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Integrated fish farming

Aquaculture Department, Southeast Asian Fisheries Development Center

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INTEGRATED FISH FARMING

Integrated fish farming combines fish, swine, poultry, and vegetable production. Chicken coops and pens for pigs and ducks can be constructed on the dikes or above the ponds. Fresh animal manure thus enters the pond directly, hastening the growth of natural food organisms for the fish being cultured in the pond. Moreover, livestock feeds that fall into the pond can be directly utilized by the fish.

Animal manure can also be used to grow fodder crops on the sides of dikes such as squash for its chopped-up leaves to feed herbivorous fish. And adjacent vegetable plots can be fertilized by the nutrient-rich pond water.

Integrated farming thus brings aquaculture to resource-poor, small-scale farmers who cannot afford expensive farm inputs. Recycling by-products of animal husbandry greatly lowers the cost of fish production.

Item One: Milkfish, Tilapia, Shrimp Plus Chickens

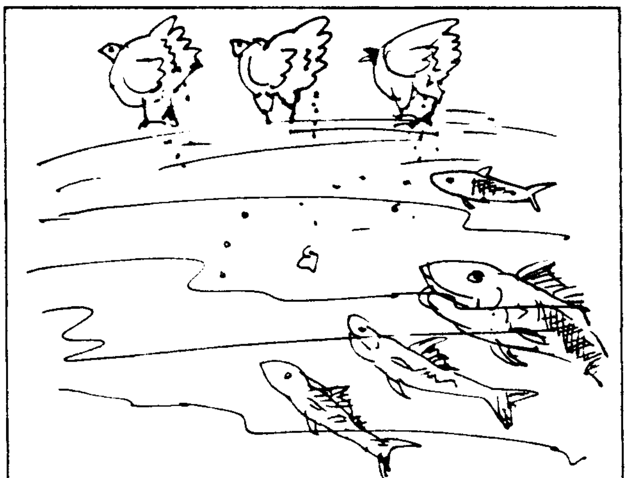
In 1984-86, the Leganes Research Station of the SEAFDEC Aquaculture Department developed the polyculture of milkfish, tilapia, and shrimp with poultry. The fish swim in the water and the chickens grow to slaughter-size in poultry houses built above the water.

The two forms of husbandry mesh well in the biological food chain. Chicken droppings that pass through a welded-wire floor in the poultry house into the water below become a fertilizer for plankton, the natural food organisms on which fish feed. The milkfish, tilapia, and shrimp then thrive on the plankton.

Further research showed that a 4m x 8m poultry house was right for a 1000 m^2 fish pond. A bamboo catwalk connected the poultry house to the dike.

Stocking in the pond consisted of 200 milkfish fingerlings, 1 500 tilapia fingerlings, and 5000 shrimp juveniles - and above it, 90 3-wk old chicks were put in the poultry house. This mix was found to give the best productivity.

The chickens were harvested after 45 days - half the period for the fish. Two chicken crops were harvested for one fish crop.



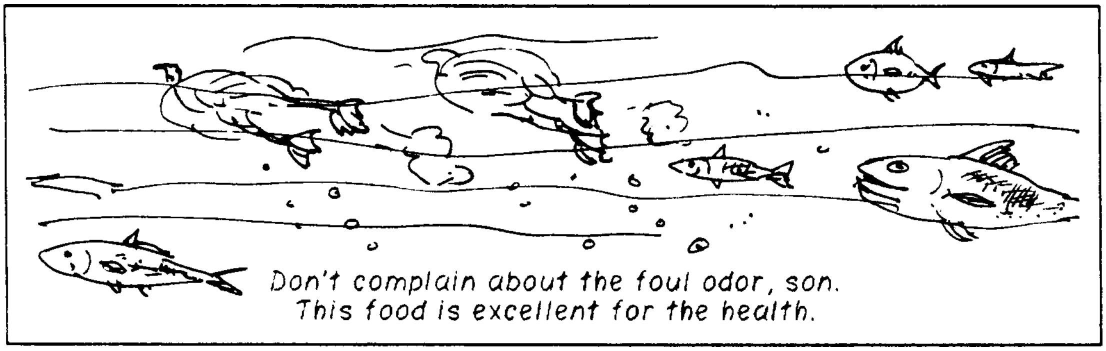
OK kids! Here comes your nutrient-rich food enhancer!

At harvest time, farmers who go into polyculture have both fish and chickens for household food and for sale.

For sanitation, it is suggested that chickens be harvested a week before the fish, and the pond water, immediately changed. When the fish are harvested after another week, the pond has the healthy smell of fresh fish.

Source: Terminal Report of Kaylin G. Corre, Research Associate, and Beato Pudadera, Jr., former Research Associate. SEAFDEC Aquaculture Department, Tigbauan, Iloilo, Philippines.

Item Two: Fish-cum-Duck Farming



The dikes of grow-out or 2-yr-old fingerling ponds are partly fenced to form a dry run and part of the water area or a corner of the pond is fenced with used material to form a wet run. The net pen is installed 40-50 cm above and below the water surface to save net material. In this way, fish can enter the wet run for food and ducks cannot escape under the net. In a large pond, a small island is constructed at the center of the pond for demand-feeding facilities. Stocking densities in China are higher than those in other countries, averaging 4.5 individuals/m^2 of pen shed including the dry run and 3-4 individuals/m^2 for the wet run.

In the early years of integrated fish-cum-duck farming, ducks went everywhere in the fish ponds to feed; this pattern has been improved. The duck-raising area has been set up to connect the duck shed, the dry run, and the wet run. Whether fish-cum-duck integration succeeds or not primarily depends on technical measures of duck raising. Both meat and egg-laying ducks can be raised in fishponds. In the summer, 14-day ducklings are accustomed to life on the water surface. The food stocks of meat ducks grow quickly, reaching marketable size (2 kg) in fishponds in 48-52 days; slow-growing stocks need 55-56 days. Ducks should be marketed as soon as they reach the marketable size or they will lose their feathers, resulting in decreased food efficiency, body weight, and commodity value.

The number of ducks to be raised in fishponds depends on the quantity of excreta per duck, which, in turn, depends on the species of duck, the quality of feed applied, and the method of raising. In raising Beijing ducks, about 7 kg excreta/duck can be obtained during the 3-day fattening period. The egg-laying Shaoxin ducks raised in Wuxi annually produce 42.5-47.5 kg manure/duck; hybrids of Shaoxin and Khaki-Combell ducks annually produce more than 50 kg/duck. The stocking rate of ducks also depends on climatic conditions and the stocking ratio and density of the various fish species in the pond. In Europe, the stocking rate is usually around 500 individuals/ha. As a result, the increment of fish yield will be 90 kg/ha. In tropical and subtropical zones, it has been recommended that the stocking rate should be 2250 individuals/ha. In Hong Kong, the optimum stocking rate is 2505-3450 individuals/ha; in Wuxi, 2000 individuals/ha. For meat ducks, the stocking rate should be reduced because of the greater production of excreta. In the Taihu district, 7 or 8 fish species are polycultured in fish ponds. The stocking ratio of the various species remains unchanged when ducks are raised. If the number of ducks exceeds 3000/ha, filter-feeding fish and omnivorous fish should be increased and herbivorous fish should be reduced.

Organic-material stacking won't occur in fish-cum-duck integration on the fishpond as long as the stocking rate of ducks is appropriate and the amount of excreta does not exceed the transforming power of the fishpond. Ducks swim loosely in the wet run to search for food, their excreta drop evenly into the wet run, and the fertilization effects of the droppings are felt throughout the pond.

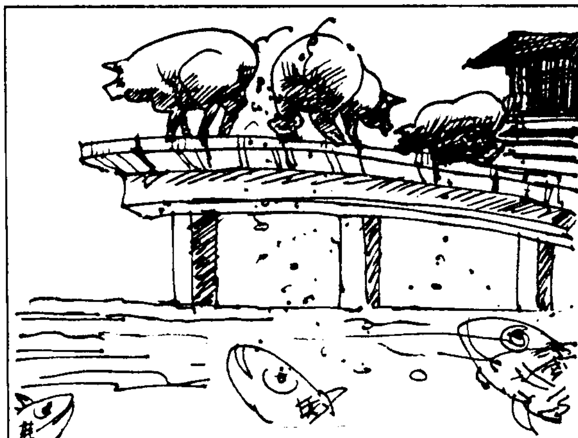
Item Three: Fish Culture with Pig Raising

Fish culture combined with pig raising is a traditional integrated fish-farming practice in rural China. Combining pig raising with duck raising and fish farming, not only increases economic efficiency but also increases social and ecological efficiency. The leftovers and residues from kitchen, aquatic plants, and products and wastes from agriculture and side occupations are often used as pig food. Pig excreta, in turn, are used as organic manure in fishponds. Pork is a main subsidiary food of the people in rural China, and pig excreta make a high-quality manure.

There are two types of pigsties in China: the simple pig shed constructed on the pond dyke or over the water surface and the centralized hog house. Both types have advantages and disadvantages. The simple pigsty is more suitable for households because of its lower cost and because of small-scale farms. The pig excreta can automatically flow or be flushed into the fishponds; this saves much labor. If the area of a fishpond is less than 8 mu,* a pigsty can be set up on the pond dyke and pig wastes will flow directly into the pond. If more than 30 pigs are raised on the same spot, there is too much manure for the direct-flow method. Manure is often heaped near the pigsty, causing a partial deterioration in water quality. Fish surfacing increases (dissolved oxygen content decreases) when pig manure sinks to the bottom of the pond or when too much manure flows into the pond.

Centralized hog houses are suitable for large-scale integrated fish farms. After dilution, the manure can be spread along the pond dyke manually from a small boat. In a large fish pond, the use of a boat and a mechanical spreading apparatus will facilitate application of manure.

In fish-cum-pig integration, the water quality must be constantly monitored because of the dissolved oxygen problem. Besides, the production period of pigs should match the demand of pig manure in fish farming.



...And I suppose this is the super-enhancer of them all...

* 1 mu = 667 m^2

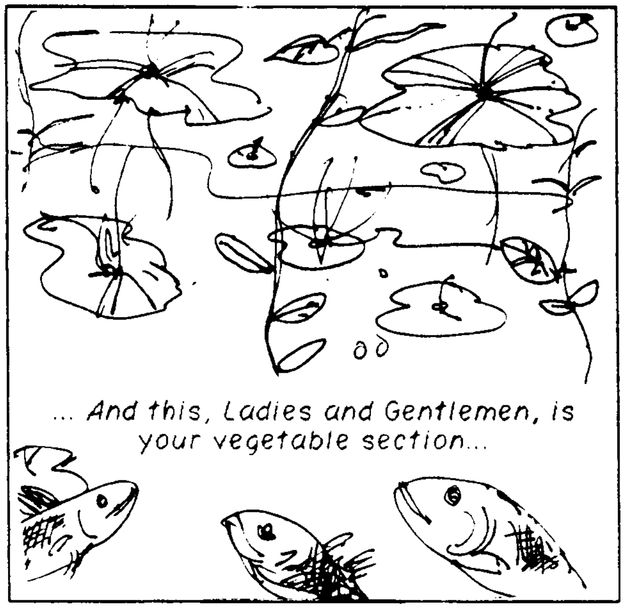
Item Four: Fish-cum-Aquatic Plant Integration

Fish farmers in southern China often culture aquatic plants in lakes, rivers, waterlogged areas, or inlets and outlets of irrigation canals. The principal aquatic plants cultured are the water hyacinth (*Eichhornia crassipes*), water lettuce (*Pistia stratistes*), and water peanut or alligator weed (*Alternanthera philexeroides*).

Water hyacinth is known as the "king of aquatic plants." Per unit area, it produces 6-10 times more protein than soybean. Aquatic macrophytes are easy to manage with less labor and lower costs. One person can manage about 50 mu of three aquatic plants and can produce 13.1% (dry weight) crude protein in 6 months.

The three aquatic plants are especially good for rearing fingerlings of silver and bighead carps. The plants should be mashed into a paste, but the residue could not be removed. To rear adult fish, with herbivorous fish as the major species, these plants are often pulverized with a green fodder-crop pulverizer and fed to the fish.

Aquatic plants are also palatable to various animals in integrated fish farms. For this purpose, they need little or no processing. The rate of utilization, therefore, is high: with a small amount of wheat and rice brans, 900-1000 kg of aquatic plants can rear one piglet to an adult with a body weight of 60-70 kg. The excreta of one pig can be converted into more than 40 kg of fish per year. Water hyacinth can be fed to ducks at a daily rate of 150 g/ duck with a little wheat and rice brans. The excreta of one duck (about 52 kg) can be converted into 3 kg of fish per year.

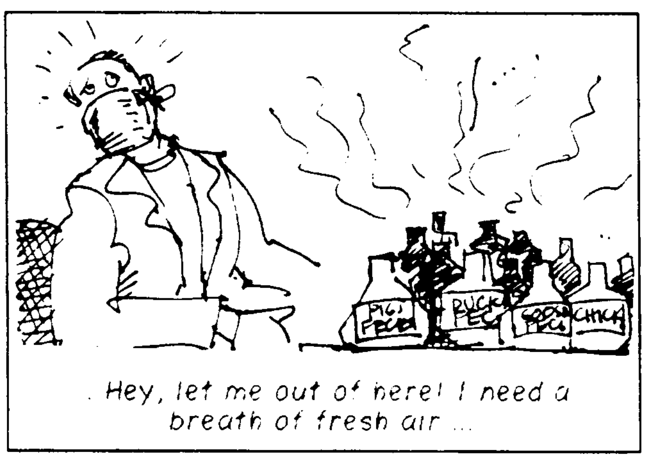


Aquatic plants have a high nutrient content as shown below.

Nutrient contents of three aquatic plants

	Dry matter (%)	Crude protein (%)	Crude fat (%)	Non-N extract (%)	Crude fibre (%)	Ash (%)	Ca (%)	P (%)	Yield (t/mu)
Alligator weed	9.2	2.18	0.18	2.49	1.19	1.25	0.23	0.03	15-25
Water lettuce	4.6	1.07	0.26	1.63	1.10	1.30	-	-	10-20
Water hyacinth	7.3	1.90	0.25	2.21	1.11	1.33	0.11	0.03	10-26

Item Five: Nutritional Elements in Pig and Poultry Manure



Pig manure includes much organic matter and other nutritional elements such as nitrogen, phosphorus, and potassium and is a fine, complete manure. Pig feces are delicate, containing more nitrogen than other livestock feces (C:N=14:1), making them more susceptible to rotting. The major portion of pig urine is nitrogen in the form of urea. It decomposes easily.

The amount of excreta of a pig is greatly associated with its body weight and food intake. A 50-

kg pig discharges around 10 kg/day or 20% of its body weight. A pig excretes 1000 kg of feces and 1200 kg of urine in the growing period of 8 months from piglet to adult. A pig's daily excretion is less than a cow's or a horse's; however, pigs are better because of their faster growth, shorter fattening period, and suitability for pen culture. Also, pigs are raised on much larger scale, so it is beneficial to collect their manure.

Nutritional elements in pig manure

Item	Organic matter (%)	Inorganic matter (%)		
		N	P_2O_5	K_2O
Feces	15	0.6	0.5	0.4
Urine	2.5	0.4	0.1	0.7

Poultry manures include the feces of chickens, ducks, and geese, and are rich in both organic and inorganic matter. Poultry manures rot quickly and their nitrogen is mostly in the form of uric acid, which cannot be absorbed directly by plants. Accordingly, poultry manures are more effective after fermentation. The annual amount of excrement per fowl is as follows: chicken, 5.0-5.7 kg; duck, 7.5-10.0 kg; goose, 12.5-15.0 kg. Although the annual excretion of each is comparatively small, the quantity of poultry culture is often great; therefore, the total amount of feces is significant.

Nutritional elements in poultry manure

Item	Organic matter (%)	Inorganic matter (%)		
		N	P_2O_5	K_2O
Chicken feces	25.5	1.63	1.54	0.83
Duck feces	26.2	1.14	1.44	0.62
Goose feces	23.4	0.55	0.50	0.95

Source of Items Two to Five: **INTEGRATED FISH FARMING IN CHINA,** Technical Manual 7, 1989, Network of Aquaculture Centres in Asia and the Pacific, Bangkok, Thailand.

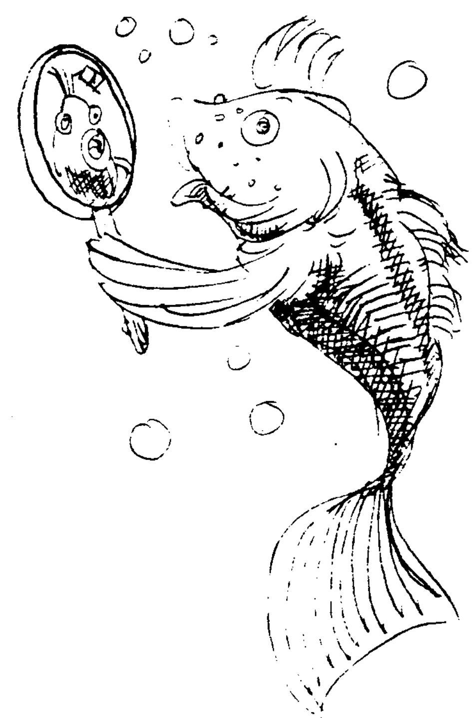
Item Six: Swine Manure as a Dietary Ingredient

Chinese integrated fish farms combine polyculture of carps with organic fertilization derived from agriculture. A study examined the response of a polyculture of silver, bighead, common, and Crucian carps to varying amounts and frequencies of fermented pig manure application.

Net fish yield averaged 10.2 kg/ha/d with an average manure application rate of 31-48 kg dry weight /ha/d. Daily manuring increased net fish yields by 38% over applying manure at 5- or 7-day intervals. Silver carp accounted for 62% of this increase. Net fish yield was directly proportional to the amount of manure applied over the range 0-48 kg dry weight manure/ha/d. Net fish yield increased 1.2 kg/ha/d for each 10.0 kg/ha/d increase in the manuring rate. Planktophagic fishes accounted for about 75% of this response. The conversion of manure to fish biomass was in the ratio of 8.3 kg dry manure: 1 kg wet fish weight. The contribution of primary productivity to fish yields was estimated in control ponds to which nothing was introduced except inorganic nitrogen and phosphorus equivalent to the amounts introduced as manure in the experimental ponds. The average net fish yield in these control ponds was 4.3 kg/ha/d. Net fish production was directly proportional to the rate of microbial decomposition of cellulose at the sediment surface. This, and water quality measurements, demonstrated the importance of the heterotrophic food chain in these aquaculture systems.

Source: **Animal Nutrition Research Highlights**, June 1991, publication of American Soybean Association. P.O. Box 27300, St. Louis, MO., U.S.A.

Item Seven: Potential Health Hazards of Fish from Manured Ponds



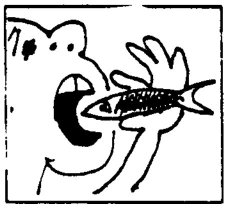
Om, gosh! Pimples! The chicken dung in my diet must be the culprit.

The introduction of a fishpond as a farm subsystem should not pose any unacceptable risks to public health. There is a possibility that livestock manured ponds may present health problems for humans because some diseases of animals are transmissible to human beings. Although there are few data in the literature on disease transfer through the use of manure as a pond fertilizer, it does appear that the risk of disease transmission via fish grown in such ponds is low. Furthermore, such fish are nutritionally and economically beneficial for farmers and consumers. Fish are not susceptible to most infections of warm blooded animals (livestock and man); they are healthy and demonstrate good growth in well managed manured ponds. The main danger lies in the passive transfer of disease-causing microorganisms like *Salmonella*. However, there is a rapid decrease and weakening of microorganisms in manured ponds in the tropics, probably due to high temperature, pH, and dissolved oxygen. As a final safeguard, fish raised in manured ponds should be washed and cooked well prior to consumption.

The construction of fishponds may provide breeding sites for disease-transmitting insects, particularly mosquitoes that may transmit malaria. However, mosquito breeding in ponds can be largely controlled by good design and management, in particular by preventing vegetation either hanging into or emerging through the surface of the pond. On the other hand, the fish themselves may aid mosquito control by the consumption of larvae.

Source: **Research and Education for the Development of Integrated Crop-Livestock Fish Farming Systems in the Tropics** (1988) by P. Edwards, R.S.V. Pullin, and J.A. Gartner. ICLARM, MC P.O. Box 1501, Makati, Metro Manila, Philippines.

Item Eight: Taste Tests



The International Center for Living Aquatic Resources Management (ICLARM) and the Central Luzon State University (CLSU) conducted two taste-test experiments: one for fish raised in pig-fish ponds and the other in duck-fish ponds. Fish grown in ponds fertilized with inorganic fertilizer were used as the controls.

Fish from the experimental ponds were randomly selected and harvested. The fish were prepared by removing the gills, internal organs, scales, and fins. The cleaned fish were cooked by steaming. One fish from each treatment (manure level or inorganic fertilizer) was placed in each platter. The fish were coded so the taste panel could not identify them.

Each taste panel was composed of six persons selected to include males and females, laborers and scientists, and different cultures (Malay and Caucasian). The panelists were asked to evaluate the taste of the fish on the basis of the following scores:

10 - Excellent	5 - Slightly fair
9 - Very good	4 - Slightly poor
8 - Good	3 - Poor
7 - Slight good	2 - Very poor
6 - Fair	1 - Extremely poor

Results are shown in tables below. In both tests, fish reared in manured ponds received higher ratings than those reared in ponds receiving inorganic fertilizer. Further, high manure levels gave higher ratings than lower manure levels. This palatability of fish grown in manured ponds is further supported by observations made during the sale of fish produced from the experiment. Buyers would line up on pond dikes to buy the fish as the fish were harvested. The buyers were well aware of the nutrient source for the ponds.

It is suggested to hold the fish grown in manure ponds overnight or for a few days in "clean" water to allow them to "clean" themselves out. This was initially done but was stopped when the buyers wanted to take the fish directly from the pond. Immediate sale minimized both labor and weight loss during holding (10 to 15% in 14 h). The fish should be removed from the pond alive and rinsed before sale. The only complaints received about bad tasting fish occurred when the fish had died in the pond mud during harvest or were inadequately rinsed before sale.

Taste tests of Nile tilapia reared in ponds fertilized with inorganic fertilizer and pig manure

Panelist	Score: Inorganic fertilizer input	Score: Manure input (pigs/ha) 40	Score: Manure input (pigs/ha) 60
1	8	5	7
2	6	3	8
3	10	9	9
4	4	10	10
5	8	7	9
6	3	9	6
Total	39	43	49

Taste tests of Nile tilapia reared in ponds fertilized with inorganic fertilizer and duck manure

Panelist	Score: Inorganic fertilizer input	Score: Manure input (ducks/ha) 750	Score: Manure input (ducks/ha) 1250
1	5	9	9
2	6	6	10
3	7	9	10
4	6	9	9
5	6	8	7
6	6	8	8
Total	36	43	53