International Journal of Marine Science, 2025, Vol.15, No.5, 277-286
http://www.aquapublisher.com/index.php/ijms

Case Study Open Access

Genetic Variation in Growth Traits of *Scomberomorus* spp. Under Selective Breeding: A Case Study in Hainan Waters

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International Journal of Marine Science, 2025, Vol.15, No.5, doi: 10.5376/ijms.2025.15.0025
Received: 20 Aug., 2025
Accepted: 12 Oct., 2025
Published: 25 Oct., 2025

Preferred citation for this article:
Wang H.M., and Wang L.T., 2025, Genetic variation in growth traits of *Scomberomorus* spp. under selective breeding: a case study in hainan waters, International Journal of Marine Science, 15(5): 277-286 (doi: 10.5376/ijms.2025.15.0025)

Abstract *Scomberomorus* spp. is one of the important economic fishes in China's offshore fisheries and aquaculture industries, but its wild population resources are under pressure from overfishing and environmental changes. Improve the growth performance of mackerels through selective breeding is expected to improve breeding efficiency and alleviate their dependence on wild resources. This study takes mackerel in Hainan as an example to analyze the genetic variation characteristics of growth traits (including body length, weight and growth rate) and the selection of breeding effects. The results show that the main growth trait of mackerel has a moderate level of heritability, and the selected breeding population exhibits faster growth rates and higher weight genetic gain relative to the natural population. At the same time, the genetic gain of different breeding generations shows a decreasing trend, showing that the impact of continuous selection on genetic variation needs attention. Case studies show that selective breeding strategies based on genetic parameter evaluation can effectively improve the growth traits of mackerels and provide practical basis for regional seawater fish breeding. This study provides scientific reference for the cultivation of mackerel species and the sustainable use of marine fishery resources in Hainan and other regions.

Keywords Mackerel; Breeding selection; Growth traits; Genetic variation; Hainan

1 Introduction

Mackerel belongs to the genus *Mackerel* of the Mackerel family, including blue-spot mackerel, spot mackerel, Kang's mackerel and other offshore species. Mackerel has delicious meat and rich nutrition. It is an important economic fish in coastal fisheries and is distributed in the Bohai Sea, Yellow Sea, East China Sea and South China Sea. Among them, Hainan waters are rich in Kang's mackerel and spot mackerel. Local consumption demand is strong, and mackerel has become one of the famous dishes on the Hainan fishermen's festival table.

However, in recent decades, wild mackerel resources have been affected by overfishing and environmental pollution, and the population and individual size in some sea areas have decreased significantly. Historical data show that the average body length of mackerels in the northern seas was as high as 630 mm, but has dropped to about 532 mm in recent years. Resource decline has prompted China to list mackerels as a key target for proliferation, release and artificial breeding, and to carry out seedling release in the Bohai Sea, the Yellow Sea and the East China Sea to restore populations (Wen et al., 2018). But at the same time, China's mackerel breeding work started late, and there are still challenges such as poor growth performance, low survival rate of seedlings, and degeneration of strains. Degradation of aquatic germplasm and poor disease resistance not only limit the increase in breeding output, but also increases breeding risks.

This study takes mackerel populations in Hainan sea as the object, and evaluates the heritability and selection response of growth traits through genetic parameter analysis, and explores the impact of targeted breeding on genetic variation of mackerel populations. The research results will provide a scientific basis for the selection and breeding of regional mackerels, and also provide reference for the genetic improvement and sustainable resource utilization of other seawater fish in China.

2 Biological and Ecological Characteristics of Mackerel

2.1 Species distribution and ecological niche in Hainan sea area

The mackerels in Hainan waters are mainly composed of *S. commerson* and *S. guttatus*. They are widely distributed in tropical to subtropical offshore waters and are ocean-migrating upper fish. Mackerel has the habit of swimming at high speed and eating fiercely. It occupies a high trophic level of marine food networks and plays an important role in maintaining the balance of offshore ecosystems.

In the coastal coast of Hainan, mackerels migrate significantly in season. Every spring, when the coastal water temperature rises, the spawning group migrates to the coastal coast and completes spawning and breeding in coastal waters; then the adult fish migrate to the sea with abundant bait foraging, and may move to deeper seas for winter in winter. Analysis of trace elements of otoliths shows that blue-point mackerels migrate for long distances between spawning grounds, bait yards and wintering grounds, and their life history experiences are significantly different (Pan et al., 2020; Sougueh et al., 2023). Similar migration patterns are expected for mackerels in Hainan, allowing them to make full use of resources in different seas, but also means that environmental changes may have a greater impact on their reproduction and growth (Weng et al., 2020).

2.2 Life history characteristics and growth patterns

Mackerel grows rapidly and has a relatively short life cycle. Studies have shown that narrow-band mackerel can grow to about 60 cm~80 cm at one in one age, and the total length can reach more than 100 cm within two years, and then the growth rate gradually slows down. Most mackerels mature sexually at 1.5~2 years old and are multi-spawning fish. They lay eggs in batches from spring to early summer every year. The absolute reproductive power of single female fish increases significantly with the individual size (Weng et al., 2020). A survey of blue-point mackerel breeding populations in the Yellow and Bohai Seas shows that dominant body recombination is concentrated in 0.5 kg~1.0 kg, accounting for 52% of the population. Rapid growth and early maturity are beneficial for population replenishment, but also make it more sensitive to fishing pressures (Mackie et al., 2005).

2.3 Economic and ecological value in marine ecosystems

As an important economic fish, mackerel also plays the role of a "medium predator" in marine ecosystems, controlling small and medium-sized fish and cephalopod populations, thereby affecting the structure of the food web. Mackerel has extremely high economic value and is popular among consumers for its delicate meat and little thorns. Especially in Hainan, mackerel is expensive and is one of the "best fish" and has contributed significantly to the increase in income of local fishermen. In short, mackerel has both ecological and economic value, and its resource management and breeding of good varieties are crucial to the sustainable development of fisheries (Roa-Ureta et al., 2019).

3 Seawater Fish Selection and Breeding Strategies

3.1 Basic principles and methods of selective breeding

Selective breeding is a traditional method of achieving genetic improvement of germplasm through targeted selection of individuals with excellent phenotypic traits. Among aquatic animals, breeding is used to achieve genetic improvement of quantitative traits such as growth, disease resistance, and meat through population selection and family selection (Kashyap et al., 2024). Compared with terrestrial animals, fish domestication and artificial breeding history have been shorter, but practice has proven that many farmed fish have made significant progress through selective breeding. In China, traditional aquatic genetic breeding is mainly concentrated in the field of freshwater fish, and the breeding potential of seawater fish is also huge. Fish have high reproductive power and large population size, and can build large-scale breeding groups in a short period of time, achieving high selection intensity and significant selection response (Janssen et al., 2017). However, seawater fish breeding also faces problems such as long generation cycles, high breeding facilities requirements, and inbred risks, and requires scientific breeding plans and long-term and stable investment.

3.2 Breeding practices in seawater fish

In the breeding practice of seawater fish, group breeding and family breeding are common strategies. Group breeding (also known as large group individual selection) is the choice of individuals with the best phenotype from each generation as parents. Its advantages are simple operation and short-term effectiveness, and are suitable for species with high reproductive power. Family selection and breeding can select excellent families by establishing multiple artificial family lines and comparing the average phenotypic performance between family lines, which can improve selection accuracy and effectively control inbreeding (Tong et al., 2023). For marine aquaculture varieties, a series of successful breeding cases have been carried out at home and abroad. For example, Chinese scientific research institutions have selected and bred five generations of wild yellow croaker groups to cultivate a new "Big Yellow croaker East China Sea No. 1" product that is resistant to low temperatures and fast growth. The growth rate and survival rate of yellow croaker in the breeding group were significantly higher than that in the control group, and the production performance advantages were obvious (Zhao et al., 2021; Ding et al., 2024). Experience shows that scientifically designed breeding programs can make full use of genetic variation and achieve effective improvement of seawater fish traits.

3.3 Learning from other species

In emerging breeding objects such as mackerel, we can learn from the successful experience of other species, gradually establish basic groups, measure genetic parameters, and implement continuous breeding. Excessive incommendation should be avoided during the selection process to prevent loss of population genetic diversity and inbred decline (Kobayashi et al., 2025). At the same time, breeding goals should coordinate multiple traits to avoid adverse responses related to traits by focusing only on a single indicator. For example, while improving growth rate, taking into account disease resistance and environmental adaptability, we can cultivate new varieties of seawater fish with excellent production performance and adaptability.

4 Case Background and Study Area Overview

4.1 Current status of Hainan offshore fishery resources

Hainan Province is located in the tropical region and has a coastline of 1 500 kilometers. The water temperature in the offshore waters is between 23 ℃ and 30 ℃ all year round, and fishery resources are very rich. In recent years, Hainan has actively built a modern fishery system, and emerging models such as deep-water cage farming have developed rapidly, and the output value of marine fishery in the province has continued to grow. In 2024, the province's fishery output value increased by 11.2% year-on-year, of which the output value of seawater aquaculture increased by 13.0%. However, the traditional fishing fishery in Hainan's offshore has stabilized or even declined, and the sustainable supply of high-quality economic fish resources is under pressure. To this end, Hainan Province has vigorously developed the aquatic seed industry and made artificial breeding and seed supply of precious varieties such as mackerels as key tasks. Thanks to excellent water quality and technical research, Hainan has successfully broken through the key technologies of artificial breeding of mackerels and filled the gap in the domestic seedlings (Pan et al., 2020). At present, due to its fast growth and high value, mackerel has become one of the important varieties of deep-sea cage breeding along the southern coast of China. This regionalized aquaculture promotion provides basic groups and practical conditions for this study.

4.2 Regional characteristics of mackerel breeding and breeding

Hainan mackerel breeding and breeding have significant regional characteristics. Hainan's sea area belongs to a tropical marine environment. The high temperature and high salt hydrological conditions prolong the growth period of mackerel, which is suitable for its rapid growth most of the year. However, high water temperature also means that when breeding, you need to pay attention to the heat resistance and low oxygen resistance of fish, and cultivate strains that are adapted to the extreme high temperatures in summer. Secondly, Hainan has abundant bait biological resources, and small middle and upper-level fish and crustaceans provide sufficient natural bait base for mackerels, which is conducive to their growth and development (Rajesh et al., 2017). However, extreme climate events such as monsoons and typhoons can cause significant fluctuations in the offshore environment, with phased effects on the feeding and growth of mackerels (Fardilah et al., 2024). Therefore, when conducting mackerel breeding experiments in Hainan, it is necessary to consider the interference of seasonal environmental factors on growth trait evaluation. Since mackerel is a predatory fish that swims at high speed, it is difficult to domesticate and reproduce under artificial conditions. Mackerels are lively and frightened by nature. They require special water conditions and sedation measures when induced by broods and artificial egg collection (Chiu et al., 2025).

4.3 The influence of Hainan water environmental factors on the growth of mackerel

In this study, we successfully obtained sufficient fertilized eggs for family construction by simulating natural light temperature cycles in parent fish ponds and reducing artificial interference. These regional factors have had an impact on the formulation of breeding programs. We chose to cultivate family lines in spring and summer based on the environmental characteristics of Hainan waters, and adopted a scattered and multi-point cage breeding method to reduce weather risks. The research area was selected in the deep-water cage breeding area along the eastern coast of Hainan. The water quality in this sea area is clear, the flow rate is moderate, and the bait is rich, which provides ideal conditions for the growth of mackerels and ensures the consistency of the environment during breeding experiments (Figure 1) (Chen et al., 2021).

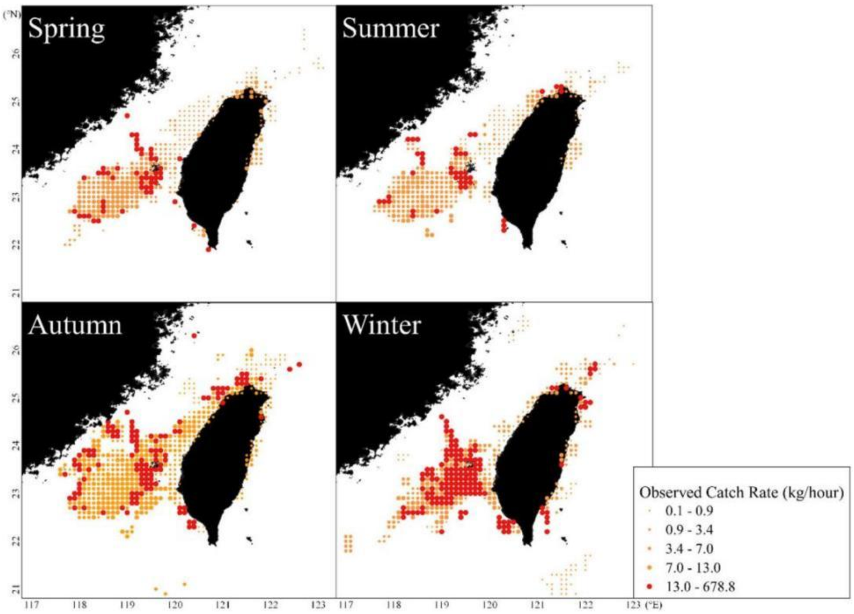

Figure 1 Seasonal mean observed catch rates of *S. commerson* caught using trammel nets in the WT (Adopted from Chen et al., 2021)

5 Genetic Variation of Growth Traits

5.1 Heritability estimation of major growth traits

Before conducting genetic assessment, the heritability level of the main growth traits of mackerel was first determined. Heritability reflects the proportion of trait phenotypic variation explained by genetic factors and is a basic indicator of selection and breeding of aquatic animals. This study was based on a semi-compatriot family model and heritability estimates were performed on the body length, weight and growth rate of a mackerel fish. The results showed that there was a moderate degree of variation in heritability of different growth traits. Among them, the estimated heredity value of body weight is about 0.3, which is a moderate heredity; the heredity of body length is slightly lower, about 0.15~0.2. This is consistent with the research results of other seawater fishes. For example, the weight heritability of red-fin oriental horns is 0.36 and the body length is 0.14, both of which are within the medium or low heritability range. The moderate level of heritability indicates that the growth traits of mackerel are significantly affected by genetic factors, and better improvement effects are expected through selection breeding. Heritability is not static and may change with the development stage of the fish body. Studies have found that the growth traits in the juvenile Nile tilapia have a higher heritability and decreases with increasing age (He et al., 2018). This may be due to the increased effect of environmental factors in the later stage, or the narrowing of genetic differences between individuals after growth enters the inflection point. In mackerels, we also observed a similar trend, with higher heritability estimates for body length and weight in young age (within 6 months of age), while lower heritability before and after sexual maturity (12~18 months of age) (El-Nady and Obeida, 2000).

5.2 Genetic correlation between body length, weight and growth rate

There is often a genetic correlation between growth traits, i.e. genetic improvement of one trait may be accompanied by changes in another trait. This study analyzed the genetic correlation between body length, weight and growth rate of mackerel. The results showed that body length was highly positively correlated with body weight, with its genetic correlation coefficient close to 0.9, and its phenotypic correlation coefficient was about 0.8, and its correlation reached a very significant level ($P<0.01$). This means that by selecting parents with larger weight, offspring will often increase in size accordingly. Therefore, weight can be used as the main selection indicator in breeding practice, and body length will be improved simultaneously. High correlation is also reflected in most farmed fish, such as the genetic correlation between Oriental Snake body length and weight is as high as 0.92 (Wang et al., 2022). In contrast, the genetic correlation between growth rate and final weight may be more complex. If the measured growth rates are not correlated with weight at harvest at different times, choosing early rapid growth families may not guarantee adult weight maximization (Oliveira et al., 2016).

5.3 Population differentiation and variability under selection pressure

When a population continues to experience directional selection pressure, the frequency of alleles within it will change directionally, causing the population's genetic structure to deviate from its original state. This population differentiation is the expected result of selective breeding, but it is wary of the consequences of a significant decline in genetic diversity (Imron et al., 2015). In this study, we compared the differences in neutral molecular markers between selected groups and unselected natural groups. It was found that after two generations of growth trait selection, the allelic diversity of the breeding population decreased slightly, and specific allelic frequency shifts occurred at some growth-related loci (Landguth and Balkenhol, 2012). This suggests that targeted selection has caused a certain degree of genetic differentiation among breeding populations. Some model prediction studies have also shown that continuous artificial or fishery selection will drive the evolutionary changes in fish populations in genetic life history characteristics, such as early maturity or growth rate changes. In breeding practice, we hope to accumulate favorable variation, but we must prevent the population genetic basis from being too narrow. To this end, we maintained a relatively large effective population size at each generation of breeding and introduced new wild individual ancestry for periodic hybridization to enrich the genetic background.

6 Hainan Case Results and Analysis

6.1 Comparison of growth performance between selected breeding groups and natural groups

By comparing the growth traits of Hainan mackerel breeding groups (two generations in succession) and natural groups, the results achieved by artificial selection can be clearly seen. The results showed that the breeding population performed better than the control natural population throughout the breeding cycle. By 18 months of age, the average weight of individuals in the breeding population was about 15% higher than that of the control population and the average body length was about 7%. The growth curves of the two groups were significantly separated in the middle and late stages, and the breeding groups showed higher growth rates in the late stages of breeding. This result is similar to the breeding experiment of yellow croaker. The growth rate of body length and weight of the selected offspring in the later stage exceeded that of the unbred control (Figure 2) (Zhou et al., 2019; Chen et al., 2020). It can be seen that the growth potential of mackerel has been successfully tapped through directional selection, which has greatly improved the growth performance of the population. Considering that there are many restrictions on the natural sea area environment, the actual increase in yield of artificial breeding lines under breeding conditions may be more significant. This means that promoting good varieties is expected to reduce dependence on wild mackerel fishing and contribute to resource conservation.

6.2 Differences in genetic gain in different breeding generations

Genetic gain between different breeding generations is an important basis for evaluating breeding effects. In this study, we observed that the average body length and weight of mackerels were significantly improved after the first generation (F_1), but the genetic gain amplitude of the second generation (F_2) was reduced. Specifically, F_1 has increased weight by about 10% compared with the unsuccessful population, while F_2 has only increased by about 5% further compared with F_1, and the second generation has almost no advantage in terms of body length. Similar phenomena have also been reported in the breeding of other fish. For example, the body length and mass of the yellow croaker F_2 are only 0.029 and 0.134, respectively, which is significantly lower than the previous generation's 0.26 and 0.18. This suggests that after a generation of strong selection, favorable variation in the population has been partially fixed, with the potentially reduced selectable variation, resulting in weaker selection responses in subsequent generations (Wang et al., 2022). Faced with this situation, we took two measures: First, appropriately reduce the selection intensity of the second generation to avoid excessive elimination and exhaustion of mutations; second, a small number of wild individuals from unrelated groups were introduced in the F_2 generation and hybridize with the breeding group to restore some genetic diversity. Practice has proven that these measures help to continue genetic gain, causing new signs of improvement in the growth traits of the third generation.

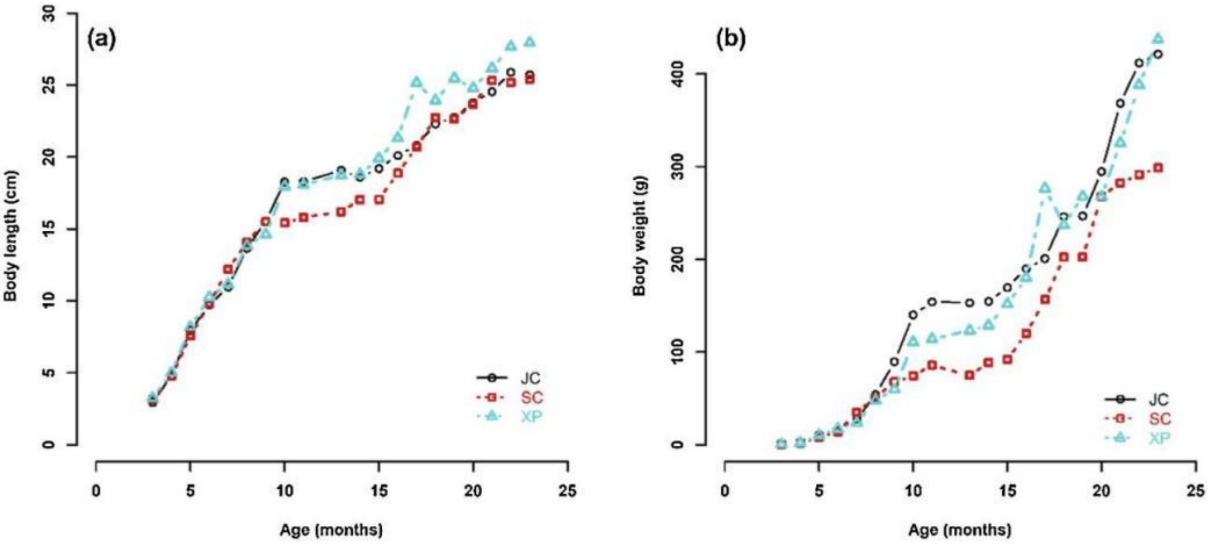

Figure 2 Growth condition of cage-cultivated large yellow croaker from Jiaocheng (JC), Shacheng (SC) and Xiapu (XP), Ningde City (Adopted from Chen et al., 2020)

6.3 Case-specific factors affecting breeding effect

During the breeding process of Hainan mackerel, we also observed the influence of some case-specific factors on breeding effects. First, there are environmental fluctuations factors. During the experiment, a strong El Niño incident happened, and the water temperature near Hainan was about 2 °C higher than usual. This led to the decline in feeding and impeded growth in both groups in summer, partially covering up the growth advantages of breeding groups. Secondly, the evaluation error may be caused by a relatively small family coefficient. Due to the relatively concentrated breeding season of mackerels, only 20 and a half-compatriot families were constructed in the first batch, which to some extent limited the accuracy of genetic parameter estimation. The number of families was subsequently increased to 31 by extending the egg-laying induction period, making heritability estimates more reliable (He et al., 2018). As a high-value large predator fish, mackerel is sensitive to management factors such as feed nutrition and breeding density. If the feed supply is insufficient or the density is too high, the growth advantage of the breeding group will be weakened (Yu et al., 2024). This reminds us that the high yield potential of good varieties can only be fully utilized under optimized breeding conditions. Therefore, while promoting good varieties, it is necessary to improve breeding management, such as providing high protein feed and reasonably controlling stocking density.

7 Case Inspiration and Promotion Value

7.1 Reference significance for regional breeding models

The practice of selective breeding of mackerels in Hainan provides useful inspiration for regional marine fish breeding models. The case highlights the significance of carrying out breeding of characteristic varieties according to local conditions. In the past, China's aquatic breeding work focused on freshwater varieties such as grass carp and tilapia, while Hainan took the lead in achieving breakthroughs in seawater famous varieties such as mackerel, proving the feasibility of targeted breeding for regional dominant species. This model can be promoted nationwide: coastal areas can carry out breeding of good varieties based on the main local aquaculture fish (Wang and Wu, 2025), form a regional good varieties system of "one province, one product" or "one bay, one product" to improve the core competitiveness of local fisheries. This case emphasizes the role of scientific genetic assessment in breeding. By measuring the heritability and correlation of growth traits of mackerel before breeding, we must adjust our breeding strategies in time and focus our main focus on the weight traits with the greatest potential for genetic improvement. This data-driven decision-making improves selection efficiency and avoids ineffective efforts.

7.2 Reference effect on breeding of other seawater fish in China

Similarly, in other species breeding, systematic genetic parameter determination and analysis should become a necessary link. In recent years, a considerable number of genetic assessment data of varieties have been accumulated in China, such as yellow croaker, shrimp, mandarin fish, etc. These data should be used to guide breeding practices and limited resources should be invested in traits and groups with the greatest genetic potential.

The successful breeding cases of Hainan mackerel show that genetic improvement and fishery resource conservation can complement each other. Increased breeding yield through artificial breeding can reduce the fishing intensity of wild populations while meeting market demand (Sun and Mai, 2025). When the breeding industry can provide stable mackerel products, consumers will no longer rely on fishing for wild individuals, thus giving wild resources the opportunity to recuperate. Going further, the practice of preserving wild gene banks during breeding also provides guarantees for resource protection. The living germplasm resource library and sperm freezer we established preserved the original germplasm of mackerel in Hainan and surrounding waters, leaving a way out for future breed improvement and resource recovery. This concept of combining "breeding, breeding and protection" is worth promoting in the fishery production of other species.

7.3 Thoughts on promoting industrialization and sustainable use of resources

The organization and implementation of Hainan mackerel breeding project reflects the strong advantages of industry-university-research cooperation. The division of labor and cooperation between the two sides has accelerated the breeding process and enabled enterprises to master the breeding technology of good breeding through participation. This "small core and big collaboration" model is exactly the direction of the development of modern aquatic seed industry. China has relatively insufficient original technology in the field of aquatic breeding, and scientific research institutions, universities and enterprises need to jointly build a collaborative innovation system and cultivate new varieties with independent intellectual property rights through joint research and development. The successful experience of Hainan case shows that only by closely combining scientific research with production, allowing breeding experts to go to the front line, and allowing enterprise technical personnel to participate in breeding can we quickly and well breed new varieties needed by the market.

From an industrial perspective, this case has significant demonstration and promotional significance. As an economic fish that used to rely mainly on fishing, mackerel has achieved breakthroughs in breeding in a short period of time through artificial breeding and improved product supply capacity. This sets an example for other marine fish farming in China and enhances the industry's confidence in breeding of good varieties. With the country's high attention and policy support for the aquatic seed industry, more and more seawater fish will be included in the breeding program. A batch of new fish species with faster growth rate and stronger disease resistance will continue to emerge, helping the transformation and upgrading of the marine aquaculture industry. Currently, China's marine fish farming output only accounts for 6.6% of the national aquaculture fish, and there is huge room for development.

8 Future Outlook and Application

Traditional breeding relies on parental phenotypic screening, has a long cycle and is susceptible to environmental influences. Genome selection uses genome-wide molecular marker information to predict individual species values, and potentially excellent parents can be selected in the juvenile stage. This method is especially effective for high heritability traits such as growth. At present, with the significant reduction in sequencing costs, low-coverage whole genome sequencing combined with genotype filling has become a more economical solution than SNP chips. Review studies show that GS significantly improves the selection accuracy and genetic progress of disease resistance and growth traits in a variety of farmed fish such as Atlantic salmon and tilapia. Therefore, in the future, GS breeding programs can be fully implemented for the important traits of mackerel. At present, scientific researchers have successfully constructed the chromosomal genome of spotted mackerel (Indo-Pacific sharp-tooth mackerel). On this basis, by genotyping a large number of individuals in the breeding population, establishing a phenotype-genotype database, and using statistical models to predict the breeding value of individuals, we can accurately select excellent seedlings from the offspring. The introduction of genome selection will greatly improve breeding efficiency, and it is expected to shorten the generation interval of mackerels and obtain new varieties with excellent performance as soon as possible.

When there are major genes or known molecular markers in certain important traits, marker-assisted selection can be used to accelerate breeding. If key genes or QTL sites related to mackerel growth rate, muscle quality, etc. can be found, corresponding DNA markers can be developed to assist seed selection. For example, if a single nucleotide polymorphic locus (SNP) is found to be highly correlated with the muscle fat content of mackerel fish, we can screen young fish carrying favorable alleles through molecular testing and retain them as parents. Label-assisted selection has been successful in some aquatic animals, such as Pacific oysters that improve antivibriopathy through molecular marker selection, and Atlantic salmon that significantly reduces ISA virus infection rates through family marker selection. For mackerels, genetic markers related to disease resistance and stress resistance can be identified through genome-wide association analysis (GWAS), so as to carry out targeted MAS breeding.

The emergence of gene editing technologies such as CRISPR-Cas9 provides the possibility to accurately improve the traits of aquaculture varieties. Through gene editing, target sites can be modified at the genome level and targeted improvements that are difficult to achieve in traditional breeding. For example, knocking out myostatin (MSTN), a negatively regulated muscle growth, can promote significant hyperplasia of fish muscles and accelerate individual growth. This technology has been used to cultivate "bodybuilding fish" crucian carp and carp strains, confirming its potential to improve growth. For mackerels, if a key gene that limits growth can be identified, it can also be tried to silence or knock out through gene editing to directly increase growth rate. In addition, gene editing can also be used to verify the function of candidate genes and better guide the MAS and GS selection directions. For example, by knocking out or overexpressing a gene that is suspected to affect the growth or disease resistance of mackerels, observing its trait changes, to determine whether the gene is worthy of focus in breeding.

As genomic data accumulates for more mackerel species and populations, we can construct a pan-genomic map of mackerel fish to cover genetic variation information for all lines. This helps us to have a more comprehensive understanding of the genetic diversity of mackerels and to improve breeding strategies using information such as structural variation. Some studies have found that the loss of structural variations in certain large fragments during domestic domestication may affect the performance of traits, which can be monitored and taken into consideration through pan-genomic analysis. At the same time, using AI technologies such as machine learning, we can mine massive genomic and phenotypic data to find the genetic laws of complex traits, thereby improving the accuracy of trait prediction.

Acknowledgments
The authors would like to thank all teachers and colleagues who provided guidance and assistance during this research, and for the peer review's revision suggestions.

Conflict of Interest Disclosure
The authors confirm that the study was conducted without any commercial or financial relationships and could be interpreted as a potential conflict of interest.

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