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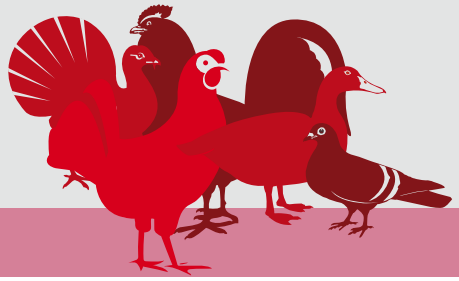
Smallholder Poultry Production

DISTRIBUTION AND CHARACTERISTICS OF DUCK-FISH FARMING SYSTEMS IN EASTERN CHINA



DISTRIBUTION AND CHARACTERISTICS OF DUCK-FISH FARMING SYSTEMS IN EASTERN CHINA

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Contents

Preface

This paper is part of a series that describes the opportunities and limitations of smallholder poultry production. The major structural changes that have occurred in poultry production and marketing in recent decades have lead to a strong and internationally integrated poultry industry. In developing countries, however, the majority of poultry are still kept by smallholders in less intensive systems. The advantages of these systems are the low levels of inputs that they require and the unique products they produce. These systems are practiced by people who have few other options and it is important that they survive as long as they are needed for social reasons, food security and livelihood support.

The paper presents findings from the analysis of duck-fish integration systems based on field interviews carried out with 53 households/companies from 22 municipalities in three provinces of eastern China. The study covered characteristics of important duck-fish production systems, development trends, future prospects and other important issues of duck-fish integration in eastern China, one of the most important areas for aquaculture production and duck husbandry.

We hope this paper will provide accurate and useful information to its readers and any feedback is welcome by the author and the Animal Production Service (AGAP)[1] of the Food and Agriculture Organization of the United Nations (FAO).

[1] For more information visit the FAO poultry website at: http://www.fao.org/ag/againfo/themes/en/infpd/home.html or contact: Olaf Thieme – Livestock Development Officer – Email: olaf.thieme@fao.org
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Distribution and characteristics of duck-fish farming systems in eastern China

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SUMMARY

Aquaculture is a diversified production sector with different production systems and practices. Duck-fish production, one of the integrated fish farming systems traditionally practised in China and many other countries in the world, still plays a significant role in fish and duck production in China (Yang and Hu, 1989). This traditional fish farming system is challenged by changing environmental and socio-economic factors. This study is a part of the efforts of the Food and Agriculture Organization of the United Nations (FAO) to evaluate the current status and future prospects of some aquaculture production systems with respect to common issues such as the impact on human health.

This study covered 22 municipalities in three provinces in eastern China, namely Jiangsu, Zhejiang and Jiangxi. With FAO funding support, it was carried out by the Freshwater Fisheries Research Centre (FFRC) of the Chinese Academy of Fishery Sciences in collaboration with the Provincial Fisheries Research Institute in each province. FFRC staff, together with researchers from provincial fisheries research institutes in each province, conducted field interviews with 53 households/companies whose major production activity is duck-fish integration. The field interviews mainly aimed at collecting data on the characteristics of different duck-fish systems. Information on their scope and distribution was collected with the assistance of fisheries officials. The field study was conducted in July–October 2007.

This study is the most extensive investigation on duck-fish integration in the past two decades in China, covering detailed characteristics of important duck-fish production systems, development trends, future prospects and other important issues of duck-fish integration. It provides a general picture of the duck-fish integrated fish farming systems in eastern China, the most important area for aquaculture production, as well as duck husbandry throughout the country. This study provides detailed information on the technical and socio-economic aspects of duck-fish integration in the country. It provides important documentation of the characteristics of different duck-fish systems and represents the scope of different duck-fish systems in the three provinces.

1. INTRODUCTION

Aquaculture continues to grow more rapidly than all other animal food-producing sectors. Since 1970, it accounts for an average global annual growth rate of 8.8 percent per year,

compared to only 1.2 percent for capture fisheries and 2.8 percent for terrestrial farmed meat production systems (FAO, 2007). In addition to the rapid growth in production and expansion in area and across the regions in the world, aquaculture is also characterized by extremely diversified systems and models practised. In particular, aquaculture is often organically integrated with other traditional agricultural or food-producing activities, such as crop farming, animal husbandry, horticulture and vegetable plantation. This kind of integration is greatly attributed to the dependence of aquaculture and other agricultural activities on common resources, such as water and land.

Duck-fish integration is a common type of integration between fish culture and animal husbandry. It is greatly attributed to the mutual need of fish and duck for water in addition to other considerations and benefits. Integration of different animals in the production system usually leads to a more complicated material cycling and energy flow in the system. There are more internal and external factors influencing the system's performance. It is essential to accurately assess the status of different types of integration between fish culture and other agricultural activities, and how they are affected by different social, economic and technical aspects in order to predict future trends and guide best practices for sustainability. It is timely to conduct a detailed study on duck-fish integration, an integrated aquaculture system of global importance in terms of animal food production and environmental impacts. It will be examined whether such a traditional farming practice still fits into the present concept of sustainable development and what modifications should be made.

China has practised aquaculture for thousands of years and its aquaculture production has ranked top in the world for nearly two decades. Its aquaculture production reached a historical 35.94 million tonnes in 2006 (BOF, 2007a). Currently, it is also the top duck raising country in the world. In 2005, the total amount of ducks kept at the end of the year in China was 725 020 million, or 69.28 percent of the world total (Gong *et al.*, 2007). The same year, 1 804.36 million ducks were slaughtered in the country, or 75.51 percent of the world total.

Traditional Chinese aquacultural practices have been characterized by the integration of fish and other agricultural activities. Together with the development of inland aquaculture in the country, ducks were introduced to fishponds in some parts of the country. In the 1980s, duck-fish integration became a popular model of integrated fish farming in some parts of China, which was promoted by the government. Various studies on the principles and optimal models of duck-fish culture were carried out in the 1980s and 1990s. Presently, duck-fish integration still remains an important fish farming system in a number of provinces in the country.

Jiangsu, Zhejiang and Jiangxi Provinces have traditionally had major industries of both inland fish culture and duck rearing. In 2006, inland aquaculture production of the three provinces was 2 532 790 Mt (Jiangsu), 1 573 929 Mt (Jiangxi) and 755 072 Mt (Zhejiang), which ranked third, fourth and tenth among all provinces/autonomous regions/municipalities directly under the Central Government (MDUCGs) in China (BOF, 2007b). These three provinces are currently also among the largest duck raisers in the country and were the areas with the most popular duck-fish integration in China during the 1980s and 1990s. Preliminary information collected before the study indicates that duck-fish integration is practised in different areas of each province: this is the major reason for including the three provinces in the study.

The major objectives of this study were to: obtain general information on the distribution and scale of duck-fish integration in the three selected provinces of eastern China; identify important models and practices of duck-fish integration in the these provinces; collect detailed information on technical and economic aspects related to duck-fish integration in the these provinces; and review the past trend of duck-fish integration in these provinces and its major contributing factors. In addition, the study aimed to predict future prospects of duck-fish integration in the country by examining the driving forces and constraints.

2. DISTRIBUTION OF DIFFERENT DUCK-FISH PRODUCTION SYSTEMS IN THE THREE PROVINCES IN THE STUDY

Main duck-fish production systems

Although there are many diversified practices of duck-fish integration in the three provinces, the main duck-fish production systems can be classified into three types: duck-pond fish culture integration, duck-extensive fish culture in lakes/reservoirs/rivers, and duck-paddy-fish integration.

Duck-pond fish culture system

This is the most popular system currently practised. Here, duck and fish are most closely integrated through bidirectional material flow. In the system, the duck shed is either built on the pond dyke or above the fishpond. Some of the pond area is enclosed with netting as a swimming area for the ducks. The swimming area is connected to the fenced playing ground on the pond dyke, which is connected to the duck shed.

Duck-extensive fish culture in lakes/reservoirs/rivers

This is another type of duck-fish production system commonly practiced in the open water bodies in the three provinces. The duck shed is usually built on the river bank or lake/reservoir side. Similar to duck-fishpond system, a certain area of water and land is fenced in with netting and serves as a swimming and playing ground for the ducks.

The duck-paddy-fish production system

There are two different duck-paddy-fish production systems. A closely integrated duck-paddy-fish production system is actually the combination of duck rearing with fish culture in paddy fields (Wang, 2003). The paddy field is modified for concurrent fish culture by digging peripheral and central cross ditches. Fish stocking can be carried out before or after transplanting. The duck shed is built on the broad ridge of the field. Duck raising usually starts after the transplanted seedling turns green. Another duck-paddy system is practised in a much looser form. Here, ducks are raised in the duck shed on the pond dyke or bank of a lake/reservoir/river during most of the production period. After the paddy is harvested, the ducks are grazed on the paddy field in the daytime and return to the duck shed in the evening.

Numbers of producers of main duck-fish production systems

The number of producers of different duck-fish production systems is given in Table 1. It is based on the data collected by local fisheries officials. Since the data collected could not

cover some of the municipalities in the three provinces, the number of producers of different duck-fish production systems is actually underestimated. The collected data covered some two-thirds of the total municipalities in the provinces; there is generally limited duck-fish integration in the missing municipalities. Therefore, the number of producers given in Table 1 may account for 80–90 percent of the total number of duck-fish producers in these provinces.

Table 1 clearly shows that Jiangxi is the province with the most integrated duck-fish farmers among the three provinces. In 2006, there were some 240 233 fisheries households in Jiangxi Province (BOF, 2007c). It is estimated that households engaged in aquaculture account for some 70 percent of the total number of fisheries households in the province. In total, there are some 170 000 fish farmers in the province. The figure of 53 602 duck-fish farmers accounts for 31.53 percent of the total number of aquaculture farmers in the province. This fully demonstrates how important the integrated duck-fish production system is in the province.

Geographical scope and distribution of main duck production systems

The general scope of the three main duck-fish production systems is shown in Table 2. It needs to be pointed out that since there are no statistical data available and some of the

TABLE 1
No. of producers of three main duck-fish production systems in Jiangsu, Jiangxi and Zhejiang Provinces, eastern China

System	Jiangsu	Jiangxi	Zhejiang	Total
Duck-fishpond	1 753	25 142	612	27 507
Duck-fish in lake/reservoir/river	1 027	13 813	2 341	17 181
Duck-paddy-fish	2 935	5 819	160	8 914
Total	**5 715**	**44 774**	**3 113**	**53 602**

TABLE 2
No. of ducks and farms of main duck-fish production systems in Jiangsu, Jiangxi and Zhejiang Provinces, eastern China

	No. of ducks ('000 heads)				No. of farms			
System	Jiangsu	Jiangxi	Zhejiang	Total	Jiangsu	Jiangxi	Zhejiang	Total
Duck-fishpond	16 589.8	358 137.4	1 219	375 946.2	1 753	25 142	612	27 507
Duck-fish in lake /reservoir/ river	3 197.7	259 817.8	2 340	265 355.5	1 027	13 813	2 341	17 181
Duck-paddy-fish	797.2	131 981	80	132 858.2	2 935	5 819	160	8 914
Total	20 584.7	749 936.2	3 639	774 159.9	5 715	44 774	3 113	53 602

municipalities failed to provide the required data for the study, the figures in Table 2 may reflect 80–90 percent of the actual scope.

Table 2 shows a significant difference in the general scope of different duck-fish production systems in the three provinces. It is clear that the general scope of duck-fish production systems is largest in Jiangxi Province, followed by Jiangsu Province. The scope of duck-fish production systems is much smaller in Zhejiang Province. It is interesting to point out that the scope of duck-fish integration is in an inverse relationship with the general economic development level of the province. This suggests that duck-fish production system is suitable for less development areas. The duck-fishpond production system is the most dominant of the three major duck-fish production systems, in terms of number of farmers and number of duck raised. The duck-paddy-fish production system is much smaller in scope in all the provinces. This may be due to the greater complexity in the arrangement between duck and paddy farmers.

Geographic distribution of different duck-fish systems within the three studied provinces

The distribution of different duck-fish production systems in the three provinces, as shown in Tables 3 to 5 is uneven between and within the provinces.

The practice of duck-fish integration in Jiangsu and Jiangxi Provinces is more concentrated in certain parts of the province where water resources are more abundant. In contrast, the duck-fish production system is more evenly distributed in Zhejiang Province on a relatively small scale. This is partially due to the geographic conditions of the province, which is basically a hilly area unsuitable for the large and concentrated operations of such a system.

TABLE 3
Distribution of different duck-fish systems in Jiangxi Province

City	System	No. of farms	No. of ducks ('000)
Jiujiang	Duck-fishpond	162	920
	Duck-lake/river/reservoir	59	1 020
Shangrao	Duck-fishpond	996	1 422.3
	Duck-paddy-fish	8	21
	Duck-lake/river/reservoir	406	2 439
Yichun	Duck-fishpond	6 283	15 410
	Duck-lake/river/reservoir	3 373	39 360
Nanchang	Duck-fishpond	215	210

TABLE 4
Distribution of different duck-fish systems in Zhejiang Province

City	System	No. of farms	No. of ducks ('000)
Hangzhou	Duck-fishpond	23	60
	Duck-paddy-fish	160	80
Huzhou	Duck-fishpond	216	275
	Duck-lake/river/reservoir	1 960	1 106
Jiaxing	Duck-fishpond	10	30
	Duck-lake/river/reservoir	60	250
Jinhua	Duck-fishpond	20	60
	Duck-lake/river/reservoir	5	100
Lishui	Duck-fishpond	228	308
Ningbo	Duck-fishpond	16	37
Shaoxing	Duck-fishpond	51	313
	Duck-lake/river/reservoir	307	780
Taizhou	Duck-fishpond	18	56
	Duck-lake/river/reservoir	8	100
Wenzhou	Duck-fishpond	30	80
	Duck-lake/river/reservoir	1	4

TABLE 5
Distribution of different duck-fish systems in Jiangsu Province

City	System	No. of farms	No. of ducks ('000)
Changzhou	Duck-fishpond	71	650
	Duck-paddy-fish	2 400	180
Nanjing	Duck-fishpond	315	5 960
	Duck-lake/river/reservoir	75	1 067
Nantong	Duck-paddy-fish	17	1.2
Suzhou	Duck-fishpond	7	19.5
Taizhou	Duck-fishpond	300	1 600
	Duck-paddy-fish	272	164
	Duck-lake/river/reservoir	731	674
Xuzhou	Duck-fishpond	230	150
	Duck-lake/river/reservoir	171	130
Yangzhou	Duck-fishpond	657	3 070
Yizheng	Duck-fishpond	11	35.9
	Duck-lake/river/reservoir	3	125.4
Zhenjiang	Duck-fishpond	162	5 104.4
	Duck-paddy-fish	246	452
	Duck-lake/river/reservoir	47	1 201.3

3. CHARACTERISTICS OF DUCK-FISH PRODUCTION SYSTEMS

Household profiles of duck-fish farmers

Household size

Fifty-two households with the duck-fish system as their major production activity were interviewed in the study. The household size ranged from two to seven persons/household. The average household size is four persons/household, which represents the typical household size in China's rural areas.

Educational background

The educational background of the household heads who usually manage production was included in the interview. The results are shown in Table 6. On average, the household head received 8.94 years of education. This means that, in general, they had completed the compulsive education set by the government. It also reflects that those managing the duck-fish production system have a relatively low level of education.

Age

Table 7 shows the age distribution of the household heads interviewed: the average age was 46.02 years old. This suggests that the duck-fish production system was often operated by relatively older people.

TABLE 6
Years of education received by heads of households managing the duck-fish system

Level	Primary school	Secondary school	High school	Technical high school
Years of education	6	9	12	12
Sample size	14	25	12	1
Share of total (%)	26.9	48.1	23.1	1.9

TABLE 7
Age groups of household heads managing the duck-fish production system interviewed in Jiangsu, Jiangxi and Zhejiang Provinces, eastern China

Age (years)	31–40	41–50	51–60	61–70
No.	16	21	13	2
Share of total (%)	30.8	40.4	25.0	3.9

Layout of duck-fish farm

Facilities involved in the duck-fish production system are limited. They basically consist of three major components: the duck shed, the playing ground and swimming areas for the ducks, and the fish culture area.

The duck shed is constructed on a pond dyke or on the bank of a lake, reservoir or river close to a water surface or a particularly broad ridge of paddy field. Few farmers construct their duck shed above the fish pond. The duck shed is usually supported by wood or bamboo posts. The roof is commonly covered with asbestos tile or rigid plastic sheets or other light waterproof materials. The duck shed is usually fenced off with bamboo or wood pieces that are no longer needed for, or remain from, the construction of the roof. Straw is laid on the ground floor or above the ground floor. In the latter case, the ground is often cemented, with grooves to facilitate the collection of duck waste.

The duck playing ground is fenced with netting or a bamboo screen and is adjacent to the duck shed. The fence extends to the water to establish an enclosed area in the fish pond or natural water for duck swimming. The fence is mainly used to prevent the ducks from escaping, not fish from entering the area.

The layout of the duck-fish farm of different systems is shown in Figures 1–3.

FIGURE 1
Layout of the duck-fishpond system

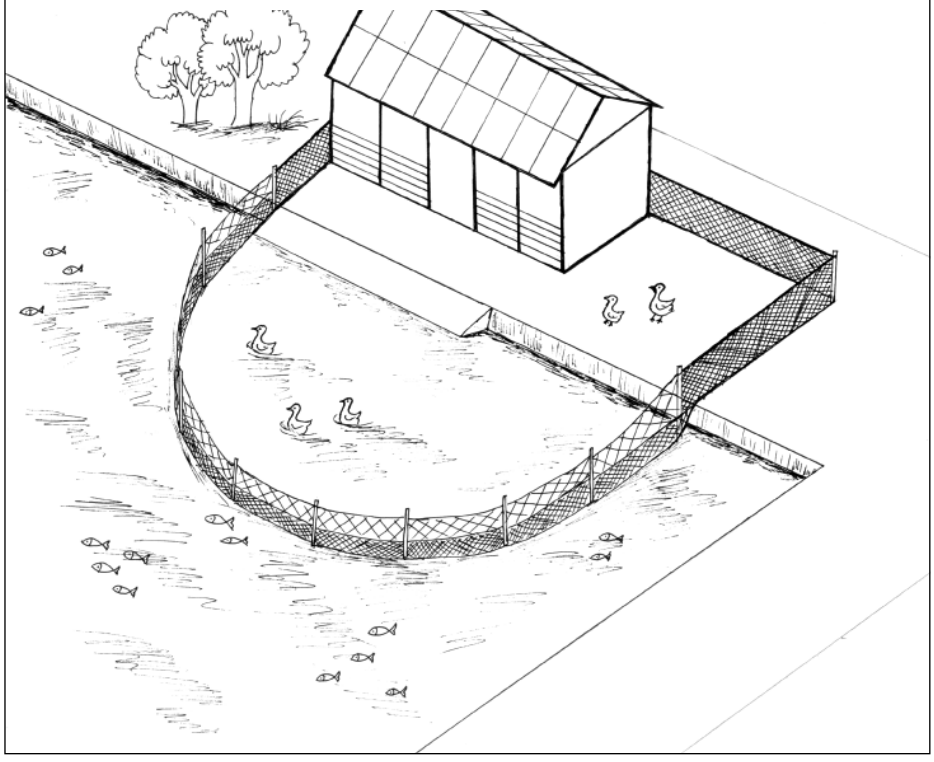


FIGURE 2
Layout of the duck-lake/reservoir system

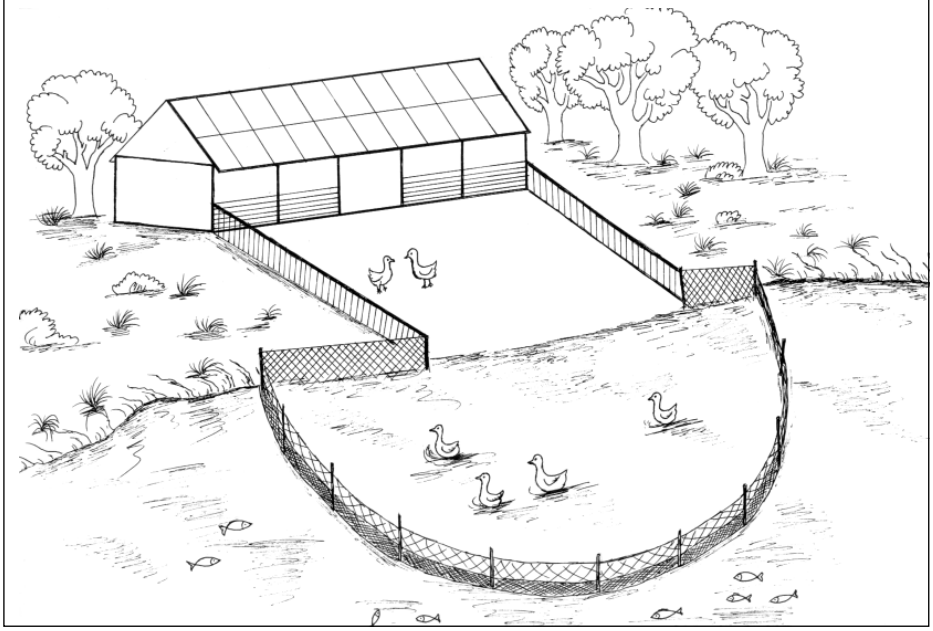
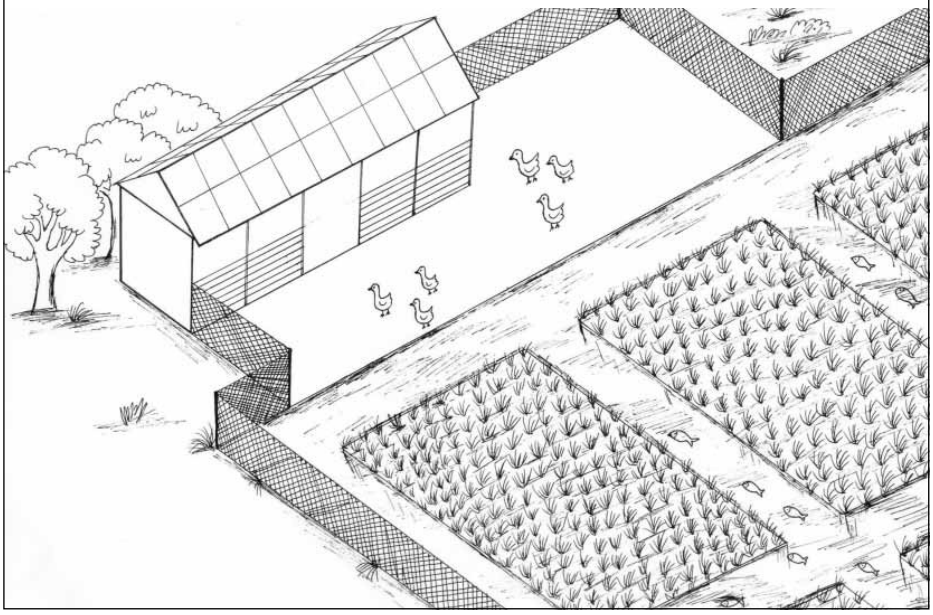


FIGURE 3
Layout of the duck-paddy-fish system



4. DUCK BREEDS AND FISH SPECIES IN DUCK-FISH INTEGRATION IN CHINA

Duck breeds

According to the interview with the duck-fish farmers in the three provinces, some ten different duck breeds are used in duck-fish production systems (Table 8). These breeds generally fall into two categories, an introduced duck breed, such as Cherry Valley duck (an improved strain of Peking duck), and different local duck breeds. Table 8 shows that Cherry Valley duck is the most popular duck breed in the duck-fish production system, used by more than a third of the interviewed farmers. The second most important duck breed is Shaoxing duck, a famous local duck breed. Cherry Valley duck is characterized by fast growth and a large body size. Shaoxing duck and other local strains are relatively smaller and have a better meat flavour.

Fish species in the duck-fish production system

Polyculture is presently the major fish farming systems in China. Extremely diversified fish species are involved in duck-fish production systems in the three eastern provinces studied. The interviewed duck-fish farmers reported some 20 fish species used in their duck-fish production system – silver carp, bighead carp, grass carp, Crucian carp, Chinese bream,

TABLE 8
Duck breeds used in duck-fish production systems in Jiangsu, Jiangxi and Zhejiang Provinces, eastern China

Duck breed	Cherry Valley duck	Shaoxing duck	Longyan duck	Ma duck	Red feather duck	Gaoyou duck	Hybrid duck	Cyan shell egg duck	Other breeds
No. of farms	16	9	6	3	2	2	2	2	3
Share (%) of total farms	35.6	20.00	13.3	6.7	4.4	4.4	4.4	4.4	6.7

TABLE 9
Fish species used in duck-fish production systems in Jiangsu, Jiangxi and Zhejiang Provinces, eastern China

Species	Bighead	Silver carp	Grass carp	Crucian carp	Chinese bream	Common carp	Black carp	Other species
No. of farms	47	43	42	39	18	14	13	26
Share (%) of total farms	88.68	81.13	79.25	73.58	33.96	26.42	24.53	49.06

common carp, black carp, catfish, Mandarin fish, tilapia, yellow head catfish, colosoma, red common carp, freshwater crayfish, snakehead and a few unidentified species. Table 9 lists the important fish species in duck-fish production systems and the number of farmers who use them in their production. Obviously, carp species, particularly Chinese carp, play an important role in duck-fish production systems. Among all identified fish species, there are only two exotic species, tilapia and colosoma.

The importance of silver carp and bighead in duck-fish production systems is mainly due to the character of both the fish species and the production system. Effluents from duck raising can significantly promote the production of natural food organisms, particularly plankton in the fishpond, and silver carp and bighead are the fish that can use them most effectively.

5. PRODUCTION PATTERNS

On-farm material flow and productivity

On-farm material flow in the duck-fish system can be generally divided into two types: duck integrated with fish culture in ponds or open water bodies and integrated production systems of duck with fish culture in paddy. Material flow in production systems of duck integrated with fish culture in ponds or open water bodies (lakes, reservoirs and rivers/canals) is similar to that shown in Figure 4. The major variations are the types and amount of feed input used. Commercial feed is commonly applied in semi-intensive or intensive fishponds integrated with duck. Fish yield can reach 6-15 tonnes/ha in such practices, whereas only supplemental feed (green fodder and by-products from grain processing and oil extraction) or no feed is applied in extensive fish culture practices integrated with duck. The fish yield is usually 3–5 tonnes/ha or even lower.

Pond dyke and cropland play very important roles in effective duck-fish production systems. Pond silt and excessive waste from duck raising can be well used for growing green fodder, grains and vegetables. Not only can it improve the economic efficiency of the system by reducing the feed cost, but it can also minimize the environment impacts when a large number of ducks are raised.

Figure 5 shows the material flow in integrated production systems of duck with fish culture in paddy. There is no fundamental difference from the previous system except that the linkage between fish, duck and crop is tighter in this production system. Fish yield is much lower in this kind of system, normally 450–750 kg/ha (paddy area), in addition to the normal paddy production of 7-8 tonnes/ha (Liang Y. *et al.*, 2004). The low fish yield is mainly due to short growth period and limited water surface.

Calendar of farm activities

The calendar of farm activities in the duck-fish production system is complex, changing with systems and practices, as summarized in Table 10.

Fish culture operations in ponds/reservoirs/lakes and rivers/canals generally follow the same pattern in production calendar. Fish culture in paddy fields assists paddy plantation. Stocking of fish can be undertaken shortly before or after the transplanting of paddy. Fish is usually harvested some time after paddy harvesting to extend its growth period.

FIGURE 4
Material flow in the integrated duck-fishpond production system

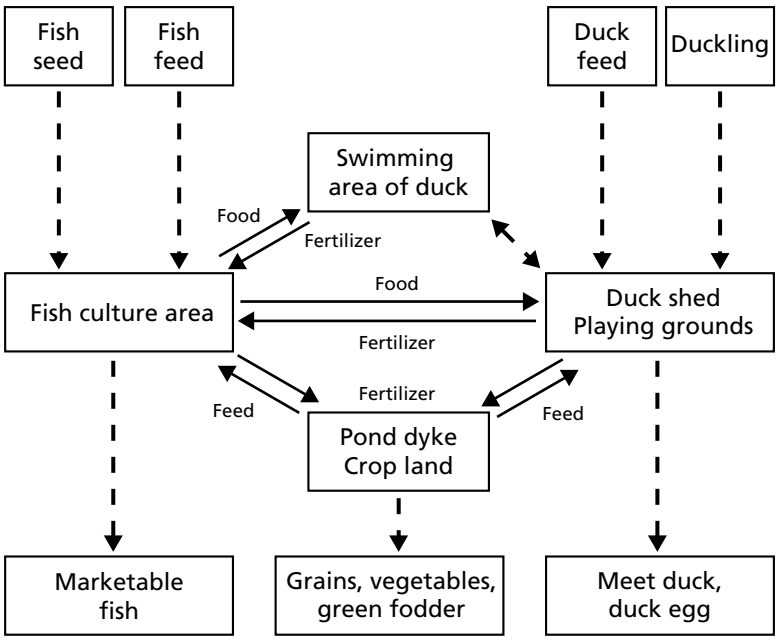


FIGURE 5
Material flow in the duck-paddy-fish integrated production system

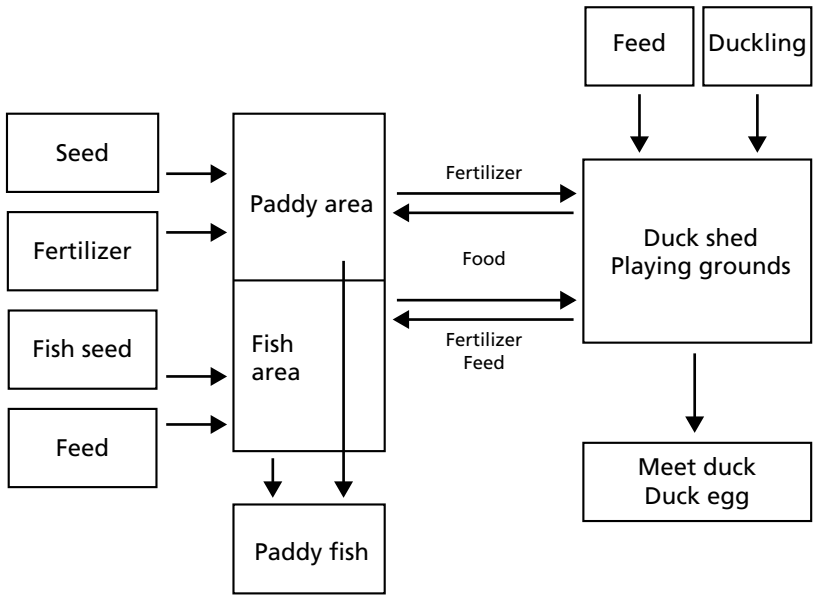


TABLE 10
Calendar of farm activities in duck-fish production systems

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Stocking of fish in pond/lake/reservoir					Selective harvesting of fish						Preparing of the ponds		
	Feeding of fish												
			Planting of Sudan grass on dyke					Planting of rye grass on dyke			Total harvesting of fish		
					Stocking of fish*								
			Prevention and treatment of fish disease										
	Purchasing of the first batch of ducklings		Marketing of the first batch of meat duck										
					Laying of eggs of first batch of ducks								
Feeding of ducks, carrying out disease prevention and daily management													
Marketing of old ducks										Marketing of old ducks			
		Changing of duck shed /10–15 day											
				Carrying out paddy nursery operations									
					Transplanting of paddy	Weeding, carrying out pest control and fertilization			Harvesting of paddy				
					Stocking fish in paddy				Fish harvesting in paddy				

* Stocking of summer fingerling for producing large-sized fish seed for grow-out culture in the following year.

The complexity lies mainly in duck-raising activities. In general, farmers usually start operations after the Chinese New Year (late February to early March) by purchasing their first batch of ducklings. When ducks are raised for meat ducks, the culture period is 45–55 days. The ducks change their shed every 15 days when the duck density is also adjusted. Under normal operations, the next batch of ducklings is purchased when the previous batch of ducks change their shed. This is a continuous rotating process except for the interruption in the hot summer (July–August). Farmers can normally produce 8–10 batches of meat ducks a year.

When ducks are raised for egg production, the production cycle is different than that for meat duck production. It takes some 120 days for ducklings to start laying eggs. The egg laying period for each batch of ducks ranges from 6 to 12 months. The length of the period depends on three factors: the price of the duck egg, the price of the spent duck and the egg-laying rate of the duck. If the egg price is low, the spent duck price high and the egg laying rate low, farmers will shorten the egg laying period and sell the spent duck. When egg price is high or the spent duck price is low or the egg laying rate is high, farmers usually keep the layer ducks for a longer period. Farmers usually purchase the second batch of ducklings (for egg laying) some six months after purchasing the first batch. In this way, the first batch of ducks can be replaced by a new generation after laying eggs for six months.

6. ECONOMIC CHARACTERISTICS

Types and source of feed inputs

In all practices of duck-fish integration, feed is used in duck raising. Most farmers use specialized duck feed from commercial feed manufacturers. Different types of feed are used for different rearing stages, e.g. ducklings, fattening and the egg-laying stage. Some farmers use farm-made duck feed with locally purchased ingredients. Farm- made feed is much cheaper than commercial feed. Normally, to produce 1 kg of meat duck, 2.5-3 kg of feed are needed. One egg-laying duck needs some 50 kg of feed in a year. The cost of commercial duck feed is CNY1.60-2.45/kg[3], depending on the growing stage of duck and location. Feed for ducklings during the first 15 days costs more; farm-made feed is much cheaper.

The feed application used in fish culture depends on culture systems and practices. Fish culture in lakes, reservoirs and rivers usually depends on natural food released by effluents discharged from duck raising. When fish culture is integrated with pond fish culture, the feed application depends on the species and density of fish cultured. No artificial feed is applied when silver and bighead are stocked as the major species at high stocking density. When Grass carp, Chinese bream and Crucian carp are stocked as the major species, commercial pellet and terrestrial grass are commonly applied. Terrestrial grass is often grown on the pond dyke. Commercial pellet feed for fish usually costs CNY 2-2.5/kg. It is difficult to estimate the feeding rate and food conversion rate (FCR) in polyculture ponds fertilized with duck waste.

[3] CNY1≈0.145 US dollar as at March 2008.

Labour and other inputs

Most of the interviewed farmers (39 out of 52) hire labour for duck-fish production in addition to family labour. The number of hired workers at each farm depends on the farms' operational scale. Most farms hire one to two workers, who are each paid CNY 500-1 000/month in addition to free room and board.

Other inputs used in duck-fish production include fish seed, ducklings, a constructed and maintained duck shed, fuel/power, duck vaccinations and other drug/chemicals for disease prevention and treatment.

Most farmers interviewed produce fish seed for grow-out culture in their own water body with purchased post-larvae. Some farmers entirely or partially depend on purchased fish seed for grow-out culture. Ducklings used in duck-fish production are purchased either locally or from other areas. The price of duckling varies greatly, from CNY2/each to CNY4.5/each, depending on the season and location. Only farmers who have their own hatchery are self-sufficient in duckling supply.

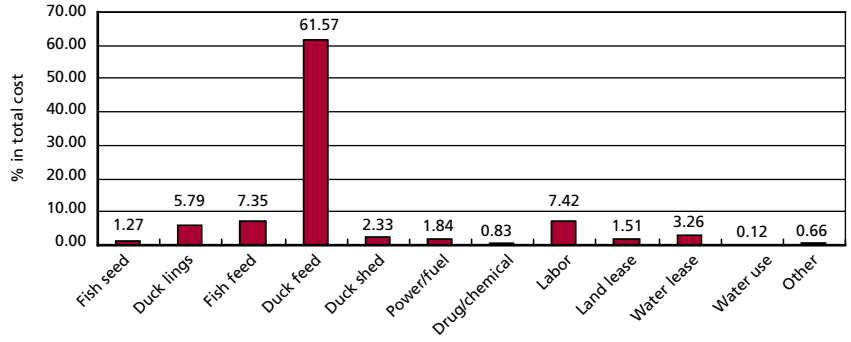
Break-down of production costs

The duck-fish farmers interviewed identified 12 different items of production costs. Figure 6 shows the break-down of production costs of the interviewed duck-fish farms. It is clear that duck feed makes up the largest share in the production cost, 61.57 percent, which is followed by labour cost, at 7.42 percent. Fish feed is usually the major production cost in sole fish culture, often accounting for 40–60 percent of the total production cost. The study shows that it accounts for 7.35 percent of the total cost of duck-fish production. This well demonstrates the benefit of duck-fish integration. Another relatively larger share of production cost in the duck-fish production system is from ducklings, at 5.79 percent. The result of the study implies the importance of improving feed management in duck raising.

Outputs

Outputs from the duck-fish production system include marketable size fish of different species, duck eggs and meat duck. Meat ducks/old ducks and duck eggs are the major outputs

FIGURE 6
Break-down of production costs in the duck-fish production system



in the production system considering their contribution to farm revenue. On average, meat duck and duck egg account for 76.30 percent of the total farm output value. Layer ducks are usually sold out after they lay eggs for about 12 months. The time when layer ducks are culled depends on two factors, the rate of egg-laying and the price of the egg. The egg-laying period of a batch of ducks may be shortened if the price of egg is not sufficient.

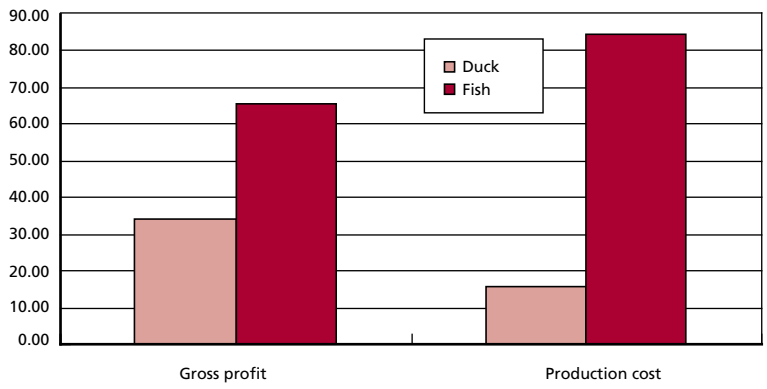
Marketable size fish is another important output from duck-fish production systems. The species of fish produced found depend on practices and are very diverse as polyculture is practised in different water bodies. In production systems in lakes, reservoirs and canals, silver carp and bighead carp make up the major portion of the production. In the fishpond and paddy field system, fish species often vary with location and intensity in fish culture.

Economic analysis

The analysis of economic data collected from the 52 interviewed farms indicates that duck-fish integration is a sound, economically efficient production system. In 49 of the 52 farms, the benefit/cost ratio was higher than 1, i.e. nearly 94 percent farms made a profit. The average benefit/cost ratio reached 2.19, which indicates high profitability. Compared to duck raising, fish production activities have better economic efficiency. The benefit/cost ratio reached 10.40. The benefit/cost ratio from duck raising was only 1.98.

Economic performance of major production activities in integrated duck-fish farms is summarized in Figure 7. In terms of share of the net income (gross profit) of the duck-fish farm, fish culture and duck raising contributed 34.2 percent and 65.8 percent, respectively. Considering that the share of fish culture and duck raising in total production is 15.6 percent and 84.4 percent, respectively, fish culture activities in the duck-fish farm are much more economically efficient, greatly benefiting from duck raising, which significantly reduces the feed cost in fish production.

FIGURE 7
Share of fish culture and duck raising in total gross profit and production cost (%)



Marketing aspects related to duck-fish production system

Fish production in the duck-fish system shows strong seasonality, mainly due to the climatic features in the country. The main harvesting and marketing season starts just before and ends just after the Chinese New Year, although selective harvesting starts 4-5 months after stocking. The marketing of fish products is more concentrated during the Chinese New Year and other important holidays. This has often caused a slack in the market price of the products. The production of duck eggs and meat does not show distinct seasonality because it is generally a rotational system. The marketing of products is more or less balanced compared to fish products, but there is usually a 1-2 month interval in meat duck production between the Chinese New Year period and the hot summer.

Markets and methods of disposing products from the duck-fish system are diversified and highly dependent on the scale of operations. Small-scale farmers' products are usually marketed locally; large-scale farmers' products are sold to both local and distant market. Most of the farmers sell their products to wholesalers at the farm gate or at local wholesale markets. Some farmers sell their products at the local retail market in addition to wholesalers at the farm gate. Many farmers have regular buyers for their products. Market distances cover a wide range: some markets are just a few kilometres away from the farm, while other can be several hundred kilometres away.

Fish products from the duck-fish system are normally marketed live. This is very important for the farmer to fetch reasonable prices of the products as market price of dead fish is much reduced. Individual households are the major final buyer of fish products, although a proportion of them are sold to restaurants. Meat duck are also marketed live except from extremely large-scale farms with their own processing plants. The live ducks are finally sold to three different buyers – the processing plant, the restaurant and the individual household; the processing plant and the restaurant are the major buyers of meat duck because few households slaughter and prepare ducks at home. Duck eggs are usually marketed fresh. Some farmers process their duck eggs into salted eggs or century eggs, a traditional egg processing method. Duck processing does not require specialized equipment except for some additional labour cost. This simple process can increase the value of egg ducks by 5–15 percent.

Market prices of products from duck-fish production vary greatly according to season and location. Compared to duck prices, fish prices do not fluctuate much, but have been kept at a relatively low level in China in the past decades. The price of fish depends mainly on species, season and location, and normally ranges from CNY4 to 9 per kg. Specially raised meat ducks are usually sold at much lower prices (usually at CNY7–10 per kg) than culled egg-laying ducks (usually at CNY16-24 per kg). The price of fresh duck eggs is usually CNY8-10 per kg.

7. DEVELOPMENT TREND AND FUTURE PROSPECTS

Development trend

There are no statistical data available on the scope of duck-fish production systems (e.g. number of farmers and production) available in China. Therefore, it is very difficult to have a good idea of the past development trend of the duck-fish production systems in the

studied provinces as well as the whole country. A rough assessment is based on limited information collected during the study.

According to the feedback from the farmers interviewed, there has been significant expansion in the operational scale of all kinds of duck-fish production systems in recent years. Such expansion is mainly driven by increased market prices and improved efficiency in overall economic performance and resource use. A few farmers experienced a reduction in the production scale, which was mainly due to resource limitations, such as drought and diverted land use, such as the building of roads.

Although there are no statistical data that can reflect the expansion in the general scope of different duck-fish systems, many local fisheries officials agree that there has been a significant increase in the total number and production scope of duck-fish production systems. Some information collected during field interviews may be helpful to gain a more objective view. One item of data collected in the interview was the number of years in which the interviewed farmers had been operating duck-fish production, as shown in Table 11.

Table 11 shows that nearly 60 percent of the interviewed farmers entered duck-fish operation within the last five years, and 23 percent in last ten years. This can be considered a good indicator of the expansion in the general scope of duck-fish production.

The scope of some duck-fish systems has reduced in recent years although the general scope of duck-fish production has expanded in China. A typical example is the duck-fish culture in river/canal close to urban areas in Zhejiang Province, a system that used to be very commonly practised. In recent years, it has now reduced mainly due to more strict control over the activities that may potentially cause environment degradation, especially of the aquatic environment.

Future prospects

Constraints

Duck-fish production has achieved significant development and has become an industry of significant scope in the three provinces. However, it also faces a number of constraints currently.

Uncertainty due to potential threat of the avian influenza

Since 2004, there have been a number of cases of the bird flu in duck farms in a number of provinces in China. Many ducks were deeply buried or burned in the surrounding area whenever a suspected case of bird flu was found at an individual chicken or duck farm.

TABLE 11
Years of farmers operating duck-fish production system

Years of operation	1-5	6-10	10-15	15-20
No. of farmers	31	12	4	5
Share of total (%)	59.62	23.08	7.69	9.62

The number of ducks buried can reach 300 000-400 000 for just one case. Farmers suffered tremendous economic loss, although the government subsidized the affected farmers based on the number of ducks lost. As the bird flu remains an unresolved issue, it is still a great threat to the duck farmers. The good economic performance of the duck-fish integrated production system found in this study is largely due to rebounding from heavy losses from previous bird flu epidemics. Whether the current positive trend of the duck-fish production system can be maintained is largely determined by the effective control of bird flu epidemics.

Environmental issues

In recent years, conservation of natural environment, particularly the aquatic environment, has been attracting greater public concern in China. Production systems closely related to the aquatic environment are under increasing public concern over possible adverse environmental impacts. Aquaculture is blamed as a source of pollutants under certain circumstances. Some duck-fish production systems are strictly controlled in the water bodies close to urban centres that serve as important water sources. For instance, duck-fish production along canals in the suburb in Zhejiang Province used to be a popular practice. Poorly managed large-scale duck-fish farms often cause a high fertility in canals due to waste discharge, and affect other uses of water and the overall environment. The number of these farms reduced significantly due to environment control. An increase in strict control is likely to be imposed on natural water-based production systems that may discharge waste into the environment. Duck-fish production systems closely attached to natural water bodies (lake, river and reservoir) are most likely to be affected. However, the reservoir-based duck-fish production system is more dependent on the reservoirs' main function. Duck-fish production operated in reservoirs mainly used as a water source for domestic and industrial uses will face a more challenging situation.

Socio-economic issues

China is currently experiencing rapid socio-economic changes, affecting all traditional production systems. Duck-fish production is no exception. With improving living standards of the rural population, occupations characterized by labour-intensive and tough working conditions become less attractive to people, particularly the younger generation, despite a decent income. The average age of the interviewed farmers being over 46 years old is good evidence. Such a situation will remain or even become worse unless there is significant improvement in the working conditions of those engaged in the production system.

There is a general scarcity of all kinds of natural resources in China due to the large population base and rapid economic development. Water and land resources, on which the duck-fish production system depends, are among those over which there exists high competition. The duck-fish production system can generate a much higher income than traditional agricultural activities, such as crop farming, sole fish farming or poultry husbandry. However, its disadvantage in economic efficiency becomes obvious when compared to industry or housing. Therefore, duck-fish production will face stronger pressure from other businesses in competition for resources in peri-urban areas in the country.

Potential for development

There is still potential for developing duck-fish integration in China, although it is currently facing a number of constraints. There are three reasons for this kind of outlook. First, both fish and duck are traditionally important animal food for the Chinese people. They are increasingly gaining popularity among consumers in recent years for various reasons: they are recognized as healthy food by an increasing number of consumers, and demand for fish and duck/duck egg is expected to increase, especially as the population increases and people's living standards improve.

Second, good practices of duck-fish and duck-fish-paddy is generally part of the Chinese "circular economy". In this kind of system, natural resources – water, land and material inputs, particularly feed – can be fully used in multiple ways in the production cycle. Wastes produced in different components can be digested to a very large extent, if not completely, within the system. In addition, this system may bring other ecological and economic benefits, for instance, integrated pest management in the paddy field.

Finally, the duck-fish production system is a much more economical system than most traditional crop farming and poultry husbandry systems. China will remain an agricultural country for a long period despite its rapid development in the past two decades. Improving the income level and living standards of the rural population will remain priority tasks in national economic development. With greatly diversified socio-economic and natural conditions in the country, the duck-fish production system can play an important role in fulfilling these tasks, particularly in areas with available necessary natural resources and a good market.

REFERENCES

BOF (Bureau of Fisheries). 2007a. *China fisheries statistic yearbook*. Ministry of Agriculture, Beijing, China

BOF. 2007b. *China fisheries statistic yearbook*, pp 21-25. Ministry of Agriculture, Beijing, China.

BOF. 2007c. *China fisheries statistic yearbook*, pp 78-79. Ministry of Agriculture, Beijing, China.

FAO. 2007. *The State of World Fisheries and Aquaculture 2006*. Department of Fisheries and Aquaculture. Rome

Gong, G., Gu, H., Wang, X. & Wang, Z. 2007. *Development status, problems and trend of water bird culture in China* (available at www.chinabreed.com/poultry/develop/2007/09/20070918143759.shtml).

Liang, Y., Liu, X., Zheng, Y., Tang, H. & Xiang, B. 2004. Experiment on comprehensive benefit from combined ecological model of paddy-duck-fish and paddy-fish-vegetable. *Freshwater Fisheries,* Vol. 34 (4):40-43.

Wang, X. 2003. Effect and method of ecological cultivation and culture of fish-paddy-duck. *China Poultry,* 25 (12):17-18.

Yang, H. & Hu, B. 1989. Integrated management of fish-livestock-poultry farming, pp.175-180. In *Integrated fish farming in China–NACA technical manual,* No. 7. Bangkok, Thailand, Network of Aquaculture Centres in Asia-Pacific (NACA).