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Eel Aquaculture Industry in Taiwan

Abstract

In Taiwan, eel aquaculture is the most important sector of the aquaculture industry. The species cultured is mainly the Japanese eel *Anguilla japonica*. Both the warm weather and fine quality of groundwater in Taiwan are very suitable for the growth of Japanese eel, which are easily stocked in outdoor ponds for intensive culture. Owing to the endeavor of eel farmers and the government's guidance over the past years, the development of the eel aquaculture industry went through the embryonic stage in the 1950s, transition stage in the 1960s, expansion stage in the 1970s, and prosperous stage in the 1980s. In the 1990s, because of the acute shortage of elvers and strong competition for the Japanese market from mainland China, the depression stage emerged. Whether the sustainability of eel aquaculture in the 21st century can be achieved is an urgent issue. The production cost must be further reduced, the product quality must be elevated and the domestic markets must be expanded to keep the industry playing an important role in Taiwan's aquaculture industry.

Key words : Eel aquaculture, Japanese eel *Anguilla japonica*, Taiwan

The history of eel aquaculture in Taiwan can be traced back to 1923, when the Japanese eel *Anguilla japonica* was first experimentally cultured⁽¹⁾. The milestone for its commercialization was the successful research conducted at Lukang Experiment Station (now Lukang Branch), Taiwan Fisheries Research Institute (TFRI) in 1957^(1,2,3). The export of elvers or cultured adult eels to Japan in 1964 and 1968, respectively, promoted the internationalization of the eel aquaculture industry in Taiwan⁽¹⁾.

Resulting from the endeavor of eel farmers and the government's help over the past half century, this industry has already become the most profitable aquaculture sector in Taiwan. Yet in recent years, the prosperous development of eel aquaculture in

mainland China along with the shortage of elvers made the scale of this industry to decline. Its historical development in Taiwan must be understood to find out a way for sustaining the industry.

In Taiwan, some small-scale test of eel aquaculture had been conducted from 1923 to 1942, stopping for several years during World War II, and then restarting again from 1952. The main events of the eel aquaculture industry in Taiwan^(2,4,5), based on a ten-year period since the 1950s are described in this paper, accompanied with the statistical data published by the Fisheries Administration, Committee of Agriculture⁽⁶⁾, to depict its development over 1950-1999. Data included in this paper are for the Japanese eel only.

1950-1959 (Embryonic stage): Culture methods for Japanese eel were established through a series of trial-and-error tests.

Table 1. Main events of the eel aquaculture industry in Taiwan from 1950 to 1959.

1952	First pond culture trials in Taoyuan, by China Fisheries Company, Ministry of Economics.
1954	Trials at Chupei Experiment Station, Taiwan Fisheries Research Institute (TFRI).
1956	Trials at Chupei Experiment Station transferred to Lukang Experiment Station, TFRI.
1957	Trials at Lukang Experiment Station succeeded and the technology transferred to eel farmers.

1. Elver supply

Catches of wild elvers were first officially recorded in 1955. The highest recorded quantity was 70,000 in 1956 and the highest value was NT\$ (New Taiwan Dollar) 18,000 in 1959 (Fig. 1 A). The average price of elvers (catch in value/ catch in quantity) was lower than NT\$ 0.2.

2. Culture area

Eel culture area was first recorded in 1953; the

highest was 5 ha in 1955. None was recorded in 1958 (Fig. 1 B).

3. Aquaculture production

Eel aquaculture production was first recorded in 1958. The highest recorded quantity was 91 tons in 1959 and the highest value was NT\$ 4.27 million in 1958 (Fig. 1C). The share of eel aquaculture production to the total aquaculture production was less than 0.2% in quantity or 1% in value (Fig. 1D).

1960-1969 (Transition stage): Eel aquaculture technology was improved and the Japanese markets were expanded.

Table 2. Main events of the eel aquaculture industry in Taiwan from 1960 to 1969.

1964	Steady annual increase of culture area since this year. Shortage and increasing prices of elvers. Nets introduced from Japan to catch elvers at I-Lan coast, yet due to poor packaging and transportation techniques, survival was very low. Elvers sold by weight. Japan imported elvers from Taiwan, owing to the drastic reduction of local catch.
1966	Drastic reduction in market price of cultured eels due to overproduction; export to Japan began to be considered.
1968	Formulated feed for eels was tried under the guidance of Kaohsiung Branch, TFRI. Transportation, by vessel, of live eels to Japan failed. Machine for roasting eels introduced from Japan.
1969	Formulated feed produced; 362 tons of live eels successfully exported to Japan by air.

1. Elver supply

Low elver catch was observed from 1960 to 1967. In 1968, elver catch drastically increased to 53.9 million, and in 1969 reached 55.5 million. In 1969, the value of elvers caught was already over NT\$ 20 million in 1969 (Fig. 2A). The average unit price of elvers was from NT\$ 0.1 to 0.4.

2. Culture area

Eel culture area steadily increased annually since

1964, reaching about 158 ha in 1969 (Fig. 2B).

3. Aquaculture production

Slight increases were recorded from 1960 to 1967. The highest recorded production was 1,522 tons valued over NT\$ 110 million both in 1969 (Fig. 2C). The share of eel aquaculture production to the total aquaculture production in 1969 increased sharply to 2.7% in quantity and 12.2% in value (Fig. 2D).

1970-1979 (Expansion stage): The industry continuously grew due to its high profitability; several organizations were formed to integrate and promote its development.

Table 3. Main events of the eel aquaculture industry in Taiwan from 1970 to 1979.

1970	Culture area reached 273 ha. Shortage of elvers resulted in export ban since this year.
1971	Eel Exporters Association (<i>now</i> Eel and Shrimp Exporters Association) and Eel Producers Cooperative (<i>now</i> Eel and Shrimp Producers Cooperative) formed to establish systematic production and export, and to prevent ill competition.
1972	Culture area reached 1,000 ha. The price of elvers once reached NT\$ 22.5 per piece. Culture trials of European eel (<i>Anguilla anguilla</i>) did not succeed.
1973	Eel Producers and Exporters Coordination Group formed to adjust the supply and demand. Processed eels successfully exported to Japan. Import of elvers from Korea was permitted.
1974	Elver resources abundant, the price per piece went down to NT\$1-2.
1977	Culture trials of American eel (<i>Anguilla rostrata</i>) did not succeed.
1979	Eel Price Regulatory Foundation (<i>now</i> Eel Development Foundation) formed to keep the farmers from bankruptcy and to help expand the eel markets.

1. Elver supply

Annual elver catch was all over 10 million, more than 200 million in 1970 and 1978. The highest recorded value was nearly NT\$1,600 million in 1978; the lowest was NT\$20 million in 1975 (Fig. 3A). The average unit price was from NT\$1 to 8.

2. Culture area

Eel culture area steadily increased annually, rising sharply in 1972, when the area was over 1,000 ha; in 1978, the area was over 2,000 ha (Fig. 3B).

3. Aquaculture production

Aquaculture production, both in quantity and value, almost annually increased. Production in quantity from 1970 to 1979 increased 12 times, from about 2,000 tons to over 26,000 tons, and in value 40 times, from NT\$150 million to 6,200 million (Fig. 3C). Although the share of eel aquaculture to the total aquaculture production never reached 16%, the share in value was all more than 42% since 1972 (Fig. 3D), demonstrating the high profitability of eel aquaculture.

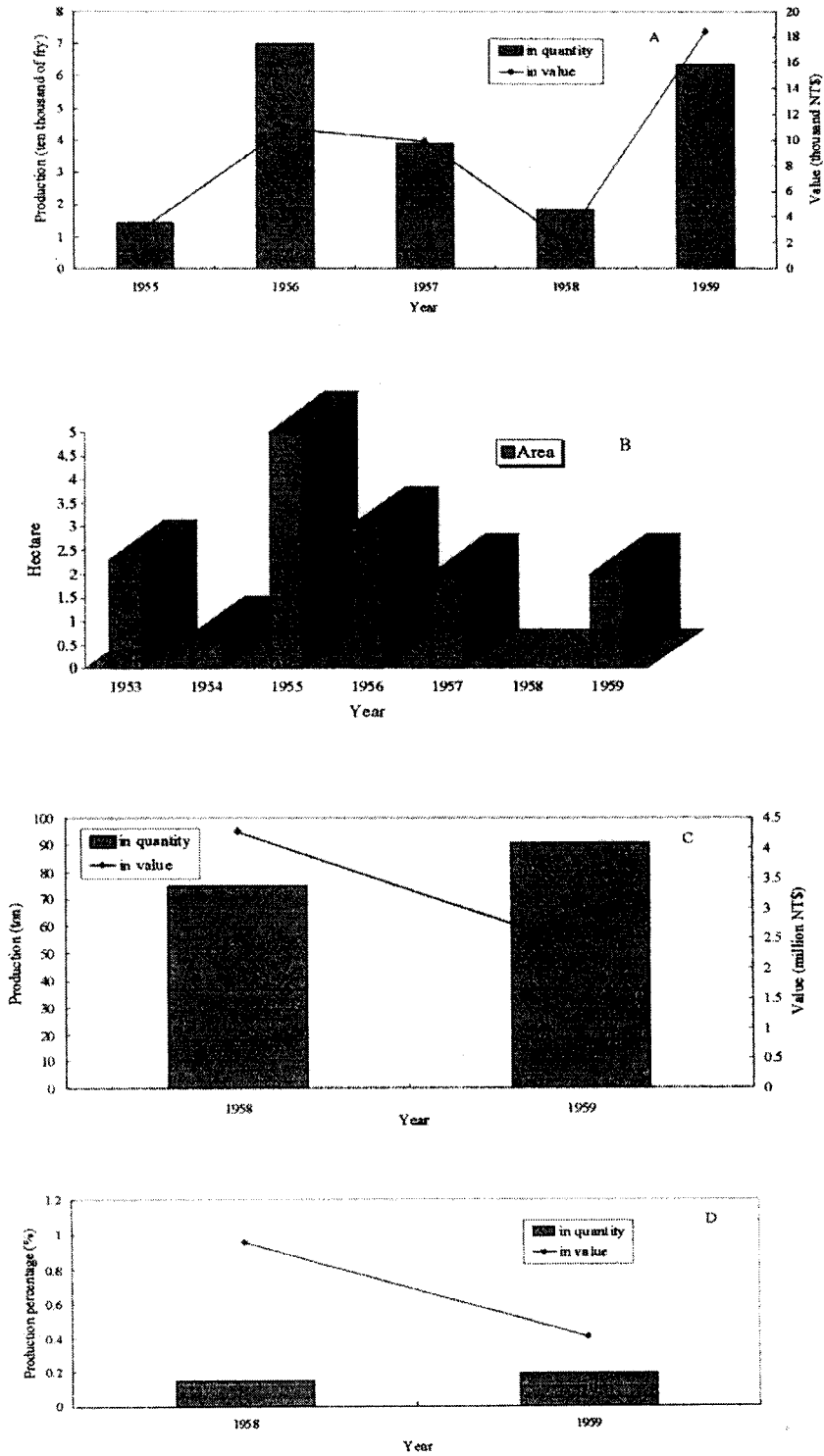


Fig. 1. Elver catch (A) culture area (B) aquaculture production (C) and share to the total aquaculture production (D) of the Japanese eel *A. japonica*, in Taiwan (1953-1959). (Source: Fisheries Statistical Yearbook, Fisheries Administration, COA, Executive Yuan, ROC)

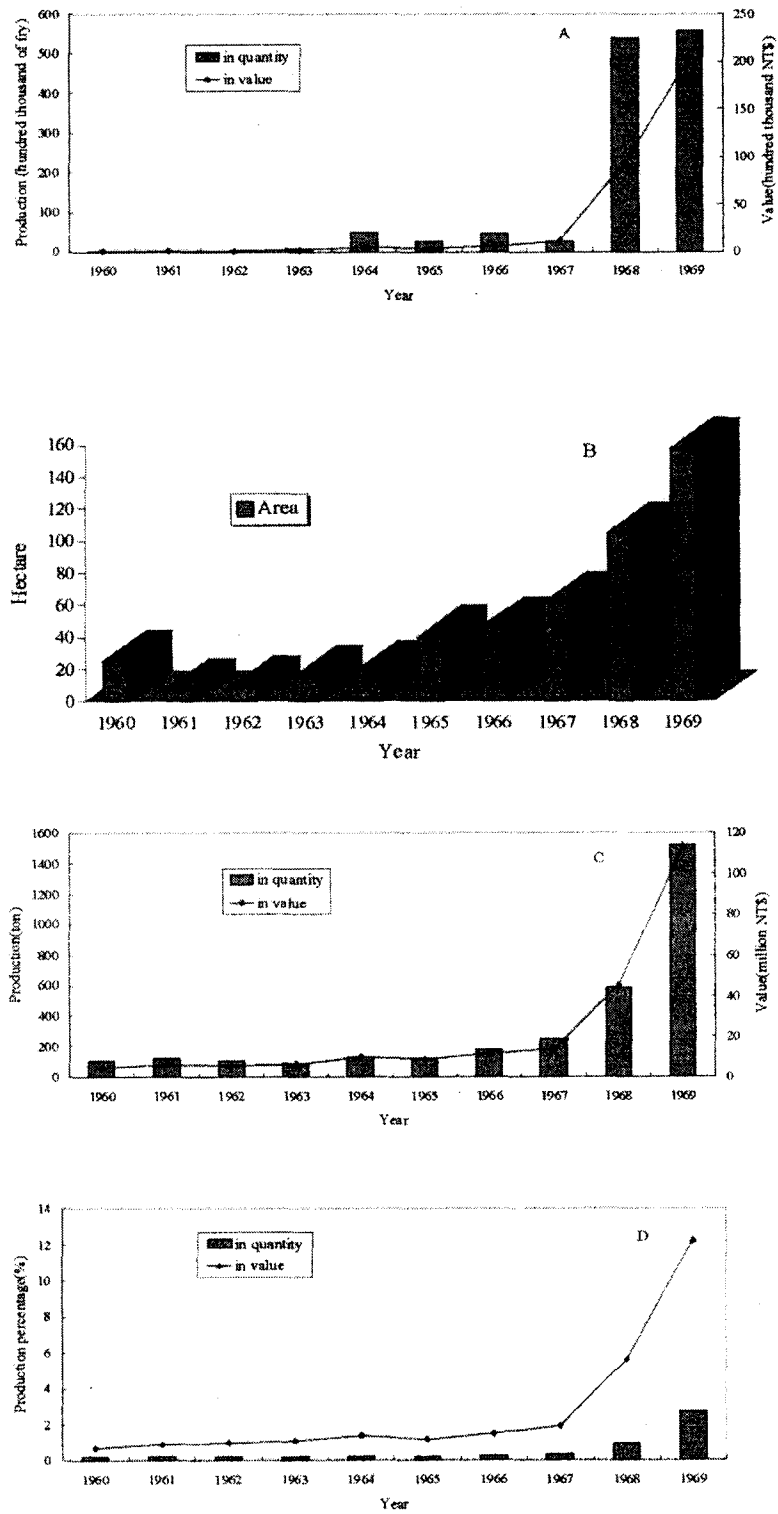


Fig. 2. Eelver catch (A) culture area (B) aquaculture production (C) and share to the total aquaculture production (D) of the Japanese eel *A. japonica*, in Taiwan (1960-1969). (Source: Fisheries Statistical Yearbook, Fisheries Administration, COA, Executive Yuan, ROC)

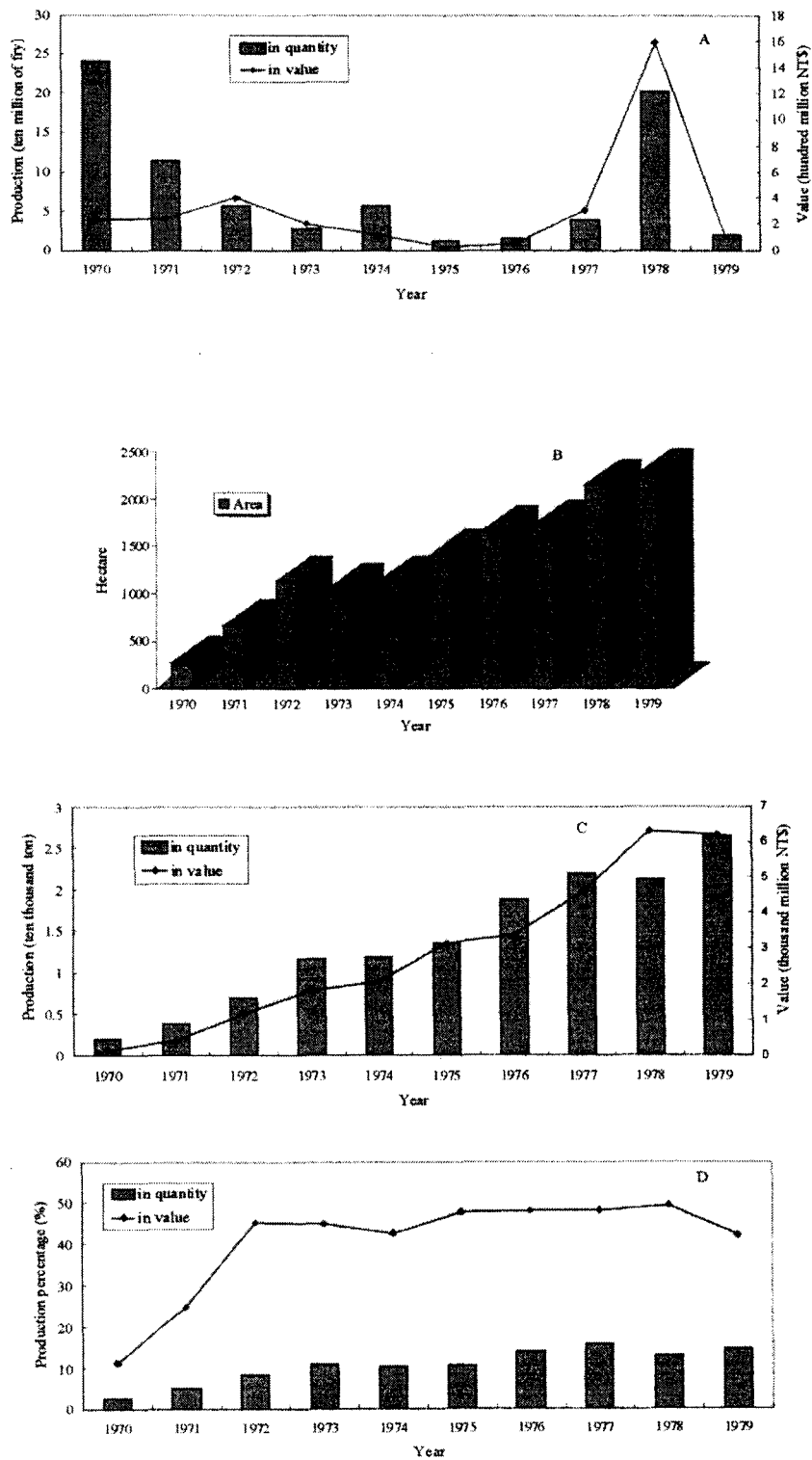


Fig. 3. Elver catch (A) culture area (B) aquaculture production (C) and share to the total aquaculture production (D) of the Japanese eel *A. japonica*2, in Taiwan (1970-1979). (Source: Fisheries Statistical Yearbook, Fisheries Administration, COA, Executive Yuan, ROC)

1980-1989 (Prosperous stage): Golden stage of the eel aquaculture industry in Taiwan: highest recorded culture area and production.

Table 4. Main events of the eel aquaculture industry in Taiwan from 1980 to 1989.

1980	"Soft ponds" (with earthen walls) were developed to culture eels. Culture area reached 2,395 ha; production was more than 33,000 tons.
1981	Abrupt reduction of culture area and production caused by world economic recession; recovery not noted until 1984.
1983	Number of eel processing plants reached 32, with the function to regulate supply and demand and to stabilize the industry <i>per se</i> . Mainland China started to export cultured eels to Japan.
1984	"Soft ponds" sprung up at HuNei and Ch'iehTing, Kaohsiung; the water volume needed was reduced and the fry size at stocking was larger than in traditional ponds, reducing the production cost.
1985	Frozen Roast Eel Processing Group of Frozen Seafood Industry Association formed to integrate the processors.
1988	Culture eel production over 50,000 tons.
1989	Culture area over 4,000 ha.

1. Elver supply

The highest recorded catch was nearly 138 million in 1989; the lowest being 10 million in 1980. The highest recorded value was NT\$ 850 million in 1989; the lowest being NT\$ 30 million in 1982 (Fig. 4A). The average unit price of elvers was from NT\$ 3 to 11.

2. Culture area

Eel culture area steadily increased annually since 1982; the total area was over 3,500 ha in 1988 and

over 4,000 ha in 1989 (Fig. 4B).

3. Aquaculture production

Aquaculture production, both in quantity and value, roughly progressed steadily. The highest production was over 50,000 tons worth nearly 14,900 million in 1988 (Fig. 4C). The share of eel aquaculture to the total aquaculture production in quantity was from 12.6% to 19.2%; the share in value was from 30.7% to 43.8% (Fig. 4D).

1990-1999 (Depression stage): Faced with elver shortage and strong competition from Mainland China for the Japanese market, the depression stage emerged.

Table 5. Main events of the eel aquaculture industry in Taiwan from 1990 to 1999.

1991	Indoor super-intensive recirculating eel culture system was studied by the Taiwan Fisheries Research Institute.
1995	Indoor super-intensive recirculating eel culture system was installed at eel farms. Number of eel processing plants reduced to only 8.
1997-98	Abrupt shortage of elvers. In 1998, culture area was reduced to 1,500 ha and eel production was reduced to 17,000 tons.
1999	Elvers harvested abundantly, the amount stocked in ponds reached a record high of 50-60 tons. Imbalance of production and demand resulted in low eel price, even lower than production cost.

1. Elver supply

The highest recorded catch was 155 million in

1991 and the highest value was NT\$ 1,660 million in 1996 (Fig. 5A). Average unit price in 1990 was only

NT\$ 5, jumping to NT\$ 38 in 1994. Elvers were surprisingly abundant in 1999 and the unit price was reduced to NT\$ 14.

2. Importation of elvers

For the scale of eel aquaculture in Taiwan, the domestic elver supply could not meet the demand, making importation necessary. The number of imported elvers was not only affected by the domestic supply in Taiwan; it also depended on the production in other areas and culture desire of farmers. The highest record of imports in quantity and value was 354 tons and NT\$ 1,064 million, respectively, both in 1990 (Fig. 5B).

In recent years, although the amount of wild-caught elvers was not high, the imports did not greatly increase owing to business risks or transfer of culture techniques to Mainland China.

3. Culture area

Because of the high elver cost, the culture area annually declined from 1990 to 1998, except in 1992, due to the amounts of both domestic and imported elvers were high in previous years. The culture area increased in 1999, resulting from abundance and hence low elver price. The highest record was 4,458 ha in 1992, and the lowest being only 1,535 ha in 1998 (Fig. 5C).

4. Aquaculture production

Affected by the shortage of elvers and strong competition for the Japanese market from Mainland China, aquaculture production annually decreased from 56,000 tons in 1990 to 17,000 tons in 1999. Production in value decreased annually since 1994; from NT\$ 13,000 million in 1994 to NT\$ 4,400 million in 1999 (Fig. 5D).

It is worth to note that eel aquaculture is still the most important aquaculture industry in Taiwan; although the production in quantity is not necessarily on the top, production in value ranks first. The share of eel aquaculture to the total aquaculture production in value reached 40.0% in 1992, but this trend has been declining in recent years (Fig. 6A).

5. Eel exports

Eel exports, both in quantity and value, almost

annually declined from 46,000 tons valued at NT\$ 12,200 million in 1990 to 9,000 tons valued at NT\$ 3,670 million in 1999 (Fig. 6B), declining at a rate of 80.4% and 69.9%, respectively.

Cultured eels were mostly exported to Japan. About 93% of total eel exports in quantity and 96% in value were exported to Japan from 1990 to 1999.

The exported eels were either live or processed, with the volume of the latter being always higher than the former from 1990 to 1994. The turning point was in 1995, when the number of processing plants was reduced to only 8, resulting in higher volume of exported live eels since then (Fig. 6C).

Averages per decade

1. Elver supply (Fig. 7A)

During the 1950s and the 1960s, eel aquaculture was just at its embryonic and transition stages and the elver demand was low. The industry was at the expansion stage through the 1970s, led to the record high elver supply. In the 1980s and 1990s, although the culture technology had already reached maturation, the reduction of natural elver resources resulted in lower production. Because of the competition for elvers in the 1990s, the catch in value reached a record high of NT\$ 700 million.

2. Elver price

The unit price increased through the decades. In the 1990s, the highest unit price of NT\$22 and the strong competition from Mainland China forced many farmers to stop their operation.

3. Culture area (Fig. 7B)

Eel culture area steadily increased through the decades. Although the highest value was in the 1990s, the area dropped annually from 4,458 ha in 1992 to 1,535 ha in 1998. Obviously, the decade average culture area only can not reflect the depression phenomenon in this industry.

4. Aquaculture production

The highest average aquaculture production in quantity was 37,000 tons in the 1980s during the

prosperous stage; the highest in value was NT\$ 10,000 million in the 1990s (Fig. 7C). Compared to the previous decade, the highest arising rate of share of eel aquaculture to the total aquaculture production

both in quantity and value was 9.9% and 37.6%, respectively, from the 1960s to the 1970s. In the 1990s, 3% share in quantity and 4% share in value were lower than in the 1980s (Fig. 7D).

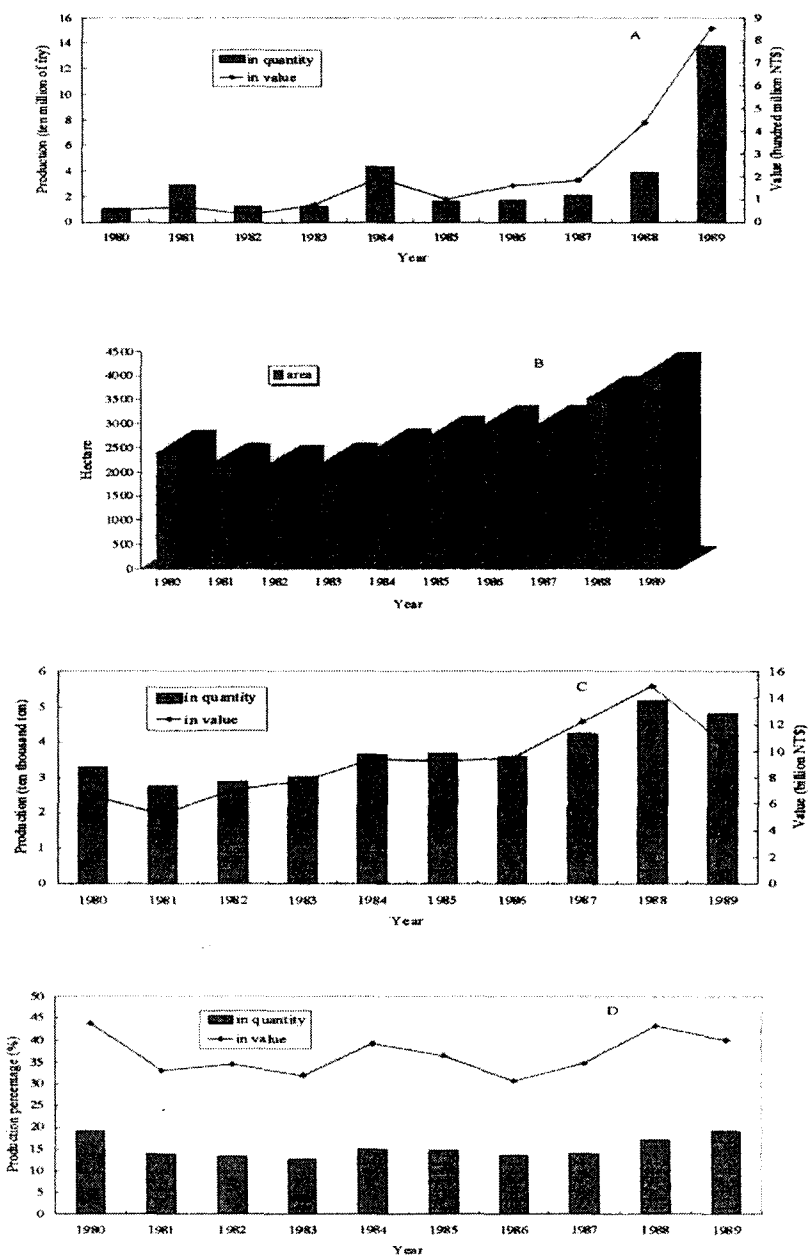


Fig. 4. Elver catch (A) culture area (B) aquaculture production (C) and share to the total aquaculture production (D) of the Japanese eel *A. japonica*, in Taiwan (1980-1989). (Source: Fisheries Statistical Yearbook, Fisheries Administration, COA, Executive Yuan, ROC)

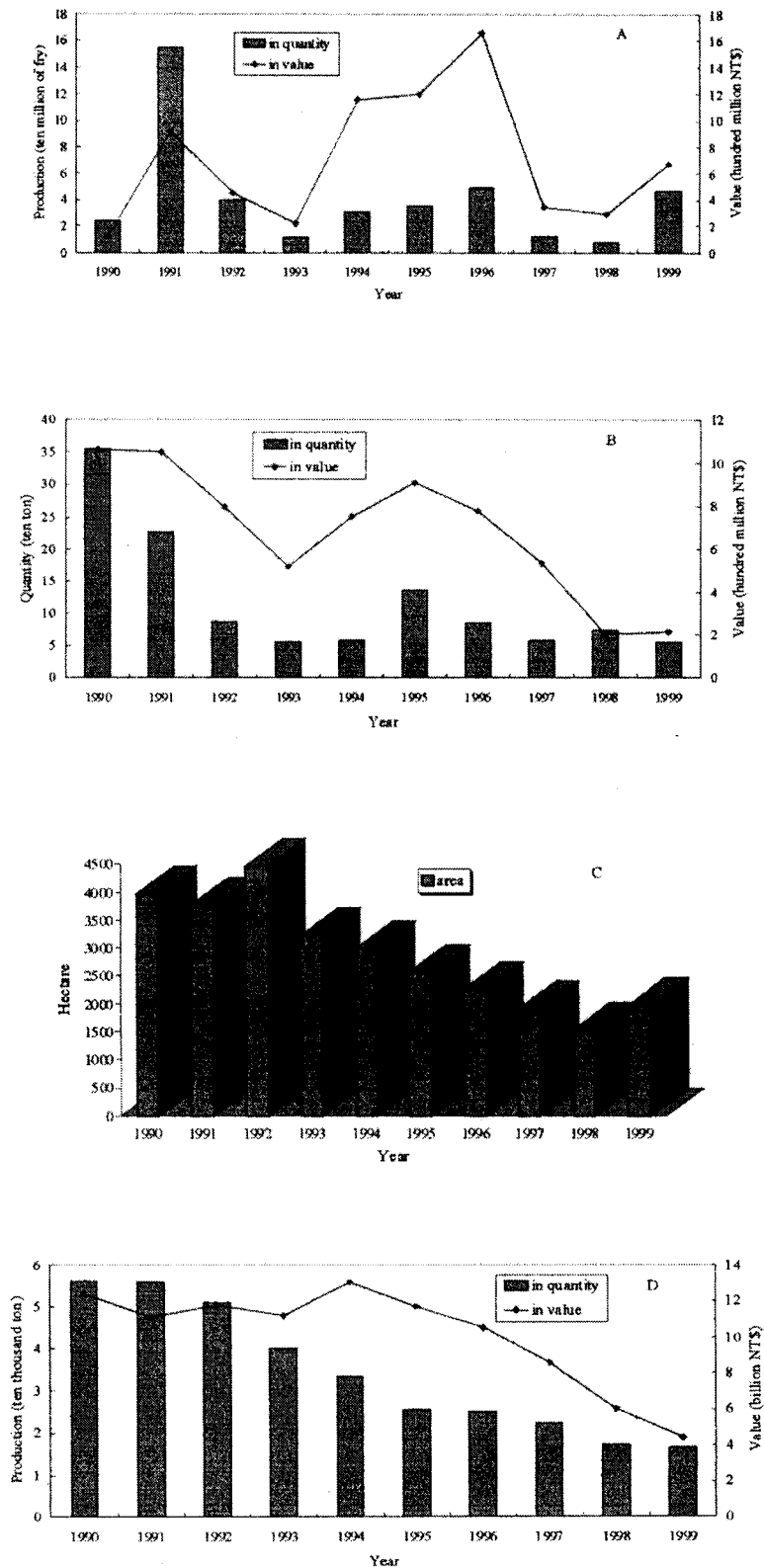


Fig. 5. Elver catch (A) elver imports (B) culture area (C) and aquaculture production (D) of the Japanese eel *A. japonoca*, in Taiwan (1990-1999). (Source: Fisheries Statistical Yearbook, Fisheries Administration, COA, Executive Yuan, ROC)

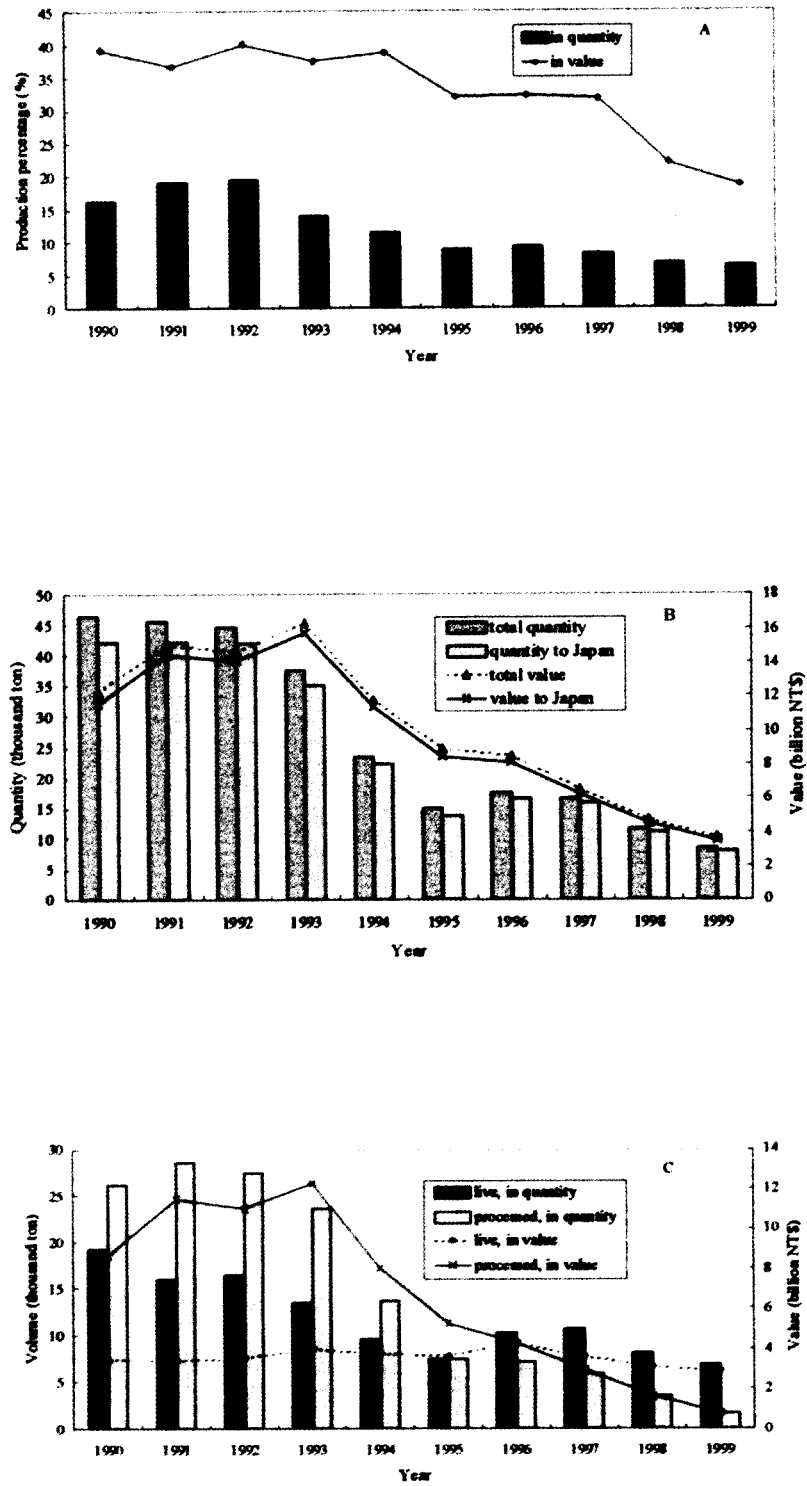


Fig. 6. Share to the total aquaculture production (A) and exports (B, C) of the Japanese eel *Anguilla japonica* in Taiwan (1990-1999). (Source: Fisheries Statistical Yearbook, Fisheries Administration, COA, Executive Yuan, ROC)

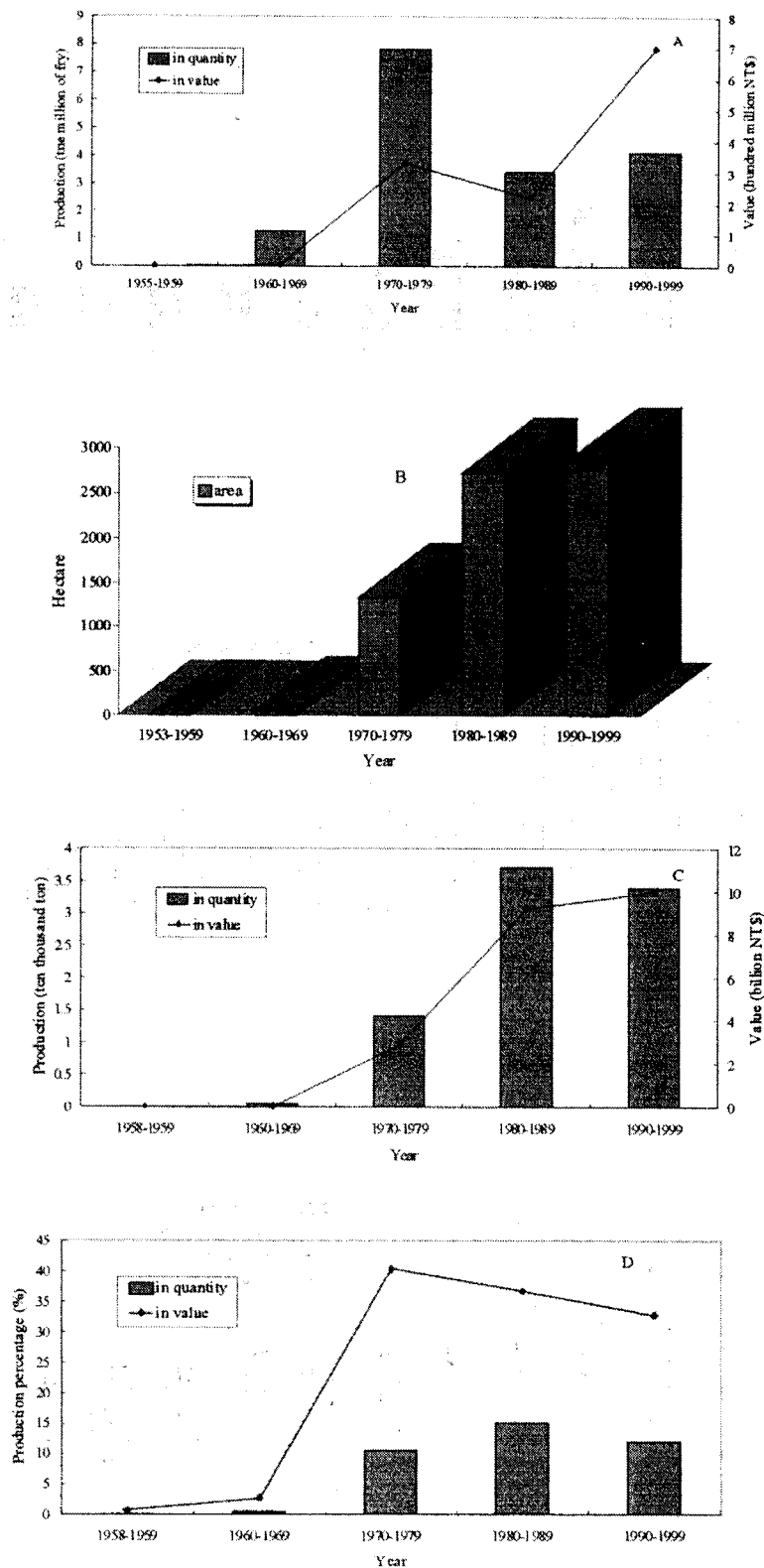


Fig. 7. Elver catch (A) mean culture area (B) mean aquaculture production (C) and mean share to the total aquaculture production (D) of the Japanese eel *A. japonica*, in Taiwan (1955-1959). (Source: Fisheries Statistical Yearbook, Fisheries Administration, COA, Executive Yuan, ROC)

Ways to sustain the eel aquaculture industry

The division of labor of the eel aquaculture industry in Taiwan is sophisticated and delicate. It includes elver catching, selling and rearing, on-growing, harvesting and processing. The reasons for this industry can be developed from nothing to the most important aquaculture sector in Taiwan are the endeavor of eel farmers and the government's guidance over the past years.

In recent years, strong competition from Mainland China and the imbalance of production and marketing led to the depression stage of the industry. In fact, the development of this industry through all stages can be shown more clearly by putting the relevant data together (Fig. 8; Fig. 9). To avoid the depression phenomenon from further going and to keep the industry sustainable, the production cost must be reduced, the product quality must be elevated and domestic markets must be explored.

Reduction of production cost

Strengthening of the management is one of the efficient ways to reduce the production cost. Following the changes in socioeconomic conditions, the shortage and aging of manpower may emerge as a problem in eel aquaculture. "Two-step" or "three-step" culture method can be applied in accordance with the climate, to save labor and groundwater.

In general, eel processing plants also function as a buffer to regulate eel markets. The number of plants had dropped from 32 to 8 in Taiwan, the annual production being only about 10,000 tons and their competitive ability is being greatly affected by the fluctuation of live eel price, labor shortage and workers' high wages. This unfavorable situation must be overcome.

Elver cost shares about 40% of the eel production cost. Although artificial breeding and release of adult eels to the presumed spawning ground have been

conducted for years, yet there is still much to be desired in these aspects.

Elevation of product quality

Eel is a traditional food for the Japanese. Every year, the fact that about 95% of eel products in Taiwan are being exported to Japan demonstrates that product quality is at a high level; yet the quality must be further improved to maintain or increase the current market share. The Eel and Shrimp Producers Cooperative had installed an examination center near the Chiang Kai-Shek International Airport to check the drug residues on the intended-to-export live eels, preventing unqualified eels from exportation.

Expanding the domestic markets

In 1999, elver supply was surprisingly abundant. The pond stocking volume reached 125 tons (50 tons in Taiwan, 35 tons in Japan, 35 tons in Mainland China and 5 tons in Korea), about 4 times more than that in 1998. If elvers of European eel were added, the total stocking volume was as high as 260 tons.

Production has now exceeded demand, which led to eel prices being far lower than the production cost. Domestic markets must be expanded to balance the export market and to stabilize the eel prices. The government has granted NT\$30 million to help expand the domestic markets and it has been predicted that a total of 5,000 tons could be sold in the domestic markets this year.

In general, due to the limitation of natural elver resources, the quantity of elver stocking of the Japanese eel can be restricted to some extent. However, since European eel elver supply is abundant and stable, if its stocking is not controlled, the eel prices will remain low.

Conclusions

In Taiwan, the eel aquaculture industry is the most important and profitable aquaculture sector, with a

record high production of 56,000 tons in 1990 and highest recorded value of nearly NT\$ 14,900 million in 1988. In recent years, the industry plunged into the depression as a result of elver shortage and powerful competition from Mainland China. The

imbalance of production and demand further resulted in low eel prices, even lower than the production cost. Programmed production and expansion of the domestic markets may help stabilize the eel aquaculture industry.

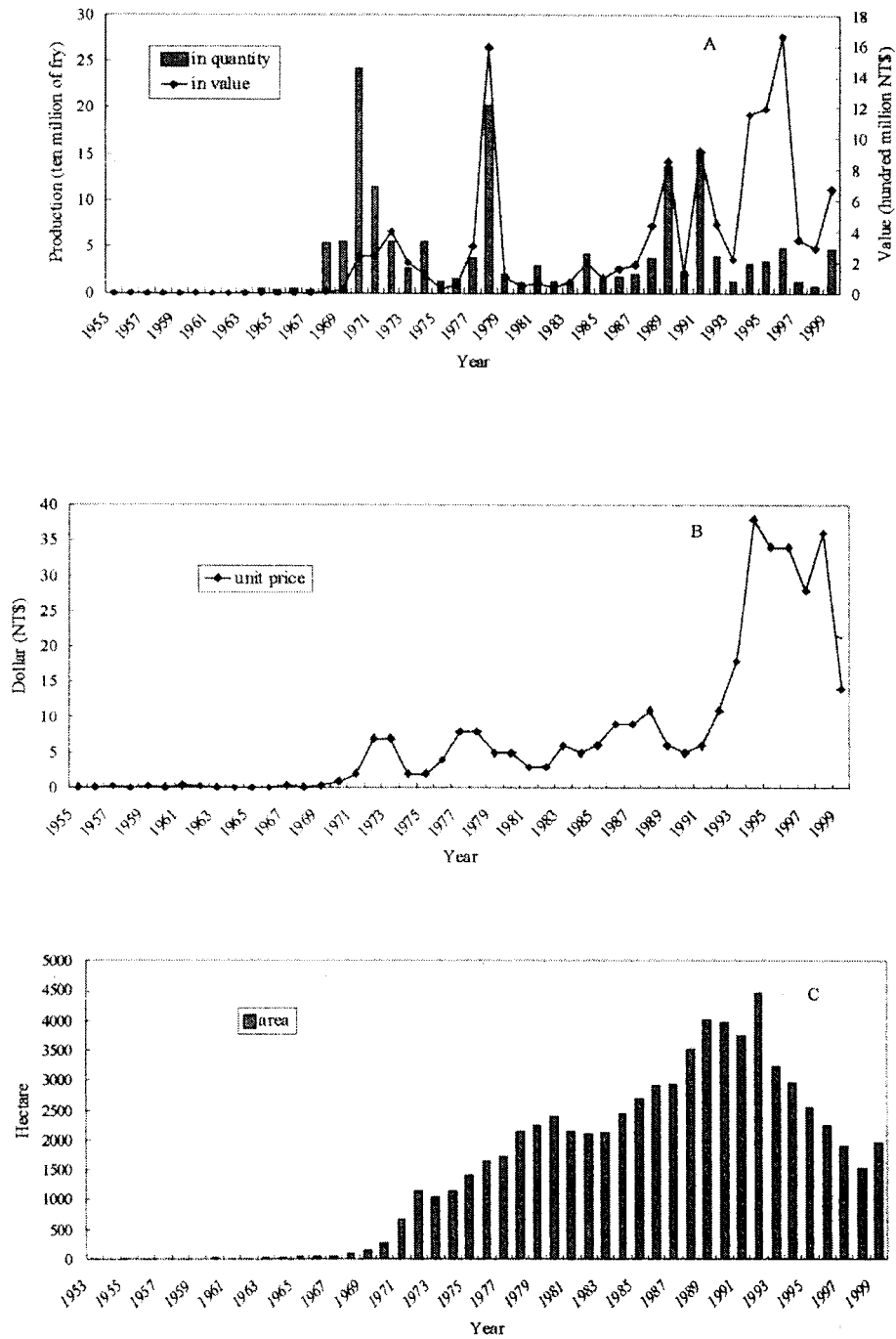


Fig. 8. Elver catch (A) and its average unit price (B) and culture area (C) of the Japanese eel *Anguilla japonica* in Taiwan (1953-1999). (Source: Fisheries Statistical Yearbook, Fisheries Administration, COA, Executive Yuan, ROC)

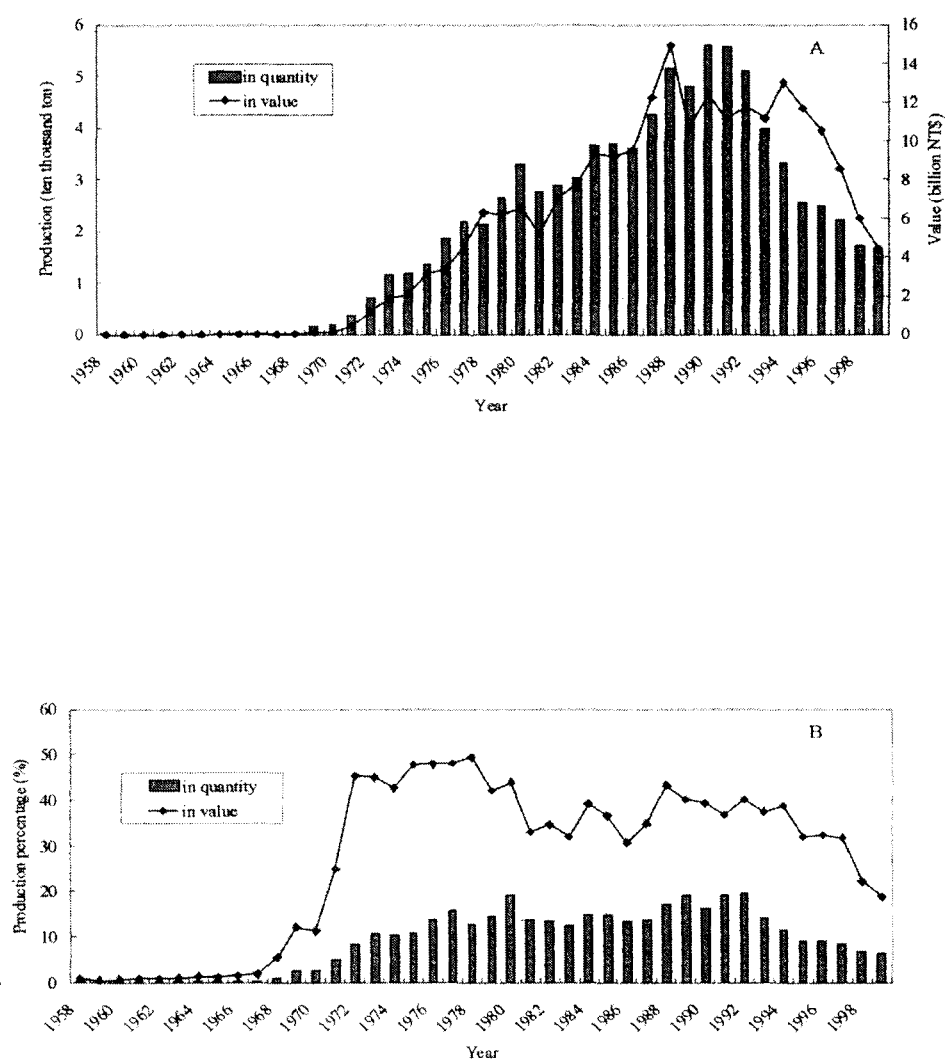


Fig. 9. Aquaculture production (A) and its share to the total aquaculture production (B) of the Japanese eel *Anguilla japonica* in Taiwan (1958-1999). (Source: Fisheries Statistical Yearbook, Fisheries Administration, COA, Executive Yuan, ROC).

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