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An Investigation and Research on Taiwan Grey Mullet *(Mugill cephalus)*

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Abstract: The objectives of this study were to investigate and research very closely on the grey mullet (*Mugil cephalus*) in Taiwan: distribution of wild and cultured, amount of fish catch, fry, growth, purpose of fish breeding, purpose of fish fry breeding, distinguish of grey mullet and mullet roe, import and export of grey mullet roe, the techniques of artificial propagation and progress in the grey mullet culture industry.

Keywords: Breeding, distribution, fry, grey mullet, mullet roe, propagation

1. INTRODUCTION

Grey mullet (Mugill cephalus) local name：Mugil grandis .Every year after the winter solstice, grey mullet travel from the Taiwan Strait to the south to spawn[1], so the fishermen call it a letter fish. The grey mullet roe made from the fish eggs of the female grey mullet which had a unique flavor and is expensive. The fishermen joked that the grey mullet was the year-end bonuses of this year. But in recent years, the global climate change and artificial overfishing have greatly reduced the number of mullet fishing[1,2] The grey mullet aquaculture industry had reached the complete breeding level[2,] and the aquaculture technology could even make the sex singular[3]. Only the female fish with high added value can be raised, so that one grey mullet could be eaten in addition to meat, and the eggs were taken down to make grey mullet roe for Increase

farming profit. So, Taiwanese people call the grey mullet a "wujin". The name of wujin means that gray mullet was a much economical valuable fish. The grey mullet had a spindle shape with a white abdomen and a [6-7] dark brown band on the side of the body. The maximum body length[4] was 60cm.

Distribution of the grey mullet: grey mullet is part of Mugiliformes order and Mugilidae family, More than 70 species of mugilidaes worldwide. More than 20 kinds had been found on the mainland and Taiwan coast. [5]Mugilidaes were a common marine fish. It was widely distributed in tropical, subtropical waters and warm temperate waters and could be inhabited in seawater and freshwater[4].The capture of natural grey mullet in Taiwan was from the south of Hsinchu to the coastal waters of Pingtung and Hengchun. The grey mullet was distributed in warm and tropical waters around the world[1]. It' s mainly inhabits sandy muddy waters along the brackish waters and was a migratory fish [5]. The countries in the Mediterranean region also have fish eggs that were dried after salting the same species and other species such as tuna fish[4].

Amount of catch: the grey mullet was an important food fish for the coast in Taiwan[2]. In the 1990s, due to long-term fishing on the migration route and marine serious pollution along the coast of Taiwan, the rise in sea temperature affected the migration route and other factors, resulting in a decline in mullet catch [5, 6]. It is also currently being raised in fish rod[5] (increasingly prevalent). The southwestern coast of Taiwan is an awning bed that mullet migrate southward along the coast of mainland China, so the grey mullet eggs are usually harvested relative to the north.[5]

Distribution of wild grey mullet: In addition to the Yangtze River basin mentioned above, the western part of Taiwan, and the northern part of the east coast of the United States to the southern part of Florida; and the coastal areas of Queensland and coastal waters of Brazil[7].The grey mullet meat produced in Taiwan's waters is the most fertile and best quality; while the quality of grey mullet meat produced in Florida's waters is similar to that in Taiwan; however, the quality of grey mullet meat produced in the coastal areas of Queensland and Brazil is poor[8]. The grey mullet, which migrates along the western coast of Taiwan, is a fish that grows in the sea port of the Yangtze River in mainland China. Every year before and after the winter solstice, when the temperature of the sea drops suddenly, the grey mullet group goes south along the marine current, along the Taiwan Strait, from Hsinchu and Miaoli. Taichung, Chia, Tainan, Kaohsiung and Pingtung all the way down the mountain. After the Linbian River[7], spawning began. The trace was from Fangliao and Hengchun went all the way to the eluanbi and even the south to the South China Sea.

The purpose of grey mullet breeding: At present, Taiwanese farmers were engaged in the purpose of grey mullet culture. They were mainly divided into two parts[9]. One was to raise mullet for about one year for the fish meat market demand or to provide the fish source for spawn-mullet culture; the second is to need more long culture time[10]. The longer spawn-mullet was cultivated to provide eggs for making mullet roe.

DISTRIBUTION OF CULTURED GREY MULLET IN TAIWAN

Intensive aquaculture: Mainly in the three counties of Chiayi, Tainan and Kaohsiung district; Yunlin, Changhua County, polyculture in clam Pool[11]. Most of the mullet polyculture is in the two districts. Some farmers were engaged in mullet farming In Yilan County. Now, these grey mullet cultured areas were about 700 hectares in Taiwan[4].About 300 hectares were single-breed mullet, and 400 hectares were polyculture, with a total annual output of about 2,000 metric tons, which has exceeded the number of wild mullet caught[4].

Grey mullet fry: The fry used for breeding grey mullet, in the past, mainly to catch natural seedlings in sea, the natural seedlings were used when the mullet fry migrated from the spawning ground to the estuary

freshwater area. Pick up (fishing on the shore with a triangular net) and catch the small fry. Much distribution of natural grey mullet fry waters in Taiwan, from KeelungTo Fulong, Danshui to Hsinchu, Miaoli, Jia to Beimen of Tainan. Now, gradually Adapted to artificially propagated fry to supply wild fish fry insufficient seedlings and improved harvesting of natural fish fry. There are too many confusiones in picking up the types.

Growth of grey mullet (wild and cultured): Wild grey mullet, its growth is completely in accordance with nature's survival rules, from egg hatching to fry, to growth, the time elapsed, it takes about two to three years, is the fishing boat we see captured at sea wild grey mullet, its largest life is five-year-old fish[12].The wild grey mullet on the west coast of Taiwan is a benthic fish. Its main food in sea usually takes the following foods: algae, blue-green algae, organic debris, copepods, sediments and other planktonic biology.

Grey mullet was a high economic value food fish. The fry were mostly seen in March and April each year. Many fishermen open the sluice during this period, put the seedlings into the base pool, and the feed such as hemp, soybean residue, and peanuts. Hope that they will grow rapidly and catch up with the fish harvest before winter[10].

EXPERIMENTAL

Selection of berried female mullet: The first was to choose from the good grey mullet fish ponds cultivated in the special pool; the second was to select the sexual mature grey mullet from the grey mullet culture ponds above the 2 years, but it is more troublesome.[9] Sexually mature female mullet had enlarged and soft abdomen, obvious ovary contour, reddish and prominent genital tract; male grey mullet had beautiful purple-red on both sides of the body, starting from the dorsal fins with white neat rows arranged from top to bottom [13]. The smaller circle points, the better the sexual maturity, the red hole in the genital area.

Hasten parturition: Every year from April to July, when the water temperature is stable above 20 °C, it can start hasten parturition. The oxytocin mainly uses luteinizing releasing hormone analogue (hereinafter referred to as LRH) and chorionic gonadotropin (hereinafter referred to as HCG). Dosage: Female mullet is LRH-A3, 3-6 micrograms per kilogram or 800-1200 IU of HCG (choose one to use); the amount of male mullet is 2/3 of female mullet. In the early stage of hasten parturition (from April to May), the combination of the two hormones is better than the single used[14]. The amount was optimum mix amount of the two hormones depends on the sexual maturity of mullet. Generally, each kilogram of female mullet used LRH-A3, 4-6 micrograms plus HCG 600-800 international units. In the middle and late stages of hasten parturition, the water temperature must be gradually increased, and the dosage was reduced accordingly. The dosage was determined according to the time of inoculation and the total weight of the hasten parturition, and then the injection was prepared by using normal saline or water for injection. The amount of each mullet injection depended on the size of the fish body, and the amount of a fish was generally 1 to 3 ml. The hormone is available till now.

When injecting the hormonal drugs, placed the selected grey mullet in a plastic basin, cover the grey mullet head with a fur cloth in the left hand, and hold the needle in the right hand. The needle was quickly pulled into the fish body in the direction of the head at the angle of 45-60 degrees, from the base of the pectoral fin into the needle, advance the injection. The depth of the needle is 0.8 to 1.5 cm. In the early stage of hasten parturition, a second injection is generally taken. When the female grey mullet is injected for the first time, the dose is 1/3, and after 12 to 16 hours, the remaining dose is injected[15]. Male mullet can be injected once,

and when the second injection of female mullet is carried out, the grey mullet is mature at the late stage of hasten parturition. Just one injection could be performed.

Spawning: Because the grey mullet competes for the spouse before spawning, and affects the spawning and ejaculation, so the ejaculation of small grid spawning pool was much higher than the large multi-group mullet mixed spawning fertilization rate. The small grid mesh is made of polyethylene. The specification is square with an area of 1 square meter and a mesh height of 1 to 1.5 meters. It had an upper cover because the mullet has a strong jumping ability and can jump more than 1.5 meters above the water surface. The prepared small net cage is placed in the pond, and the bottom of the tank is 0.5 to 1 meter deep from the water surface.

Put the grey mullet after the second injection into the cage, place one female fish and one male fish in each cage, and then put a certain amount of water grass to prepare the grey mullet for nesting and laying eggs. The female fish spawning time is related to the water temperature. The water temperature should be 20~22°C. It takes about 30 hours to start estrus and spawning. The water temperature must be maintained at 23~25°C, it takes about 17~20 hours. The eggs are concentrated and floated in the fish nest, and the eggs are laid for 12 to 15 hours to produce. It should be kept quiet during spawning, and once it is disturbed by the outside space, it will stop spawning and ejaculation immediately. The grey mullet spawning time is the quietest in the middle of the night.

Incubation: After the grey mullet spawns, the fertilized eggs could be hatched in the cage, or the grey mullet could be caught and placed in a plastic basin and placed in a static water to hatch, to the small small-scale farming. Eggs range from 500 to 1000 capsules; the big scale farming eggs can be placed in hatching buckets (cylinders) or hatching loops in fluidic water, with 600,000 to 1 million fertilized eggs per cubic meter of water. The color of fertilized egg was golden yellow. As the embryo develops, it gradually turns dark gray, and the unfertilized egg gradually turns yellow and finally white.

The length of incubation time depended on the temperature of the water. It took about 60 hours to hatch the fry at 22 ° C. It took about 36 hours at 25 to 26 ° C and about 30 hours at 30 ° C.

After the fish fry is out of the film, it depended on its own yolk sac for absorption and growth. As the yolk sac gradually disappeared, the fry begins to swim and open mouth for feeding. This development process is related to the water temperature, which takes about 3 to 5 days to wait for the fry to swim and feed. We could put it into the pond for breeding. During the incubation period, the following management tasks were mainly done:

1. **Static water hatching:** The indoor plastic basin was incubated, refreshing the water once in the morning and evening, and the water exchange rate is at least 1/2. Careful operation when refreshing the water to avoid damaged for the eggs.

2. **The water temperature should be as stable as possible**: The change range of water temperature difference did not exceed 12 °C. Otherwise it will affect the hatching rate.

3. Incubate the loop or barrel (cylinder): Always wash the filter sand screen to prevent mesh blockage and spilling eggs to escape from the seedlings. Incubate with a net, wash the cags once every 1 to 2 days, to keep the water inside and outside the box exchanged.

4. **Removed unfertilized or moldy eggs all the times.**

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RESULT

The grey mullet cultured was generally based on the berried female grey mullet, so it was different from the wild grey mullet in the breeding. The feed was beneficial to produce grey mullet roe for fish body; according to the farmers experience When the north wind began to blow, the ovary of the grey mullet grew, and it took about two months or two plus a half months to grow. The weights of two years old fish could reach 3 Jacks. Under normal circumstances, the grey mullet roe could reach about 5 or 6 hectograms weight. The 3 years old fish could reach 4 Jacks. Under normal circumstances, the grey mullet could reach about 7 or 8 hectograms weight; good aquaculture technology and experience could raise good mullet, and the grey mullet roe could reach about 10 hectograms weight. The purpose of grey mullet culture was to have a large number of grey mullet roe could be collected[16].

CONCOLUSION

Distinguish of grey mullet roe: In the dried grey mullet roe, grey mullet was generally divided into cultured and wild in sea, and the sea cage culture increased in recent years[17]. The dried grey mullet roe color was used to distinguish cultured and wild. The color of the wild grey mullet roe was more golden yellow than the color of the grey mullet roe period. The period of beginning of the production to the completion of the grey mullet roe, it took about three weeks. In the period of drying, the cultured grey mullet roe usually takes about ten days, and the wild grey mullet roe took about one week. The bigger of size, the longer time it took. The grey mullet roe produced in Taiwan waters was the most fertile and of the best quality; while the quality of mullet roe in the Florida waters is similar to that in Taiwan; however, the quality of grey mullet roe in the coastal areas of Queensland and Brazil is poor[18].

Distinguish of mullet: How to distinguish the grey mullet between cultured and wild, in general, it seemed that the grey mullet cultured was more fat and round, the size was relatively equal, there will be no significant difference, the meat was soft and the body-oil is more. The cultured mullet roe and vesiculaseminalis where had no bile color at the end; the wild grey mullet had a firmer appearance, a larger body size, and a stronger meat. It is more bitter and fatter than the culture grey d mullet meat. [8]The wild grey mullet tail was often used at stacked and squeezed when loaded into the cabin, causing the gallbladder to rupture and had the color of bile.[19,20.]

The fish eggs and ovary of the pregnant female grey mullet were collectively referred to as grey mullet roes, which was a salted aquatic processed food[18]. The testis of the male fish is a famous dish; that was grey mullet seminal vesicle, delicious meat when was braised with braised pork, or boiled soup, even cooked sesame oil was suitable.

Import and export of grey mullet roe: At present, the local grey mullet season in Taiwan before and after the winter solstice[1], the raw materials needed for the grey mullet roe produced by the industry are mostly based on imports from Brazil, the United States, Australia, and mainland China[21].

The grey mullet roe refers to a fish ovary and fish eggs that are pregnant females, collectively referred to as "mullet roe", which is dried aquatic products processed with salting.[18]

The techniques of artificial propagation of grey mullet (*Mugil cephalus*), had been established recently and mass scale commercial application of these techniques is expected in the near future. The complete culture could be defined as rearing for a complete generation cycle of an animal from eggs through larvae, juveniles,

and adults to spawners and to reproduce the successive generations in captivity. This break-through proved the feasibility of spawning artificially propagated tank-reared offspring, which will solve the problem of insufficient supply of spawners from the wild, and brings a promising future for the artificial propagation of grey mullet.[8]

DISCUSSION

The whole body of grey mullet could be made into many dishes, and economic value of grey mullet is high. For the most valuable three treasures of mullet, the grey mullet eggs of female fish, the grey mullet seminal vesicle of male fish, and the grey mullet rod were the stomach of mullet. The taste was crispy, soft and sweet, and sold by weight. The remaining grey mullet body was cheap but nutritious and delicious. The grey mullet had become Taiwan's high-profile, high-priced product; In order to improve the quality of mullet roe products, the Taiwan government had established a top mullet roe brand. Taiwan government had a national competition for the top ten high quality grey mullet roe[22.]

In order to encourage the industry to enhance the technology, processing quality and brand image of mullet culture, the Fisheries Department has been conducting the "Taiwan Top Ten Quality Grey Mullet Fish Competition" for the Taiwan Aquaculture and Fisheries Development Foundation since 1998. The competition is like “Wujin” The Golden Horse Awards, the 6th Competition and Awards Ceremony was held on January 13, (104) at the Ambassador Hotel in Taipei. In recent years, the government had promoted the conservation of offshore resources. Taking marine mullet as an example, as of January 6, 104, it has exceeded 600,000, the second highest in the past decade, and the breeding of black mullet is also good for fishermen and friends. The hacker who likes to enjoy the mullet roe was a undoubtedly good news. The Chairman of the Council of Agriculture, Mr. Bao Jichen, came to the scene to present the award and affirmed the outstanding performance of the winners. This year, the seventh-grade students and family members who were short-listed in the national competition, and the top ten mullet rookies who have won the drug residue test, have also conquered the taste buds of food experts, and finally got the anti-counterfeit label of "Taiwan's top ten high-quality mullet roe". The number of contested archives is limited, and each piece is more precious[22].

Progress in the grey mullet culture industry: Taiwan has made good progress under the efforts of researchers and fishermen[23]. However, due to the economic downturn and the increase of international competitors in recent years, the market price has fallen, and the grey mullet industry has encountered the bottleneck of transformation. Therefore, in recent years, Taiwan grey mullet aquaculture began to produce the high-quality products, combined with tourism and sound production and marketing systems, to avoid dealer exploitation, etc., so that Taiwan's grey mullet aquaculture industry enters the enterprise-oriented business mode, and enhances international competitiveness.

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