 months.

Rearing *O. niloticus* with aquatic weed is not only a way to control undesirable weeds; it will also increase the local stocks of natural fish as was reviewed by Edwards (1980), Blackburn (1968) and Soerjani(1976). Furthermore, it is a possible way of increasing the income of the villagers in the area.

From the results of this study it is suggested that further research into decreasing costs and increasing quality of aquatic weed pellet may be is appropriate. If these techniques are established they may be usefully applied in other similar freshwater reservoirs in Thailand and the South-East Asian region.

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Table 1. Water quality and plankton biomass at 5 stations in Thale Noi Lake (mean ± standard error)*. Data were were taken from Chiayvareesajja *et al.* (1988).

Parameter	Station 1	2	3	4	5
Depth(cm)**	107.2^{ns} ± 8.7	125.0^{ns} ± 8.3	103.9^{ns} ±11.0	126.5^{ns} ± 8.4	112.7^{ns} ± 9.5
Temperature**(°C)	28.9^{ns} ± 0.4	29.5^{ns} + 0.4	29.1^{ns} + 0.5	29.3^{ns} ± 0.5	30.0^{ns} ± 0.4
Do(ppm)**	5.2^{A} + 0.6	6.2^{AB} + 0.6	4.5^{AC} + 0.6	6.4^{AB} + 0.6	3.9^{AC} ± 0.6
Alkalinity**	16.0^{ns} ± 3.5	19.5^{ns} ± 3.7	16.4^{ns} + 2.8	14.9^{ns} ± 3.2	16.7^{ns} ± 2.1
pH**	6.6^{A} ± 0.3	6.9^{AB} ± 0.3	5.6^{ns} + 0.5	6.1^{AB} ± 0.4	6.1^{ABC} ± 0.3
Nitrate(ppm)**	0.0^{ns} ± 0.0	0.0^{ns} ± 0.0	0.0^{ns} ± 0.0	0.0^{ns} + 0.0	0.0^{ns} ± 0.0
Nitrite(ppm)**	0.0^{A} + 0.0	0.0^{B} ± 0.0	0.0^{AB} ± 0.0	0.0^{B} ± 0.0	0.0^{B} ± 0.0
Phosphate(ppm)**	0.0^{A} + 0.0	0.0^{B} ± 0.0	0.0^{B} ± 0.0	0.0^{B} ± 0.0	0.0^{B} ± 0.0
Sulphate(ppm)**	9.1^{A} ± 2.3	14.1^{A} + 4.0	69.0^{B} ±17.4	21.9^{A} ± 4.1	13.3^{A} ± 2.7
Phytoplankton biomass(mg/m^3)***	940.5^{A} ±268.4	440.1^{B} ±80.6	196.8^{B} ±57.0	318.0^{B} ±54.7	271.4^{B} ±52.0
Zooplankton ($no/10^4ml$)***	$1,083.7^{A}$ ±302.1	$6,251.8^{B}$ ±1,244.0	$1,751.2^{A}$ ±504.3	$4,817.1^{B}$ ±1,128.5	987.7^{A} ±460.0

* Mean values with a common superscript were not significantly different at $P < 0.05$.

** Data collected during February 1982 to February 1983.

*** Data collected during April 1982 to February 1983.

Table 2. Composition of experimental diets in feed trial study, fed to *O.nitoticus*[*]

Composition	Dietary treatments								
%	2	3	4	5	6	7	8	9	10
Fish meal	14.6	34.1	58.0	18.5	36.1	59.1	22.3	39.8	62.8
Ceratophyllum demersum	40.0	30.0	20.0	-	-	-	-	-	-
Eichhornia crassipes	-	-	-	40.0	30.0	20.0	-	-	-
Eleocharis ochrostachy	-	-	-	-	-	-	40.0	30.0	20.0
Rice bran	40.2	31.1	17.0	34.3	26.8	13.9	29.3	22.9	11.5
Cassava starch	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-
Beef wax	4.2	3.8	4.0	6.2	5.2	5.1	7.5	6.4	5.7

* from Klinnavee *et al.* (in press)

Table 3. Proximate analyses (mean ± SE) of the experimental diets (% dry weight) in Table 2**

Dietary treatments	Moisture content %	Crude Protein %	Crude fat %	Ash %	Crude fibre %	N-free extract	Gross* energy
1	10.2	16.8 ± 0.3	3.2 ± 0.1	6.7 ± 0.0	4.1 ± 0.3	59.0	363.7
2	5.8	17.1 ± 0.1	13.9 ± 0.6	17.4 ± 0.1	8.2 ± 0.0	37.8	378.5
3	6.2	24.5 ± 0.1	11.8 ± 0.1	19.5 ± 0.2	6.5 ± 0.1	31.6	371.2
4	4.4	34.4	10.6 ± 0.1	23.5 ± 0.3	4.2 ± 0.0	22.9	379.7
5	7.7	17.1 ± 0.0	14.0 ± 0.4	14.5 ± 0.2	11.7 ± 0.0	35.1	365.3
6	6.7	24.4 ± 0.1	12.4 ± 0.0	17.8 ± 0.2	8.5 ± 0.2	30.2	371.0
7	7.3	34.6 ± 0.2	10.7 ± 0.1	23.1 ± 0.4	5.8 ± 0.7	18.5	363.2
8	5.8	17.0 ± 0.1	13.8 ± 0.1	13.5 ± 0.2	12.9 ± 0.8	37.0	370.6
9	8.3	24.4 ± 0.2	11.9 ± 0.6	16.4 ± 0.3	10.5 ± 0.0	28.4	359.4
10	6.7	34.8 ± 0.1	11.0 ± 0.7	23.7 ± 0.4	6.7 ± 0.3	16.7	363.4

* Kcal/100g.

** from Klinnavee *et al.* (in press)

Table 4 Growth, survival and food conversion rate of *S.niloticus* after 11 weeks of experimental diets feeding**

	Experimental diets (mean ± SE)*									
	1 (control)	2	3	4	5	6	7	8	9	10
Initial weight(g)	7.7^{a} ±1.6	7.2^{a} ±1.5	7.6^{a} ±1.7	7.5^{a} ±1.9	7.7^{a} ±1.5	7.9^{a} ±1.7	7.7^{a} ±1.6	7.5^{a} ±1.6	7.4^{a} ±1.7	7.1^{a} ±1.9
Final weight(g)	26.2^{bc} ±7.0	16.8^{a} ±4.7	25.4^{bc} ±8.0	27.9^{cd} ±7.6	16.2^{bc} ±3.7	24.5^{bc} ±7.5	29.2^{cd} ±8.8	16.4^{a} ±5.1	22.0^{b} ±7.0	31.7^{d} ±11.0
Mean weight gain(%)	238.4^{bcd} ±4.4	132.0^{a} ±1.8	232.7^{bcd} ±5.9	266.1^{cd} ±10.9	117.1^{a} ±2.2	212.7^{bc} ±36.4	281.9^{d} ±3.0	122.1^{a} ±16.7	198.6^{b} ±16.0	346.5^{c} ±43.4
Specific Growth rate(%/fish/day)	1.6^{bc} ±0.0	1.1^{a} ±0.0	1.6^{bc} ±0.0	1.7^{bc} ±0.0	1.0^{a} ±0.0	1.5^{b} ±0.2	1.7^{cd} ±0.0	1.0^{a} ±0.1	1.5^{b} ±0.1	1.9^{d} ±0.1
Mean food conversion rate	2.6^{bc} ±0.2	3.7^{a} ±0.1	2.5^{bc} ±0.2	2.0^{cd} ±0.4	4.3^{a} ±0.3	2.7^{b} ±0.3	2.1^{cd} ±0.3	3.9^{a} ±0.2	2.7^{b} ±0.2	1.9^{d} ±0.2
Survival (%)	97.8^{a}	100^{a}	100^{a}	95.6^{a}	98.9^{a}	97.8^{a}	98.9^{a}	100^{a}	98.9^{a}	100^{a}

* Values with the same superscripts a,b,c,d are not significantly different ($P<0.01$)

** from Klinnavee *et al.* (in press).

Table 5. Growth performance of tilapia and pig (mean ± SE) during 30 May to 22 November 1987.*

Item	Tilapia	Integration Tilapia	Integration Pig
Initial number (No/compartment)	640	640	3
Final catch (No/compartment)	1155 ± 185	2360 ± 450	3 ± 0
% by number of final catch			
5 - 10 cm class	11.1 ± 1.2	11.9 ± 1.8	
10 - 15 cm class	42.9 ± 1.3	72.1 ± 1.6	
> 15 cm class	46.0 ± 1.2	16.1 ± 2.5	
Average Initial weight**	4.3 ± 0.2[a]	5.6 ± 0.1[b]	5.9 ± 0.2
Average Final weight**	62.4 ± 1.7[c]	37.1 ± 0.7[d]	69.4 ± 0.4
Average % weight gained**	1329.8 ± 102.7[e]	563.8 ± 26.9[f]	1074.7 ± 34.3
Total Production (kg/unit)**	71.5 ± 9.8[n]	88.0 ± 17.8[n]	208.3 ± 0.3
Food Conversion Rate	4.1 ± 0.7	25.7 ± 4.3	7.4 ± 0.3

** unit of initial of final weight g/individual for tilapia and kg/individual for pig; for values along each horizontal line those with a common superscript was not significantly different at $P<0.05$.

* from Chiayvareesajja *et al.* (1989).

Fish culture extension programme

Before the Phase I Project began, there were no aquaculture fish pond in Thale Noi area. During 1982-1984 (our Phase I Project period), 9 fish farms composed of 21 fish ponds with the average area of 300 m^2/pond were established Most of fish species were omnivorous and herbivorous. It is believed that if there is any extension program for fish culture in the area, the fish culture using aquatic weeds as fish feed would be accepted.

In this subproject 5 groups of fish farmers (4 in Thale Noi and 1 in Lumpum village, the nearby village) will be established. A group is composed of 10 farmers who will take care of 5 fish cages (25 m^2 each). 2500 *S. niloticus* with the size of 10-15 cm. will be raised in each cage, the culture will probably be 3 times a year. The fish will be fed with 20% protein content aquatic weed mixture. Also feeding fish with fresh aquatic weed will be tried.

In a year each selected farmers from the villages were planned to be subsidized in the fish culture programme as follows :

Cost	Subsidized from the project	Self investment
First raising		
Materials for fish cages[‡]	100%	0%
Labour for cages construction	0%	100%
Fry (2500/cage)	100%	0%
Fish feed mixture	50%	50%
Labour for fish culture	0%	100%
Second raising		
Fish cages	-	-

Fish fry	0%	100%
Fish feed mixture	20%	80%
Labour	0%	100%
Third raising		
Fish cages	-	-
Fish fry	0%	100%
Fish feed mixture	0%	100%
Labour	0%	100%

There were 3 problems appeared during the studies a) fish seed (10-15 cm long) was more expensive than in the project proposal, the actual price is 1 baht/fish instead of 0.1 Baht/fish as was mentioned in the first year report, b) a fear that the reared fish in the project can not be sold to Thale Noi fish market at a satisfactory price. c) The poverty of our selected farmers in the project as was also mentioned in the first year report.

The problem on fish marketing was partially solved, by our survey it was found that Thale Noi market absorbed 500 kg of natural fish catch a day; so it seems that the market may absorb the cultured fish of the same quantity. Our farmers who sold their cultured fish last year had no difficulty in selling their fish. They are good trader too.

To solve this problem then :

1. Two more groups of farmers were persuaded to produce tilapia fish seed in the pig-fish integrated system in their own ponds with some revolving fund from the project (without interest) and they will pay back by their fish fingerling to the project. This scheme started since May 1988. This may solve our problem of fish fry transportation from Bangkok.

It was also found that our 2 ponds fry production system worked well but it did not produce enough fish fingerling for our cage culture training.

2. Fish price problem in b. was also solved by the natural Thale Noi fish market. Last year our trained farmers sold their fish of 80-100 g size at 17-25 Baht/kg which was two times higher than the Bangkok price. At the moment this problem is solved.

3. To solve the farmer poverty, we decided to decrease the farmers fish raising from 3 raisings to 2 raisings per farmer at six months each, as follows. This aslo will increase the fish size and fish prices

Cost	Subsidized from the project	Self investment
First raising (6 months)		
Materials for fish cages (3,200 Baht/cage, 2 cages/farmer)	100%	0%
Labour for cages construction	0%	100%
Fish fry (5,000/cage)	100%	0%
Fish feed mixture	50%	50%
Labour for fish culture	0%	100%
Second raising (6 months)		
Fish cage	-	-
Fish fry	100%	0%
Fish feed mixture	0%	100%

Labour	0%	100%
Third raising[‡]		
Fish cages	-	-
Fish fry	0%	100%
Fish feed mixture	0%	100%
Labour	0%	100%

‡ Changed, with draw

According to Dr.Seva de Silva suggestions, we decrease the number of cage per farmer from 4 to 2; and increase SD from 2,500 to 5,000 fish/cage.

Schedule for year I and year II farmers to implement their first fish raising was shown in Table 1.

This subproject was set back by the heavy storm and flood since 1988 raining season as was mentioned in our REF 88/2 quartery report. The monsoon last until March 1988, after that the repairing works began.

4. The first year, third group of farmers (3), repaired their cages and released the new fingerling (Table 1).

5. The first year, second group of farmers (4), just harvested their first crop before the storm in Dec. 1988. The averaged product per farmer was 8,248 Baht in 4 months, which was about 20% lower than we expected. Their income per crop was 4 times higher than the first group of farmers (1,349-2,254 Baht/farmer); see details in first year report. Cost return benefit of this crop will be analysed.

6. 6 farmers (3 for year I group III and 3 for year II group I) started their first raise in Feb. 1988 (Table 1). Each farmers were expected to raise

their fish 2 cages, 5x5 m per farmer (SD 5,000 fish/cage), 6 months per crop and 2 crops per farmer per year.

7. The year II group 2 farmers (4, at Thale Noi) completed their cage contstruction since June 1988 but waiting fish fingerling from the project fry production systems, so did the year II group 3 farmers (3, at Lam-pam), see Table 1.

8. We would like to try new material (plastic net) for cage construction in stead of bamboo and hard wood, which increasing their price many times during the last two years; according to hard wood shortage in Thailand.

9. Dr.K.L. Wee also suggested us to decrease the number of fish raising per farmer from 2 to 1 (1 per farmer per 6 months); and also we can increase the trained farmers in a planned period.

10. Prof.T. Watanabe and Dr.K.L. Wee also agreed to suggest us to establish and aquatic weed pellet centre in Thale Noi village, so the other fish farmers can buy the pellet from the centre instead of bying the commercial fish feed from Phattalung. Also the farmers who has no time collecting weed himself can buy his pellet from the centre. At last Thale Noi farmers have their aquatic weed pellets centre in their village. If the product good enough, they may supply to other farmers in the region.

Even the result of this study showed a rather negative result on technology transfer to the Thale Noi villagers, dued to various reasons mentioned in the project evaluation section mainly on economic reason. But it was a confidence that this project will provide a cheap protein to the rural communities in Thailand; and it will show an economic feasible in the north or north-eastern part of Thailand where tilapia price was much higher than Thale Noi market. And it was also found that some farmers of our last attempt accepted our

integrated aquaculture system as shown in the evaluation section. It is hope that fish culture will be a new source of income for Thale Noi villagers in a near feature.

Table 1 Schedule for 10 farmers to implement their first fish raising.

Farmers	No. of Preparation	Cage raising	Start fish experiment	Complete the experiment
Year I (all at Thale Noi)				
group 1	3	Dec.-Feb.1986	Mar. 1987	Jul. 1987
group 2	4	Mar.-May 1986	Jul. 1987	Nov. 1987
group 3	3	May -Aug.1986	Nov. 1987[a]	-
			Feb. 1988[b]	Aug. 1988
Year II[b]				
group 1	3	Nov.-Dec.1988	Feb. 1988	Aug. 1988
group 2	4	March-Jun.1988	Aug. 1988	Jan. 1989
group 3 - (at Lam pam)	3	March-Jun.1988	Aug. 1988	Jan. 1989

[a]broken by storm (Dec. 1987)
[b]6 months per crop raising

Table 4. Tilapia 5x5 m cage culture in Thale Noi by 6 farmers (3 for yr. I gr. III and 3 for yr. II gr. I) during Feb.-June 1988.

No.	Initial wt.(kg) 5-02-88	Total wt.(kg) 24-06-88	Wt. gain (kg)	% Wt. gain
1	89.17	320.0	230.83	258.87
2	97.50	222.5	125.00	128.21
3	42.50	246.0	203.50	478.82
4	33.33	203.5	169.67	509.06
5	26.60	210.0	183.40	689.47
6	39.17	233.0	193.83	494.84
7	40.83	274.0	233.17	571.08
8	100.00	300.0	200.00	200.00
9	70.83			
10	108.33	220.0	111.67	103.08
11	90.83	175.0	84.17	92.67
12	98.33	160.0	61.67	62.72
X	69.79	233.05	163.36	326.26
±SE	±8.93	±14.87	±17.71	±68.12

Table 2. Tilapia cage culture (5x5 m cage) in Thale Noi by 4 farmers fed with aquatic weed pellets during July 1987 - Nov. 1987. (year I, group II, 4 farmers)

Cage No	No	(20-7-87) Initial Wt.(kg)	(26-11-87) Final No	Wt.(kg)	Survival (%)	Wt.again (kg)	% Wt. gain
1	2500	66.80	1600	90	64.0	23.20	34.73
2	2500	42.57	2054	100	82.16	57.43	134.91
3	2500	48.12	1785	110	71.40	61.88	128.60
4	2500	49.82	1332	102.5	53.28	52.68	105.74
5	2500	45.35	1984	84	79.36	38.65	85.23
6	2500	22.90	1122	43	44.88	20.10	87.77
7	2500	32.10	2022	77	80.88	44.90	139.88
8	2500	52.15	2142	109	85.68	56.85	109.55
9	2500	37.70	1913	79	76.52	41.30	109.55
10	2500	20.55	1298	72	51.92	51.45	250.30
11	2500	123.42	405	39.5	16.20	-83.92	-68.00
12	2500	89.85	2300	103	92.00	13.00	14.51
13	2500	48.00	2231	127.5	89.24	79.50	165.63
14	2500	47.92	2431	128	97.24	80.08	167.11
15	2500	47.60	2355	97	94.20	49.40	103.78
16	2500	33.27	1620	72	64.80	38.73	110.44
X ± SE					71.49±5.40	39.08±9.44	105.33±17.71

Feed composed of 80% dry C. demersum and 20% fish meal
Feeding rate = 5% of body wt./day

Table 5. Tilapia 5x5 m cage culture in Thale Noi by 6 farmers with aquatic weed pellets during Feb.-June 1988.

	average of 6 farmers (X ± SE)
Initial wt. (kg)/cage 5-02-88	69.79 ± 8.93
Total wt. (kg)/cage 24-06-88	233.05 ± 14.87
Wt. gain (kg)/cage	163/36 ± 17.71
% wt. gain	326.26 ± 68.12

Table 3. Fish production of 4 fish farmers after 4 months of cage culture with aquatic weed pellets.

Farmers	Production		
	Cage No(kg)	Total(kg)	Baht (23 Baht/kg)
1. Heng	90 72 97 100	360	8.280
2. Chong	128 127.5 102.5 110	468	10,764
3. Krai	103 39.5 43 84	269.50	6,198.50
4. Dub	72 79 109 77	337	7,751
Total		1,434.50	32,993.50
X ± SE		358.63 ± 41.21	8,248.37 ± 947.75

Figure 1 Thale Noi village situated on a shore of shallow aquatic weed infested lake.

Figure 2 Aquatic weeds were used as fish feed; during the last few years, aquatic weed pellet was formulated for tilapia and cat fish aquaculture. Also polyculture of fish species was tried.

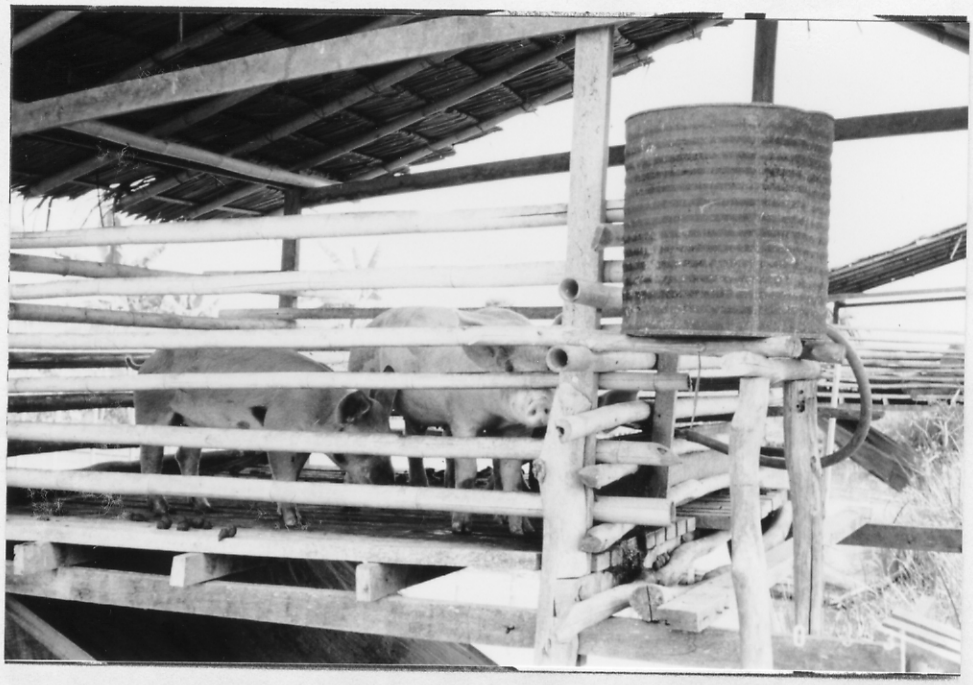

Figure 3 Aquatic weed pellet can also used for pig feed and integrated culture of animal and fish culture system was tested.

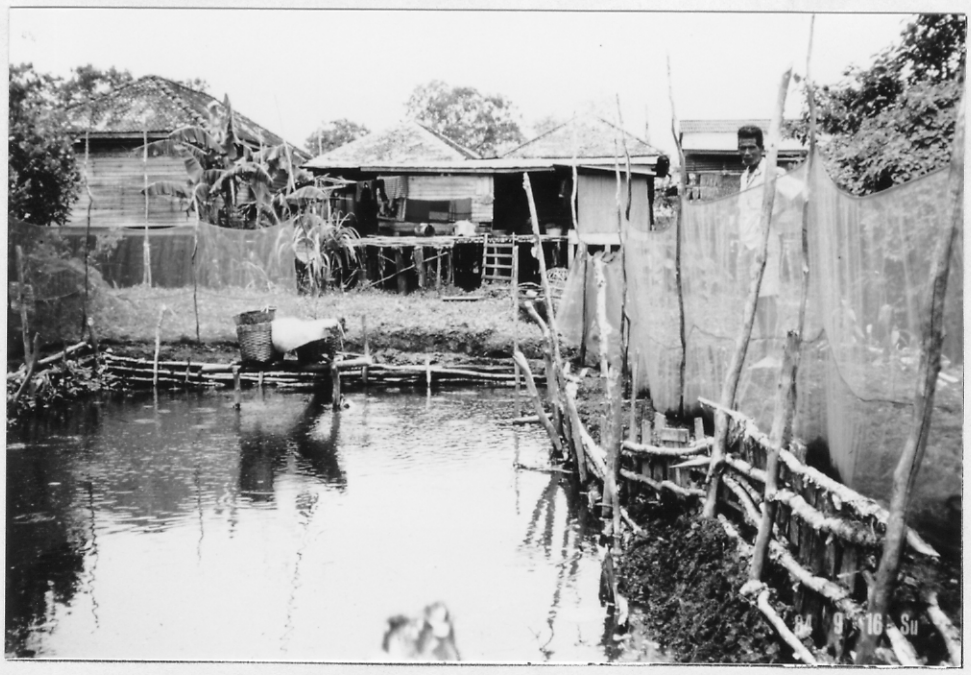

Figure 4 After the end of our phase I project (1984), 21 small fish ponds were established in Thale Noi area.

Figure 5 In 1991, more than 30 larger fish ponds (400-1000 m^2) were found in Thale Noi area. It is hoped that fish culture will be a new source of income for the villagers in the recent years to come.

Financial report

Report No.3

Project title : Aquatic Weeds (Thailand)
Centre File : 3-P-85-0266

Cash Summary

A. Cash Reciept from IDRC

Date Received	Amount (Canadian Dollars)		Amount (Thai Baht)
22 Sept. 86	$44,000	CAD	Bht821,753.88
3 Mar. 87	27,000		520,946.92
14 Sept. 87	34,000		655,569.74
16 Feb. 88	35,300		699,290.81
2 Sept. 88	54,000		1,103,872.59
23 May 89	9,000		193,870.59
1 Sept. 89	12,000		262,543.08
18 Dec. 89	10,000		219,146.67
2 Feb. 90	28,000		597,219.05
Total Cash Receipt	$253,300	CAD	5,074,213.72

B. Add : Cash Reciept from Other Sources
Interest (Year 1 - Year VI) 75,310.41
Product sale 58,491.00

C. Total Cash From All Sources 133,801.41

D. Less : Projcet Cash Expenses
Period Covered :
From 1 September, 1986 to 31 July, 1991 5,222,783.16

E. Cash Balance as at 31 July, 1991 (C-D) -14,768.03

F. Less Accrued Expensed and Estimated Expenses for next year 0

G. Estimated Cash Balance as at 31 July, 1991 -14,768.03*

* to be refunded from the next (last) payment

Report No.1

Project title : Aquatic Weeds (Thailand)
Centre File : 3-P-85-0266

FINANCIAL REPORT
For the Period from 1 September, 1986 to 31 July, 1991

Accounts Code	Item	Budget	Actual Expenses: Cash Expenses	Actual Expenses: Accrued Expenses	Variance	Explanation of Variance (see next page)
	Salaries and Allowances					
	Honoraria	238,300	217,300.00		8.81	
	Research Assistant	169,000	141,000.00		16.56	a
	Technicians	220,970	233,500.00		-5.67	
		628,270	591,800.00		5.80	
	Research Expenses					
	Casual Labour	433,657	475,177.50		-9.57	b
	Small Equipment	372,033	376,232.68		-0.58	
	Field Materials	713,821	873,563.65		-22.37	b
	Office Supplies	9,464	9,464.22		-.002	
	Labaratory Classware and Chemicals	56,480	51,476.40		8.85	
		1,587,455	1,785,914.45		-12.50	
	Travel					
	Local Travel	510,303	523,278.60		-2.54	
	Travel to Conference	51,828	66,033.02		-27.40	c
		562,131	589,311.62		-4.83	
	Extension Programme	930,235	939,256.00		-0.96	
	Publication and Workshops					
	Report	8,628	3,628.00		57.95	
	Journals	69,707	89,847.76		-28.89	d
		78,335	93,475.76		-19.32	
	Consultancies	7,601	7,601.00		-	
	Reports	29,682	-		100.00	e
	Equipment Maintenances	98,480	85,607.00		13.07	
	Training					
	M.Sc.	103,500	100,500.00		2.89	
	Ph.D.	459,517	461,456.33		-0.42	
	Equipment					
	Field Equipment	12,507	12,507.00		-	
	Laboratory Equipment	575,700	495,700.00		13.89	e
	Economic Analysis	80,000	59,654.00		25.43	e
		*5,153,413	5,222,783.16		1.34	

* not including intenst income and other sources

Funded by the Prince of Songkhla University

	1987	1988	1989	Total
Local travel	9,904	9,950	4,179	24,033
Conference	-	11,965	3,378	15,343
Total	9,904	21,915	7,557	39,376

Submitted by R. Tamaoka
Project Leader

Rattana Sitl
Institution's Finance Officer

a Variance in the expenses of Research assistant was used in Technicians expenses

b Variance was dued to rearrangement of experimental design

c Conference budget was controlled by IDRC regional office

d Variance dued to increasing of journal subscription rate

e these budgets were used in research expenses

Project evaluation

A PROJECT EVALUATION ON THE UTILIZATION OF AQUATIC PLANTS IN SONGKLA LAKE, SOUTHERN THAILAND

By

Mrs.Sutonya Thongrak*

Mr.Jaruiy Petchrat*

Mr.Chalong Maneekul*

A REPORT SUBMITTED TO

The International Development Research Centre

PROJECT TITLE : The Utilization of Aquatic Plants in Songkla Lake, Southern Thailand.

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* Department of Agricultural Development, Faculty of Natural Resources, Prince of Songkla University. March, 1991.

ABSTRACT

Songkla Lake is the largest lake in Thailand. The significance of the lake for economic, social, and ecological and environmental purpose is well accepted. So far, the utilization of the lake has been lack of appropriate plan and management. This is obvious seen in term of the marked decline of fishery resources. The people live surrounding the lake are directly affected by such a change. They are most ranged in the poor income group.

The "Utilization of Aquatic Plants in Songkla Lake" has been undertaken in 1981 which the ultimate goal is to improve the economic condition of the people in the communities surrounding the lake through the development of an environmentally and economically sound system of raising fishes feed on aquatic weeds. Thale Noi where aquatic plants bloom all year round has been selected for the project site. In this project several experiments have been undertaken, including fish culture extension program.

This evaluation was undertaken with the aim to examine the effect of the project to the communities and to indicate the socio-economic conditions of the people in this community.

It is found that people in this community depend their lives on 4 main activities, excluding off-farm work. These are fishing, rice production, aquaculture and mat making. The income obtained among household varies according to number and types of activities undertaken, from 14,480 baht to 62,900 baht per household per years. Those employ more activities are likely to obtain more income. Ninety [illegible] per cent of household is being ind[illegible]

People at Thale Noi community realize about the marked decline of fishery resources. These have to be replaced by the products from aquaculture. The attitudes towards "The Utilization of Aquatic Plants Project" is positively expressed in term of the promotion of public awareness about aquaculture.

Carnivorous fishes rearing is likely to be more accepted than herbivorous. Market for the product is the most significant factor. However, herbivorous is suitable for small farmers with rearing fish for household consumption.

To further promote and strengthen aquaculture production at Thale Noi community, the following actions could be considered.

1. Knowledge on aquaculture should be provided regularly;
2. Sufficient seeds should be provided by Government Fishery Station;
3. Promote integrated fish culture system;
4. More research on carnivorous;
5. Credit should be available with low interest rate; and
6. Centre of Aquaculture Production should be established.

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Chapter I

Introduction

1.1 Background of the Project

Songkla Lake is the largest lake in Thailand. It covers an area of 616,750 Rai (PSU, 1981). The area is extended to three southern provinces including Songkhla, Patthalung, and Nakorn Si Thammaraj. The Lake can be divided into 3 parts according to the salinity of water: (1) the uppermost part covering 70 percent of the lake surface is fresh water area; (2) the lowest part of the lake is seawater area covering about 25 percent of the lake surface, and (3) the middle area where freshwater and seawater meet, covers about 5 percent of the lake surface. The lake provides various benefits to people. It is estimated that more than 7,500 households depend their lives on the resources from the lake, particularly fishery resources and more than 100,000 households obtain its benefit indirectly (PSU, 1981). Apart from economic importance, the significance of the lake for ecological and environmental purposes is widely recognized.

So far, the utilization of the lake has been lack of appropriate plan and management. This can be seen in term of the marked decline of fishery resources caused by over fishing, using illegal fishing gears, and destruction of mangrove forests for other purposes.

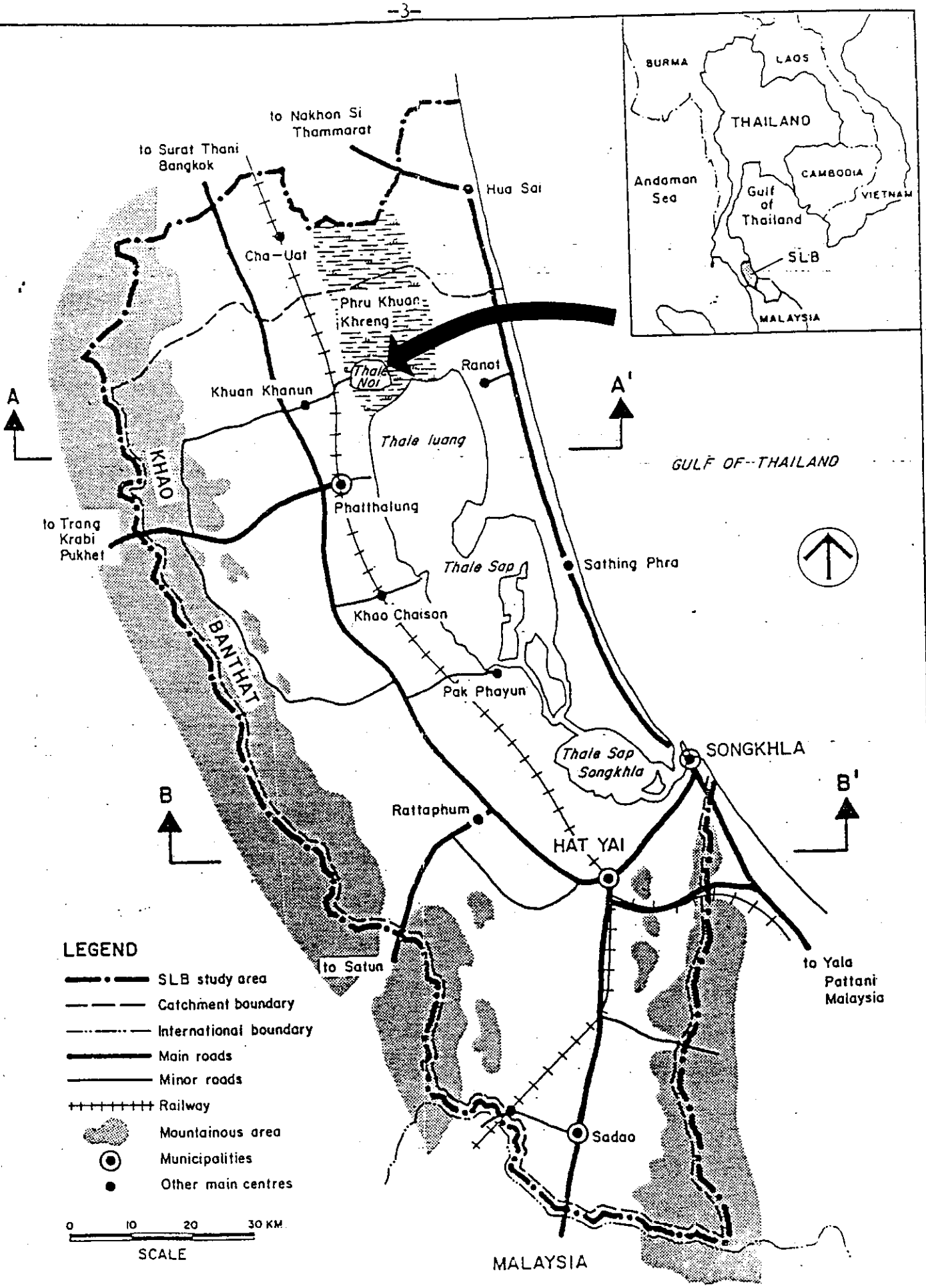
In the Gulf of Thailand marine fishery resources have also been seriously depleted due to extreme over exploited exceeding the

maximum sustainable yield and the proclamation of exclusive economic zones (EEZ) by neighboring countries preventing Thai fish vessels from utilizing some of their traditional fishing water (Thailand Development Research Institute, 1988).

As a result, it is important to increased fish production from other sources. Aquaculture is widely accepted as one of the possible options and has been given priority.

For these reasons, "the Utilization of Aquatic Plants in Songkla Lake Project" has been undertaken with mainly aimed to utilize aquatic plants for fish feed to promote aquaculture production among the people in the communities surrounding the lake, and thus, increased their income and quality of life. It is also hoped that the results from the study can also be used for other water resources, having a lot of aquatic plants like Thale Noi (Songkla Lake).

In this project, Thale Noi has been selected for the project site (Fig.1). It is a fresh water lagoon of approximately 25 sq.km. the uppermost part of Songkla Lake where aquatic plants bloom all year round. Of course, if they are going to be utilized for fish feed, they can be converted to a lot of fish production annually. Therefore, the target groups, living around Thale Noi and earn mainly on rice growing, fishing and mat making like those poor people in the rural areas in Thailand, can obtain such benefit. More details will be discussed in subsequent section.



SONGKHLA LAKE AND SURROUNDING AREA.

FIG. 1

1.2 Objectives

The project has its ultimate goal in improving the economic condition of the people in the communities surrounding the lake through the development of an environmentally and economically sound system of raising fishes feed on aquatic weeds.

1.3 Site Description

The utilization of Aquatic Plant in Songkla Lake Project is located in two sub-districts-Tambon Pahnangtung and Tambon Thale Noi, Amphoe Kuankanun, Patthalung province, 120 km. north of Hat Yai, It's about 13 km. east of Amphoe Kuankanun (Fig.1,2) and around 30 km. from Patthalung province.

The population in these sub-districts is about 14,322 with the total households about 2,616 (Table 1). Most of their houses are located very close to Thale Noi and one is very close to others like an urban slum. Ninety eight percent of the households depend their lives on agriculture.

The total landholding with also including public land and Thale Noi is about 157,331 rai. The percentage of land which is utilized for agriculture is approximately 18.6 percent of total land. Eighty three percent of these land is for rice; 9.36 percent for rubber; and the rest is for bulrush, fruit crops, upland crops, and vegetables (Table 1).

In both sub-districts, most agricultural households own land which are classified into 3 groups; less than 10 rai, 10-20 rai,

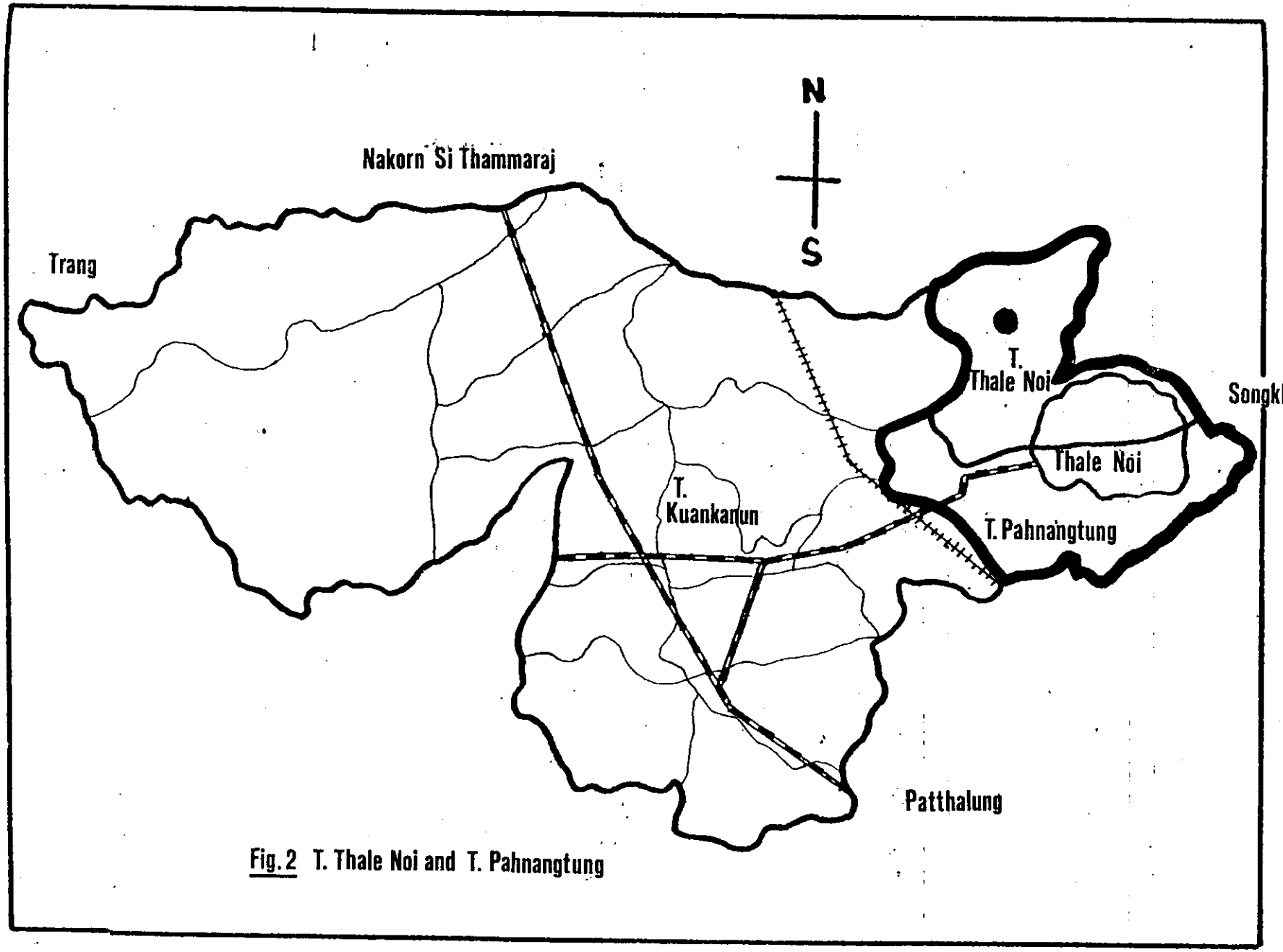


Fig. 2 T. Thale Noi and T. Pahnangtung

and more than 20 rai. Sixty three percent owns 10-20 rai, while 29 percent owns less than 10 rai, and only 7.6 percent has more than 20 rai (Table 1). From those have less than 10 rai, roughly 18 percent is landless household.

Table 1: Demographic and Farm Characteristics .

Parameters	T.Pahnangtung	T.Thale Noi	Total
Total population	8,266	6,056	14,322
Total no. of Household	1,604(100)	1,012(100)	2,616(100)
Agr.Households	1,576(98.3)	981(96.9)	2,557(97.8)
Total Land area (rai)	38,154	119,177	157,331
Agr.area	22,130	8,203	30,333(18.6)
Rice	18,694	6,478	25,172(83)
Rubber	2,642	200	2,842(9.4)
Bulrush	-	1,500	-
Fruit Crops	254	-	-
Upland crops and vegetables	540	24	564
Other land uses, including Thale Noi and other public land	16,024	112,034	128,058(81.4)

Table 1 (continue)

Parameters	T.Pahnangtung	T.Thale Noi	Total
Agricultural landholding (rai) per households			
<10	378	365	743(29)
10-20	1,013	607	1,620(63.4)
>20	185	9	194(7.6)
Occupation			
- Rice	Most*	Most*	
- mat making	*	951(94)	
- Fishing	242	703	945(36.12)
- Aquaculture	45	*	
- livestock			
beef cattle	396	149	545(20.8)
buffalo	20	53	73
pig	84	12	96
poultry	723	111	834(31.9)

Kuankanun Agricultural Office, 1990.

* no figure available.

Most of the people in both sub-districts grow rice mainly for household consumption, mat making for cash income. In Tambon Thale Noi alone there are 951 households (94%) depend partially and mainly on mat making and its product as a source of income.

Fishing has been very important for the livelihood of the people in these areas for several decades. But, since the last decade those depending on fishery have largely been affected by the marked decline of fishing resources as mentioned early. The amount of fish catch per unit of fishing effort is much lower than before, while associated costs, such as price of fuel and fishing gears increased significantly. However, number of people fishing do not decrease due to population pressure even in percentage it might decline. According to Kuankanun Agricultural Office, 1990, 36 percent of households (Table 1) in these sub-districts still earns mainly or partially on fishing as a source of protein. If they get extra fishes, they will sell for cash. Most of the fishing households are mainly from those their houses located close to Thale Noi.

Livestock production, for example, poultry, beef cattle, swine and buffalo raising are widely practiced as a source of animal protein and supplementary income (Table 1).

Apart from those activities, aquaculture has just been introduced during the last decade by a small number of farmers and then many followed. A report of Kuankanun Agricultural Office, 1990 showed that there are 45 households in T. Pahnangtung, while no figure is available in T.Thale Noi, are involved in aquaculture.

The members of some households also go out temporary to work both non-farm and off-farm activities in the province or other provinces for cash income.

According to the socio-economic survey of this community in 1982 by the Department of Aquatic Science, the average income per capita was 2,425 baht per annum which was of 6.74 baht per day. In 1990, a report of Kuankanun Agricultural Office indicated that people in both sub-districts obtained income approximately 37,500 baht per households per year which was about 6,855 baht per person/year.

It can be seen that, the income of the people in this community is very low and urgently need to be improved.

1.4. Project Characteristics

The Utilization of Aquatic Plants in Thale Noi (Songkla Lake) Project has been undertaken by the staffs from Prince of Songkla University under the plan for the conservation and utilization of Songkla Lake. This project has been undertaken since 1981 which research funds have been provided by International Development Research Centre, IDRC Canada. The ultimate goals of the project is improve the economic condition of the people surrounding the lake trough the development of an environmentally and economically sound system of raising fishes feed on aquatic weeds. The project has been divided into two phases. Phase one Project is 3 years duration from 1981-1984. In this phase, 3 main preliminary studies and demonstrated pilot projects were undertaken. There were ecological survey of Thale Noi, study the effects of various fresh-water on ecosystem of Thale Noi, and pilot project on herbivorous

fishes culture. After 3 years, it was found that using aquatic weeds as fish feed is possible as already documented in Tansakul, 1984. Although the potential to utilize aquatic weeds as fish feed arose, there were two problems concerned. First was the selection of suitable and cheap aquatic weed mixture to increase growth rate of fishes. It is quite important because feed mixture has to be utilized economically which means that fish grows rapidly and lowering costs. Another problem was the selection of suitable fishes culture systems.

From the results and problems mentioned above it is quite clear that if no further studies, the ultimate goals will not be reached. As a result, Phase II Project has been started in 1986 with 4 years duration. Phase II project has focussed on 3 main areas. First, is to study the nutritional value of aquatic weed mixtures (pellets) on growth rate of chosen herbivorous and omnivorous fishes, cultured in small enclosure in Thale Noi, and in laboratory. Second, the comparative study the culture systems of some chosen fishes both in pond and in cage has been undertaken. Finally, the extension techniques to fish culture in Thale Noi have been tested.

From the first study, the project come up with feed mixture which is composed of dry aquatic weed (Ceratophyllus dermersum), rice bran and fish meal in a ratio of 4:3:1 respectively. This mixture has been used in Banana prawn (Peaneus merguiensis) and Nile tilapia (Oreochromis niloticus). The result indicated that there is a good potential to raise these species (Details were in Chiayvareesajja and Tansakul, 1988).

The second study is about fish culture system, such as integration of pig-tilapia using weed mixture pellet as pig feed (More details were in Chiayvareesajja et al., 1988). The integrated system of tilapia aquaculture with chicken was also undertaken (more details are in progress report year 2 phase II).

Third, fish culture extension program has been undertaken by selecting farmers to participate in fish culture (Details see proposal phase II).

After fish culture extension program has been implemented, there were several problems involved including (1) fish side (10-15 cm long) was more expensive than in the project proposal (2) a fear that the reared fish cannot be sold to Thale Noi market at a satisfactory price (3) The poverty of selected farmers. Some of these problems were partially solved. (Progress Report Year II Phase II). But, the most serious problem happened when this program was set back by the heavy storm and flood. However, after flood and storm the culture extension progress has been brought into implementation again.

Apart from those, such studies as tilapia cage culture with aquatic weed mixture pellet, a study on the economics of tilapia pen culture using various feeds, and the effects of acidic water on survival and growth rate of Nile tilapia (Sarotherodon niloticus) have also been undertaken (More Details were in Chiayareesajja et al., 1987, Tantikitti and Tansakul, 1987 and Wangead et al., 1987).

Furthermore, aquatic weed mixture is also used in (1) catfish culture, (2) polyculture of nile with catfish, and nile with

snakehead, (3) integrated culture of pig with nile, pig with nile and catfish, and pig with nile and snakehead, and (4) harvesting system studies. The result is not yet documented.

It can be seen that several experiments have been undertaken in this research project in order to develop the appropriate technology that can be used by the people in the community to improved their livelihood. Since the project has been started in 1981 (Phase I) until this ongoing evaluation was taken place in July 1990, problems and shortfalls in each step of implementation were taken into account or solved before further implementation has been made.

In practical, it is very difficult to indicate whether the project is achieved or not. However, the achievement or failure might be seen if, at least, the project goals are going to be assessed. This means that aquatic weeds in Thale Noi can be utilized efficiently for fish feed and economically sound system of raising fishes. Technologies developed by the project can also be used by the target groups under their socio-economic conditions so that improved their livelihood and thus, raised their quality of life.

Therefore, this paper presents the results of the evaluation on "Utilization of aquatic weeds in Thale Noi (Songkla Lake) Project". The objective of this evaluation is mainly aimed to determine the effects of the project to the community and examine the socio-economic conditions that will help find the means for improving their community regarding aquaculture production.

Chapter II

Details about evaluation

2.1 Objectives

The evaluation attempts to examine the effect of the project to the communities so far, particularly in term of attitudes toward the project, aquaculture production and to indicate the socio-economic conditions in order to understand the livelihood of the people in the community so that appropriate means for improving their livelihood can be determined.

The results of the evaluation will also be used as a basis for further study and improving current practices regarding aquaculture production.

2.2 Methodology

To examine the effects of the project to the community and understanding the socio-economic conditions of the people at Thale Noi community, both qualitative and quantitative approaches were used.

Data were collected by using questionnaire interview. A purposive survey of 77 sample households in Moo 1,2 of both sub-districts, located very close to Thale Noi, was conducted in September, 1990. The selection of households was based on occupation differential and project participation. Fifteen of those participated in fish culture extension program were finall

interview (7 from those engaged in cage culture and 7 from those in pond culture and 1 from those engaged in both of them). Apart from those, thirty one households were selected from aquaculture production farmers. The remainders were selected from rice farmers, fishermen, and mat-making households.

The results of an analysis will be both descriptive and quantitative. Quantitative analysis is used to indicate cost, and return from different income's activities, namely rice production, fishing, mat-making, and aquaculture. Thus, income from these activities can be examined and compared, particularly those with and without aquaculture production. The attitudes toward the project as a whole, aquaculture production at Thale Noi community and social condition will be descriptively explained.

2.3 Household characteristics

Fifty nine respondents are head of households, while sixteen is wife, and eleven is daughter or son. The average head of households is ranging from 35 to 55 years old. Their level of education is quite low, 82 percent of the respondents have primary level of education. A typical household has 6 members, three of them regularly worked on the farm include fishing and 1-2 of whom is engaged in off-farm work. The later is from 45% of total household.

2.4 Land use and land tenure

The dominant cropping pattern in this community is a single crop of HYV rice which is 83 percent of agricultural area. (Table 1). After the harvest, land is left fallow for cattle to graze on. A few farmers grow local varieties of mungbean whenever residual moisture remains after rice. As for landholding, 71 percent of household has less than or equal to 15 rai, while the remainder has more than 20 rai (Table 2.1). Nearly all crop land is on their own, but 25 percent of whom has to rent public land for housing.

Table 2.1 Average landholding in T.Thale Noi and T.Pahnangtung.

Average landholding	No.of respondents	Percent
0-5	26	33.8
5-10	12	15.6
10-15	17	22
15-20	0	0
20-25	10	13
25>	12	15.6
Total	77	100

2.5 Debt and Saving

Sixty nine percent of household has no savings and 92 percent of this is being indebts. They mainly borrow money from Bank for Agriculture and Agricultural cooperatives for their investment in crop production, fishing, aquaculture to some extent, mat making, and some for household consumption and education for children. Eighty percent of those are indebts between 6,000 and 15,000 baht, while the remainders are between 20,000-50,000 baht. It is quite clear from this evidence that credit is required in the promotion of aquaculture at this community.

2.6 Sources of Income

The sources of income of the people in this community are; fishing, mat making, crop production especially rice, aquaculture, and other off-farm work. The results indicate that 55 percent obtains 1,000-3,000 baht monthly, 22 percent obtains 4,000-7,000 baht, and 23 percent receives more than 7,000 baht per household. For those engaged in off-farm work, most obtains income ranging from 2,000-5,000 baht monthly. Twenty six percent of the respondents obtains income from only one activity, namely fishing, aquaculture, rice, and mat-making. However, additional income may receive from off-farm work. The remainder (74%) obtains income from more than 2 resources. But, only nine percent of these receive income at least from four activities. Details on income from each activity and income's structure of the people in this community will be presented later.

Chapter III

Results from the findings

3.1 Attitudes towards Thale Noi

All think that a great change has occurred within Thale Noi itself. Such a change has been recognized in term of (1) the marked decline of fishery resources, (2) Thale Noi is very shallow, and (3) the aquatic weeds keep on increasing. The marked decline of fishery resources is due to population pressure and more advance fishing gears has widely been used. The more shallow of Thale noi resulted from erosion, flooding, and especially it is piled up by decomposed aquatic plants.

3.2 Knowledge on project

Sixty nine percent of the respondent, excluding those participated in fish culture extension program, knows there is a project undertaken at Thale Noi by the staffs from Prince of Songkla University. About 65 percent of these knows the right information about the project on experiment of fish culture by using aquatic weed to make fish feed. The remainders (31%) including both do not have any idea about the project, and know there is "Thale Noi Project", but do not know what the project concerns.

3.3 Attitudes towards the project

For those know about the project , most think that the project is useful for Thale Noi Community, particularly about income

generation for people working in the project and promotion of public awareness on fish culture. In addition, the project is a very good example to make use of aquatic plants. This will help get rid of them.

The project is also a useful source of knowledge for those are interested in aquaculture, mainly about basic aquaculture management.

Concerning about the promotion of public awareness, it is supported by the evidence from the survey that when fish culture extension program within the pond was being implemented there were average of 13 farmers visited each pond to get information on fish culture, such as on seed, feed and feeding, income and some like to buy young nile tilapia. The results also show that there were roughly 9 farmers have started raising fish after visiting these farmer, both in the village and outside.

However, some argue that the project is not really useful because the project only promotes or supports herbivorous fish production, while most people are likely to prefer omnivorous fishes.

3.4 Attitudes towards aquaculture production at Thale Noi Community

They all agree that aquaculture is suitable for Thale Noi Community for many reasons. The most important reason is because the marked decrease of fish catch from Thale Noi and Thale Luang. This has to be substituted by the products from aquaculture. A lot of trash fish caught can also be used is a composition of fish

rations for omnivorous fishes. Thus, cost can be minimized. Regarding to physical and biological factors, soil and water, are quite suitable for aquaculture. They also believe that not only local, but also provincial market will absorb the supply from aquaculture.

As for attitudes toward future fish raising, 61 percent of those never culture fish thought that they will culture fish. Seventy three percent of these will culture carnivorous fishes because they experienced from the neighbors that it generates good income. Moreover, the market for carnivorous fish is also good. The remainder (27%) will culture herbivorous fishes. This is due to less cost of investment and they are easy to be managed.
In contrast, 39 percent of those never culture fish will not be interested in fish culture. The reasons behind this varies among the respondents mostly because they have no land and capital. Some do not like aquaculture because of personal reason.

3.5 Attitudes towards fish rations developed by the project

Concerning about the attitudes of those participated in fish culture extension program toward fish rations, 4:3:1 which provided by the project, most think that it is suitable for herbivorous fishes, namely nile tilapia. This is because the cost is quite low, approximately 4.42 baht a kg. Therefore, it seems to be appropriate for those have limited capital for investment. Moreover, the aquatic plants is available for the whole year and they access to them. Additional advantage raised by this group is

that the utilization of aquatic weeds as fish feed promote weed control in Thale Noi. However, some farmers pointed out that fish rations developed by the project has some weak points, namely it cannot be preserved so that the farmers have to prepare rations every day or every two days. The rations is quite heavy so that it sink into the water very fast which is not suitable for herbivorous those eat at surface.

As for those raise herbivorous fishes, 50 percent know about the rations developed by the project and they think that it is useful in reducing cost in raising herbivorous fishes and it benefits indirectly to the community in utilizing local resources. In contrast, 50 percent not even know about this rations.

For the preparation of fish rations some of those participated in fish culture extension program point out that it is quite complicate, and investment cost is quite high, especially for feed grinder and boat. To collect aquatic weeds everyday or every two days also seems to be unacceptable.

If the project establish Feed Centre where feed grinder is provided and management is done by the members participated, most of them willing to be a member mainly to use feed grinder. They also willing to pay for electricity and maintenance. But, this should not be more than 5 baht for each use. On the other hand, some will be reluctant to join because they fear about management problem that may happen.

3.6 Fishing

Most of the fishermen have experienced in fishing more than 10 years. Some fishermen like fishing in a group of 2 to 4, while the others prefer to fishing alone (Table 3.1). The evidence is not clear whether the total number of fishermen decrease or increase. The average value of fishing gears including boat, motor, net and so on, owned by each fishermen is approximately 23,076 baht. Each fisherman go fishing differently, some may go every other day while the others prefer twice a week. Most fisherman spends roughly 155 days a year on fishing.

Costs and returns from fishing also indicated in Table 3.1

The yields and income obtained from fishing varies enormously among the fishermen. However, it is quite clear that they are very close related to time spent for fishing.

The average income is approximately 43,170 baht yearly which around 4,245 baht monthly. It is related to 165.04 kg. of fish at its price equals to 25.72 baht per kg. It is important to note that an average fish catch monthly now is not much more than those daily catch during the last 10 years. The price of fish varies among the types of fish, from 17.3 to 32 baht a kg. (Table 3.1).

The significant cash cost is for fuel which is amounted to 6,250.26 baht per annum. The highest cost, but non-cash , is for labor which is amounted to 15,501 baht per year and 1,292 baht a month.

As for profit from fishing, it is approximately 1,593 baht per month. By adding this amount with labor cost, it will be equal to 2,885 baht. This is what they actually receive. The net cash

Table 3.1 Cost and Return From fishing at Thale Noi.

Activities / Items	FM	FM-RF	FM-AQ	FM-HC	FM-RF-AQ	FM-RF-HC	FM-AQ-HC	FM-RF-AQ-HC	Average
Property's Value for fishing (baht)	39,600	17,450	28,666.67	19,770	28,300	13,857.14	19,117	17,460	23,076.60
[illegible] fishermen fishing togerther	4	1	4	1	1	2	2	1	2
Time Spend for fishing Yearly (day/man-hr/men)	45	167.81	200.8	205.8	67.5	200	162.5	190.7	155.01
Cost/Year (baht)	(10,860)	(25,326)	(30,753.34)	(29,877)	(13,180)	(30,957.14)	(22,162)	(29,320)	(24,058.92)
- Fuel	2,400	6,800	7,806.67	7,320	3,600	9,571.43	4,000	8,504	6,250.26
- Labor	4,500	16,781	20,080	20,580	6,750	20,000	16,250	19,070	15,501
- Depreciation	3,960	1,740	2,866.67	1,977	2,830	1,385.71	1,912	1,746	2,307.66
Income/Year (baht)	(19,200)	(32,906)	(68,421.50)	(40,500)	(27,000)	(41,425.71)	(33,657.92)	(52,462.08)	(43,169.92)
Yield (kg/month)	80	100	350	226	90	192	98.3	184	165.04
- Price (baht/kg)	30	29.25	17.30	23.40	25.0	22.43	32.0	26.40	25.72
Income (baht/month)	2,400	2,925	6,055	5,288.40	2,250	4,306.56	3,145.60	4,857.60	4,244.82
Profit (baht/year)	8,460	7,580	37,668.16	10,623	13,820	10,468.57	11,495.92	23,142.08	19,111
Cash [illegible] (baht/year)	16,800	26,106	60,614.83	33,180	23,400	31,854.28		43,958.08	36,919.66

FM = Fishing HC = Mat Making

RF = Rice Production AQ = Aquaculture

income is equal to 36,920 baht per year. Therefore, it is interesting to note that since there is no work options available for the fishermen, they are still better off from using their labor for fishing. This may be the real reason why most fishermen are reluctant to give away from fishing.

3.7 Rice production

Rice has been practiced in this area from generation to generation, mainly for household consumption. The average paddy land per household varies among the farmers. Table 3.2 shows that the farmers who solely depend their livelihood on rice has more land for it which is roughly 22 rai, while those obtain income from many sources has smaller area with ranging from 7.8 to 17 rai. However, the average is only 12.5 rai. Most of the land is rainfed. Thirty percent of the farmers produce rice not even enough for household consumption.

Cost and return from rice production is also shown in Table 3.2

The yield and income obtained per rai varies vastly among the farmers, yield and income ranging from 160 to 450 kg. and 540 to 1,575 baht respectively. The evidence is not clear whether it directly depends on the amount of fertilizer applied or not. The average yield is approximately 210 kg/rai which is much less than average yield of 304 kg. (Office of Agricultural Economics, 1989). Because it is mainly affected by long drought and pests in the

Table 3.2 Cost and Return From rice production at Thale Noi Community.

Items \ Activities	RF	RF-FM	RF-AQ	RF-HC	RF-FM-AQ	RF-FM-HC	RF-AQ-HC	RF-FM-AQ-HC	Average
[illegible] respondents	3	4	12	5	1	7	7	5	
[illegible]ge paddy land (rai)	21.75	12.25	8.32	9	17	14.14	9.7	7.8	12.50
[illegible] (baht/rai)	(1,398.65)	(517.70)	(572.04)	(653.85)	(572)	(382.91)	(567.88)	(544.80)	(651.24)
Seed	21.40	35.80	46.88	50	4	32.68	33.36	47.20	33.92
Family labour	468	105.60	104.80	167.60	36	50.80	112	144,80	148.70
Hired labour	638	134.80	134	150.80	300	160	168.80	156	230.30
Land preparation	133.75	135.00	130	96	160	107.14	101.43	104	120.92
Fertilizer	137.50	106.50	156.36	189.45	72	32.29	152.29	92.80	117.40
Income (baht/rai)	(1,575)	(560.0)	(935)	(785.40)	(570)	(591.60)	(570)	(540)	(765.45)
- Yield (1000 kg.)	0.45	0.16	0.25	0.21	0.15	0.17	0.15	0.15	0.21
- Price (baht/1,000 kg)	3,500	3,500	3,740	3,740	3,800	3,480	3,800	3,600	3,645
[illegible] (baht/rai)	176.35	42.30	362.96	131.55	-2	208.69	2.12	-4.80	114.21
[illegible] Income (baht/rai)	665.75	183.70	514.64	349.15	38	292.17	147.48	187.20	296.83
[illegible] (baht/household)	3,835.61	518.18	3,019.83	1,183.95	-34	2,950.88	20.56	-37.44	1,427.63
[illegible] Income (baht/household)	14,480.06	2,250.33	4,281.80	3,142.35	646	4,131.28	1,430.56	1,460.16	3,710.38

FM = Fishing HC = Mat Making

RF = Rice Production AQ = Aquaculture

previous year. The average income per rai is around 765 baht.

The highest cash cost is for labor, especially for harvesting. It is about 230 baht a rai, while the cost of land preparation is only 121 baht. The significant non-cash cost, for those family labor engaged for entire management on farm, is equal to 149 baht per rai. The price of rice is ranging from 3.48 to 3.8 baht a kg. with an average is 3.65 baht.

It can be seen that the profit from rice production, which is roughly 114.21 baht per rai and nearly 1,428 baht per household per year, is very low. Even so, why farmers still grow rice. One reason can be seen behind this is because rice is mainly grown for consumption. They also become secure as far as they have rice at hand.

The other factor may concern is that better alternative uses of paddy land have not been recognized or available. It is quite clear that most people in this community cannot be based on rice for cash income, given their landholding and net return per unit of land.

3.8 Mat Making

Thale Noi has become one of the most popular place for bulrush-mat-making in Southern Thailand for several decades. The results indicate that 67 percent of households have made mats over 20 years. This activity is mostly carried out by women mainly wife and daughter An average of two labors per household have

participated in this activity. Normally, they make mats everyday except when they are not home. This is also indicated by data in Table 3.3. They work on mat making for 11.6 months annually.

As for material, bulrush which was abundant in Thale Noi and surrounding area, is the main material used. Presently, the data show that 60 percent of those making mat have to buy bulrush which mostly are from other provinces, while only 12 percent has enough bulrush from their fields. The remainders are those also grow bulrush but insufficient for their uses. Because the average land allocated for bulrush is very small, with ranging only from 1 to 4 rai per household. Mats are most sold to the middle man in the village.

Cost and return from making mats is shown in Table 3.3. As the costs only include that for bulrush and paint, cash income obtained is, indeed, return to their labors. This is accounted for 1,339 baht monthly given that 82.25 mats are made. It is interesting to note that they earn only 45 baht daily which is much less than the minimum wage rate of 75 baht at provincial labor market.

The most serious claim made by this group is that the net return from mat making is becoming lower and lower. This is because the price of bulrush increase enormously while the price of mats can be little increased. Bulrush is much more expensive than before because the local supply decrease, partially resulted from fire. Even the supply from other provinces can be substituted, transportation cost has to be added. For this reason, some has produced such additional or substituted products as hats, handbags

Table 2.3 Cost and Return From Mat making at Thale Noi.

Activities / Items	HC	HC-FM	HC-AQ	HC-RF	HC-FM-RF	HC-FM-AQ	HC-AQ-RF	HC-FM-AQ-RF	Average
No. of respondent	8	5	2	5	7	3	7	5	Total=42
No. of family Labour engaged in mat making	2	2	1.5	2	1.5	2	5	2	1.9
Time spent (mont/person/year)	12	11.8	12	11.4	11	12	10.5	12	11.6
Cost (baht/Mat)	(16)	(10.40)	(22.50)	(16)	(24.29)	(12.33)	(16.14)	(10.60)	(16.03)
- Rubbish	12.30	6.80	17.5	13.20	20	10.33	13.29	8.20	12.70
- Paint & others	3.70	3.60	5	2.80	4.29	2	2.85	2.40	3.33
Return (baht/mat)	33	25	37.50	29	46.43	24	40.14	23.40	32.31
- No. of mat made monthly	97	69	85	123	63	87	57	77	82.25
- Cash income (baht/mat)	17	14.60	15	13	22.14	11.67	24	12.80	16.28
Cash income (baht/month)	1,649	1,007.40	1,275	1,599	1,394.82	1,015.29	1,368	985.60	1,339.03
Cash income (baht/year)	19,788	11,887.32	15,300	18,228.60	15,343.02	12,183.48	14,364	11,827	15,532.75

FM = Fishing HC = Mat Making

RF = Rice Production AQ = Aquaculture

and so fort in order to increase value added to the products made locally. However, this is only limited to those have more skill.

3.9 Aquaculture

The results show that all of the respondents who engaged in aquaculture started raising fish after 1982 and it quite bloomed during 1986-1988 (Table 3.4) which is after the beginning of phase I project. But, it is very difficult to conclude whether it is because of the effects of the project or not. Since the decisions were made to raise fish is due to various factors.

Table 3.4 Number of farmers started fish raising during 1983-1990.

Year Started	No. of the farmers	Percent
1983	1	3.2
1984	1	3.2
1985	2	6.4
1986	10	32.3
1987	4	12.9
1988	10	32.3
1989	1	3.3
1990	2	6.4
Total	31	100

One of the most important reason is the understanding that people in the community cannot only be based on fish from Thale Noi and Thale Luang for sources of protein and cash income. This associated with some farmers in the community are motivated by the success of other fish raising farmer in other places where they experienced. Then a few try raising fish first and the later follows. They mostly aimed to increased their income.

All respondents culture fishes in the ponds. The evidence shows that no cage culture exists in Thale Noi. It is approximately 51.6 percent of the respondents raises only carnivorous fishes, 19.4 percent raises only herbivorous fishes, and 29 percent rears both. Forty eight percent has only 1 pond, whereas 19.35% has two ponds, and the remainder has more than two ponds. The average has only 2.21 ponds. It is observed that the more pond they have, the more they raise for commercial purpose.

3.9.1 Carnivorous fish raising

As for carnivorous fishes, as shown in Table 3.5. The most popular one is catfish including Cross-breed and Gunthers walking catfish.

Table 3.5 Number of respondents and types of carnivorous fishes.

Types of carnivorous fishes	No. of farmers	Percent
1. Catfish (only)	18	75.00
2. Climbing perch	1	4.16
3. Giant Snakehead	1	4.16
4. Climbing perch and Catfish	2	8.33
5. Catfish and Freshwater Catfish	1	4.16
6. Catfish and Snakehead	1	4.17
Total	24	100.00

The reasons for choosing carnivorous fishes are in Table 3.6. The most important one is because they are popular among the consumers. Thus, increased its price. The availability of natural feed in the community and their rapid growth are additional reasons.

Table 3.6 Reasons for choosing carnivorous fishes.*

Reasons for choosing carnivorous fish	No.of farmers	Percent
1. good market	11	44
2. rapid growth	4	16
3. a lot of feed available	8	32
4. seed availability	1	4
5. previous experience	1	4
Total	25	100

* One farmer answers more than one reasons.

As for feed, the results show that the farmers use different kinds of feed. Thirty two percent uses both concentrated feed and fish rations, 20 percent uses concentrated feed together with natural feed, such as worm, coconut meal and also fish rations, 20 percent uses only concentrated feed, and the remainder uses only natural feed and fish rations. It can be seen that most farmers prefer not to use only concentrated feed because the cost is quite high (approximately 12 baht a kg. and have to buy in cash) and may not be profitable under the current price of fishes.

Concerning about time spending for fish raising, the results indicate that the farmers spend only 1.96 hrs. per day with ranging

from 0.5 hr to 4 hrs within 5.3 months per year. This varies from 4 to 10 month a year depending on number of crops and management. If intensive management, such as sufficient and appropriate feed, and drainage system are applied, it takes only 4 to 5 months for each crop, whereas it may take more than 7 months if they are neglected. Normally, one crop per year is widely practiced. It is quite clear from above that fish raising is not time-consuming activity. The farmers can also employ in other activities as well as raising fishes.

Costs and Returns from carnivorous fish raising is shown in Table 3.7 The yield and income for each pond varies enormously from 75 to 2,027 kg. and 4,500 to 87,465 baht respectively. The most significant investment cost is for pond digging. It is approximately 7,580 baht in an area of 735 sq.metre. The important cash cost are those for seed and feed which is accounted for 3,538 and 1,699 baht which is amounted to 46 percent and 22 percent of total cost respectively. Thus, total cost for each crop is nearly 7,718 baht. Given the average price of carnivorous fishes is about 40.49 baht, the profit is approximately 22,116 baht. This also varies a lot among the farmers, from 927 to 78,943 baht. It can be seen that carnivorous fish raising has good potential in generating household income.

As for carnivorous fishes market, the evidence shows that Gunthers walking catfish can be sold at a very good price which is roughly 60 baht a kg. This ranges from 50 to 70 baht. On the other hand, Cross-breed catfish can only be sold at an average of

Table 1.7 Cost and Return **from carnivorous fish raising at Thale Noi community.**

Activities / Item	AQ	AQ-RF	AQ-FM	AQ-HC*	AQ-RF-FM	AQ-RF-HC	AQ-FM-HC	AQ-RF-FM-HC	Average
[illegible] Ponds	4	1	2.7	1.5	2	2	2.5	2	2.21
Digging Cost (baht/pond)	9,400	13,225	14,666.67	1,375	6,000	8,335	2,500	5,140	7,580.21
Size of pond (sq.metre)	892	808	408	1,400	1,000	620	452	296	735
[illegible] Cost (baht/pond)	(8,222.56)	(9,419.10)	(17,886.67)	-	(3,573.30)	(5,142.50)	(6,765)	(3,634)	(7,717.53)
[illegible]	3,216.67	4,050	12,000	-	1,050	1,025	2,300	1,125	3,538.10
[illegible]	1,958.33	2,460	3,600		500	700	1,650	935	1,699.05
[illegible]	366.66	11.60	400	-	45	-	465	10	185.47
[illegible]	1,740.90	1,575	420	-	1,378.30	2,494	2,100	1,050	1,536.89
[illegible] tion (pond)	940	1,322.50	1,466.67	-	600	833.5	250	514	758.02
[illegible] Return (baht/pond)	(13,287)	(87,465.05)	(22,500)	-	(4,500)	(34,687.50)	(7,956.25)	(5,000)	(29,833.44)
[illegible] kg./pond)	325.67	2,027	1,500	-	75	937.50	167.5	125	736.81
[illegible] (baht/kg.)	40.80	43.15	15	-	60	37.0	47.50	40	40.49
[illegible] t/pond)	5,064	78,045.95	4,613.33	-	926.70	29,545	1,191.25	1,366	22,115.91
[illegible] Income (baht/pond)	7,745.68	80,943.45	6,500	-	2,905	32,875.50	3,541.25	2,930	24,418.82
Cash Income (baht/household)	30,982.72	80,943.45	17,550	-	5,810	65,751	8,853.13	5,860	53,965.59

FM = Fishing HC = Mat Making

[illegible] Rice Production AQ = Aquaculture

[illegible] only herbivorous fishes.

30 baht a kg. with ranging from 25 to 35 baht. However, it is still a profitable price. (See supplementary part I). The price of both types of catfish varies partly because of fish supply from natural sources, like in August and September when other kinds of fishes are less available in the market. It is also interesting to note that although the price of Cross-breed catfish is much lower than Gunthers walking catfish, it has several advantages. The most pointed out by those raising are (1) rapid growth, (2) big size, and (3) easy rearing, while it is more difficult and takes longer time to rear Gunthers walking catfish. Most of the farmers sell the products to the middle man at farm gates, while only small number sell their products at Thale Noi and Kuankanun market which is organized every other days. It is also claimed by the farmers that the price is perfectly determined by the middle man.

In order to more understanding the status of carnivorous fish raising and its potential at Thale Noi, particularly economic perspective, the case study of Mr.Prasorp, one of the farmer who is very interested in fish raising, will be presented. (See supplementary part I)

Concerning about the problems in carnivorous fish raising, the results show that there are a few problems claimed by the farmers. The price of concentrated feed is very high which is roughly 12 baht a kg. Let's refer to the case of Mr.Prasorp, if he uses only concentrated feed, the cost of feed will be more increased. However, this problem may be avoided by using fish rations mixed by themselves. Nevertheless, more time and investment cost has to be

spent. As for seed, normally the farmers use seed from three main sources; natural sources including rice field, waterways and Thale Noi, private nursery, and Patthalung Fishery Stations. The problem found is that the price of seed from private nursery is very high compared to that from Patthalung Fishery Station which is approximately 0.60 baht and 0.20 baht per seed respectively. Although the price of seed from Patthalung Fishery Station is much lower, the farmers cannot only depend on those from there (in case of Cross-breed catfish) because insufficient supply is provided and the farmers have to order for along time in advance. For those obtained from natural sources, mostly are Gunthers walking catfish, although it has advantage in saving cost, it is difficult to manage. Because they are different in size and growth rate. Another problem is about water management. When high stock density and high feed input are applied, creates problem in water quality. Without sufficient water supply, problem will be more severe.

Concerning about the attitudes forwards future carnivorous fish raising, particularly catfish at Thale Noi community, they all think that it will be more accepted by the people. This is mainly due to good market.

3.9.2 Herbivorous fish raising

As for herbivorous fishes, the most popular among the farmers is nile tilapia as supported by the data in Table 3.8. Carp is can also be seen in complementary to nile. The reasons for choosing herbivorous fishes includes 1) simple management is required,

particularly water management and consumption habits with can eat many varieties of aquatic plants, (2) it can be reproduced rapidly this refers to the case of nile tilapia, and (3) nile tilapia has been introduced to Thale Noi by the Utilization of Aquatic Plant Project.

Table 3.8 Types of herbivorous fishes raised by the farmers.

Type of herbivorous fish	No. of farmers	Percent
Nile tilapia	10	62.50
Nile tilapia and Local carp	2	12.50
Nile tilapia and Indian carp	1	6.25
Nile tilapia and Common carp	1	6.25
A gourami	1	6.25
Nile tilapia, Common carp and Local carp	1	6.25
Total	16	100

For those raising herbivorous fishes, they normally use fish rations and natural feed. Fish rations is prepared by a wide range of ratio of rice bran, broken rice, fish meal, and salt. Natural feed like those used for carnivorous fishes. The most widely practiced for herbivorous is one crop a year where marketable size

has been harvested and let the remainder grows alternately. However, in some case additional seed is required to replace those died or less reproduced.

Cost and Return of herbivorous fish raising is shown in Table 3.9.

The significant cash costs, similar to what already discussed in omnivorous fish raising, are for seed and feed which is amounted to 3,964.67 and 2,513.54 baht per pond respectively. Labor cost is an important non-cash cost which is roughly 1,397 baht. The total cost for each pond is about 8,633.11 baht, given that the size of pond is 735 sq.metre and digging cost is roughly 7,586 baht (see Table 3.7).

The return is obtained by multiplying yield by its price which is equal to 5,715.50 baht. The yield varies enormously among the farmers, from 68.5 to 450 kg. Its price is less variable, with ranging from 20 to 25 baht a kg.

Thus, the profit is roughly minus 2,918 baht per pond. However, it does not mean that every household who raise herbivorous fish loses (see Table 3.9). It is also important to note that, as mentioned earlier, in herbivorous fish raising the young herbivorous are left in the pond for the following crop so that cost in subsequent crop can be reduced.

If comparing the return from herbivorous with carnivorous fish raising, it is quite clear that carnivorous fish raising will generate more income and profit than herbivorous.

Table 3.9 Cost and Return from herbivorous fish raising at Thale Noi.

Activities	AQ	AQ-RF	AQ-FM	AQ-HC	AQ-RF-HC	AQ-RF-FM-HC	Average
Total Cost (baht/pond)	(10,513.75)	(5,392.50)	(18,849.17)	(3,562.50)	(9,567.75)	(4,579)	(8,633.11)
Seed	3,300	1,480.00	12,500	800	3,708	2,000	3,964.67
- Feed	3,911.25	1,277.50	3,570	1,312.50	3,995	1,015	2,513.54
- Labor	2,362.50	1,312.50	1,312.50	1,312.50	1,031.25	1,050	1,396.88
- Depreciation	940	1,322.50	1,466.67	137.50	833.50	514	758.02
Total Income (baht/pond)	(6,812.50)	(4,325)	(11,250)	(4,000.00)	(1,712.50)	(4,500)	(5,715.50)
- Yield (kg./pond)	272.50	275.00	450	200	68.5	225	248.5
- Price (baht/kg.)	25	23.00	25	20	25	20	23
Profit (baht/pond)	-3,701.25	932.50	-7,599.17	437.50	-7,855.25	-79	-2,917.61
[illegible] (baht/pond)	-398.75	3,567.50	-4,820	1,887.50	5,990.50	1,485	-762.61
[illegible] (baht/household)	-1,596	3,567.50	-13,014	2,831.25	-11,981	2,970	-1,685

FM = Fishing HC = Mat Making

RF = Rice Production AQ = Aquaculture

Concerning about the problem in herbivorous fish raising the results show that most herbivorous fishes, like nile tilapia, are not preferred by the consumers, particularly when there are other fishes available. Thus, this impeded them from having higher price. However, it is pointed out that when there is no other fish supply, herbivorous fishes are vastly accepted. The other disadvantage which is widely recognized is due to it is easily dead after catching so that narrows the markets of the product and thus, lowers its price. Moreover, the farmers claim that herbivorous grow slowly and the seed is scarce.

As for their attitudes toward herbivorous fish raising, 50 percent of those culture herbivorous think that it will be good because of supply of fish from Thale Noi will decline, while 25 percent think that it will not be sure whether it will be good or bad, and only 25 percent think that it will not be good.

3.10 Income's structure of the people at Thale Noi Community.

The status of different occupations undertaken by the people at Thale Noi community are already discussed. This section is aimed to summarize the results of what already discussed, but mainly on the variability of income obtained from each activity and when their combination has taken place.

Table 3.10 shows the income's structure of the people at Thale Noi community. This table excludes that from off-farm works.

For those employ only one activity, the income obtained is the lowest and much less than those emp[illegible] two [illegible] more. This is

Table 3.10 Income Structure of the people at Thale Noi Community (baht/year)

Occupations \ Income	FM	AQ	RF	HC	Total
FM	16,800	-	-	-	16,800
AQ	-	14,693.86	-	-	14,693.86
RF	-	-	14,480.06		14,480.06
HC	-	-	-	19,788	19,788
FM-AQ	60,614.83	2,286	-	-	62,900.83
FM-RF	26,106	-	2,250.33	-	28,356.33
FM-HC	33,180	-	-	11,887.32	45,067.32
AQ-RF	-	42,255.46	4,281.80	-	46,537.26
AQ-HC	-	2,831.25	-	15,300	18,131.25
RF-HC	-	-	3,142.35	18,228.60	21,370.95
FM-AQ-RF	23,400	5,810	646	-	29,856
FM-AQ-HC	29,657.92	8,853.13	-	12,183.48	50,694.53
FM-RF-HC	31,854.28	-	4,131.28	15,343.02	51,328.58
AQ-RF-HC	-	26,885	1,430.56	14,364	42,679.56
FM-AQ-RF-HC	43,958.08	4,515	1,460.16	11,827	61,760.24

FM = Fishing HC = Mat Making

RF = Rice Production AQ = Aquaculture

roughly 16,800, 14,694, 14,480 and 19,788 baht per year from fishing, aquaculture, rice and mat making respectively. The lowest is from rice, while the highest is from mat making.

For those based on two activities, the best combination is between fishing and aquaculture. The income obtained from this combination is approximately 62,901 baht per year. The combination between fishing and mat making, and between aquaculture and rice are also good. This amounted to 45,067.32 and 46,537.26 baht respectively. However, it is higher from those employ 3 activities, particularly the combination of : fishing, aquaculture, and mat making; and fishing, rice and mat making. Apart from the combination of fishing and aquaculture, the highest income, but mainly from fishing, it is likely that those undertake 4 activities will obtain the highest income.

It is quite clear that aquaculture will play an important role for income generation of the people at Thale Noi community (see also Table 3.7,3.9). However, carnivorous should be given priority.

3.11 Fish culture extension program

As for those participated in fish culture extension program, the results show that the reasons to join the program is because they themselves are interested in fish culture associated with they are persuaded by friends and project staffs. Whatever the reason behind their decisions, they all hope to increased income.

After this program terminated, 73.3 percent (11 from 15) of the participants stopped raising fish. These includes all participants joining in cage culture and 4 households from pond culture. For those joining in cage culture, it is pointed out that the most significant reason is because they experienced that it was too risky, that is, it was greatly damaged by flood, while fish culture in the pond is impeded by severe drought. Moreover, for cage culture it is experienced that after reproduction young nile, which is very small, left the cage for independent growth. Therefore, there is no data available in cage culture by the time of evaluation.

Table 3.11 shows the average yield of nile tilapia and price received for each farm under fish culture, extension program within the pond. An average yield is approximately 204 kg./crop. The yield varies vastly among the participants from 53 to 500 kg. this is partly because they are different in quantity of seed and feed applied. The amount of seed provided varies from 80 to 500 heads, while feed varies from 3 to 10 kg. per day for each participant. Thus, costs of seed and feed for each participant will be different (More details see supplementary part II). This not include household consumption. The price sold is an average of 24.8 baht a kg. which is ranged from 20 to 27 baht. This varies according to its size. If the size is between 3-6 heads per kg., the selling price is 25-27 baht. In contrast, if its size is smaller or bigger than those, the price will be lower.

The total gross income per crop is approximately 5,059.2 baht. It also varies a lot among the participants, from 825 to 13,500 baht. It is mainly due to yield obtained (see supplementary part II).

Table 3.11 Yield of nile tilapia per crop (kg) and selling price (baht) for each farm.

Pond's Number	Yield of nile tilapia per crop (kg)	Selling price (baht/kg.)	Value (baht)
1	250	20	5,000
2	33	25	825
3	100	25	2,500
4	180	25	4,500
5	150	25	3,750
6	500	27	13,500
7	220	25	5,500
8	200	23	4,600
Average	204	24.8	5,059.2

Concerning about the farmer's attitudes toward the market of Nile tilapia, the results indicate that 73.3 percent of the participants think that the local market demand exists,

particularly when there is no supply of fish catch from Thale Noi. Generally, the consumers prefer catfish, snakehead, climbing perch to herbivorous fishes. The other disadvantages raised are similar to those discussed above, mainly it is easily dead after catch. If it can be preserved after harvesting without changing its quality, it is hoped that future price will be more increased.

As for their attitudes toward future herbivorous fish raising, 50 percent will no longer culture such herbivorous fishes as nile tilapia, but omnivorous fishes, particularly catfish will be preferred. This is due to its marketing potential. After harvest it can also be sent to many markets; local, district, provincial level as well as other provinces without significant problems.

Apart from its disadvantages, the farmers who is raising nile tilapia point out that nile also has an advantage, particularly because it can be reproduced rapidly. Therefore, the young nile can also be sold for supplementary income and saving seed cost for the following crop. This evidence can be supported by a case study of Mr.Serm, one of the participant who is continuing raising nile after the project terminated both for selling young nile, mature nile and for household consumption. (see supplementary part II)

3.12 Supports required by aquaculture farmers

The supports that required by aquaculture farmers are as follow:

1. The provision of free or low price of seeds, particularly nile tilapia and catfish. Because in many cases the farmers want to culture such a fish but no seed is available;

2. Arranging the training course for the people who are interested in aquaculture. The topic should include principle of aquaculture management, such as water management, technique of feeding, how to take care seeds, and so fort;

3. Promotion of market for such products may be in term of arranging market so that buyers and seller can meet; and

4. Academic advice on aquaculture should be provided regularly by the government agencies especially from Local Fishery Office.

Chapter IV

Conclusion and Recommendations

Most of the people at Thale Noi community really realize that there is a marked decline of fishery resources from Thale Noi and Thale Luang. This directly affects their livelihood. Aquaculture production is widely accepted as one of the alternative, which its product can be substituted those decline so that abundant local fish supply can be maintained with additional income.

The positive attitudes towards "The Utilization of Aquatic Plants Project" is expressed in term of the promotion of public awareness about aquaculture production and its knowledge, and to make use of local resources such aquatic weeds.

As for fish rations developed by the project, it is accepted that it is suitable for herbivorous fishes and the cost is quite low in comparison to concentrated feed. As a result, it is appropriate to small farmers who have limited capital for investment. However, the farmers who are going to use such rations have to be industrious in collecting aquatic weeds and preparing the rations. If it is not so, it is likely that fish rations developed is unacceptable.

The return from herbivorous and carnivorous is very much different. The result from the study is quite clear that most successful in aquaculture production is from those rearing carnivorous such catfish. It also hoped that carnivorous fish rearing will be more accepted by the people in the community as one

of their income generating source. Market is the most important reason for this. It is also a significant factor for the farmer to choose fish to be reared.

Herbivorous fish rearing is likely suitable for household consumption production. The farmers will have fishes at hand as a source of protein for their children. If it will be reared mainly for cash income it is important to make sure that market for the products is not a problem. This partly means that the problem about post-harvest of herbivorous fishes has been solved.

It is clear from the income structure that the farmers or household who more diversify will obtain more income. This means that aquaculture, high potential occupation, should be more considered in improving their livelihood.

However, in order to promote and strengthen aquaculture production at Thale Noi community, it is necessary for the government agencies, partly is the project to play a role in this matter.

The following actions could be considered:

1. The farmers should be advised regularly about aquaculture management, including basic management on seed, feed and feeding, water, and particularly market. This can be done by arranging training course for those are interested in each topic, farm visiting, or group setting;

2. Sufficient seeds, both herbivorous and carnivorous, should be provided by Government Fishery Stations;

3. Promote integrated fish culture system to reducing cost of production coping with risk and sustaining the income;

4. For the project, if the ultimate goal is to increased the income of the people surrounding the lake, more research on carnivorous fishes should be pursued;

5. Credit with low interest rate should be set available for the farmers; and

6. Centre of Aquaculture Information should be set up at Thale Noi community by aquaculture farmers, so that it will be a centre for aquaculture activities, such as feed centre, market centre, information centre, and so fort. This may initially be supported by the project.

If these can be done, it is believed that aquaculture production at Thale Noi will be more accepted and developed. Therefore, the people in this community will obtain more income, thus, raise their quality of life.