fishes

MDPI

Article

Effects of Salinity on Growth, Digestive Enzyme Activity, and Antioxidant Capacity of Spotbanded Scat (*Selenotoca multifasciata*) Juveniles

Jianyi Liu [1,2,*,†], Tongxi Ai [1,2,†], Jun Yang [1,2], Meijuan Shang [1,2], Keji Jiang [1,2], Yane Yin [1], Lei Gao [1], Wei Jiang [1], Na Zhao [1], Jianfeng Ju [1,2] and Bo Qin [1]

[1] East China Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences, Shanghai 200090, China; 18317560278@163.com (T.A.)
[2] College of Fisheries and Life Sciences, Shanghai Ocean University, Shanghai 201306, China
* Correspondence: liujy@ecsf.ac.cn
† These authors have contributed equally to this work.

Abstract: As a euryhaline fish species that inhabits estuarine and coastal regions, the spotbanded scat (*Selenotoca multifasciata*) experiences growth influences during its larval stage due to variations in salinity. Here, we evaluated salinity required by early-stage spotbanded scat juveniles to achieve the highest growth performance, digestive enzyme activity, survival, and antioxidant capacity. We reared spotbanded scat juveniles (all 0.50 ± 0.05 g) in 0–35‰ salinity gradients for 50 days and recorded their survival rate every 10 days. After 50 experimental days, we measured morphological data, stomach and intestinal digestive enzyme activities, and liver antioxidant enzyme activities and malondialdehyde contents. In general, 5–15‰ salinity led to 100% survival. The 5‰ salinity group demonstrated the highest values for the following measures: final wet body weight; weight gain rate; specific growth rate; growth percentage; average daily gain; stomach amylase and lipase specific activities; and intestinal amylase, lipase, trypsin, and pepsin specific activities. However, stomach trypsin and pepsin activities did not demonstrate significant between-group differences (all $p > 0.05$). The 25‰ salinity group demonstrated the highest liver superoxide dismutase and glutathione peroxidase activities and malondialdehyde content. Finally, the 0‰ salinity group demonstrated the highest liver catalase activity. Thus, spotbanded scat juveniles demonstrate the highest survival rates, growth performance, and digestive enzyme activity at 5‰ salinity and the strongest oxidative stress responses at 25‰ salinity.

Keywords: spotbanded scat (*Selenotoca multifasciata*); salinity; growth; digestive enzyme; antioxidant capacity

Key Contribution: This study aimed to detect and analyze the effects of salinity on the growth, digestive enzyme activity, and antioxidant capacity of spotbanded scat juveniles. Salinity exerts substantial variations on the growth, digestive enzyme activity, and antioxidant capacity of spotbanded scat juveniles.

check for updates

Citation: Liu, J.; Ai, T.; Yang, J.; Shang, M.; Jiang, K.; Yin, Y.; Gao, L.; Jiang, W.; Zhao, N.; Ju, J.; et al. Effects of Salinity on Growth, Digestive Enzyme Activity, and Antioxidant Capacity of Spotbanded Scat (*Selenotoca multifasciata*) Juveniles. *Fishes* **2024**, *9*, 309. https://doi.org/10.3390/fishes9080309

Academic Editor: Héctor G. Nolasco-Soria

Received: 9 July 2024
Revised: 28 July 2024
Accepted: 29 July 2024
Published: 5 August 2024

Copyright: © 2024 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

1. Introduction

Spotbanded scat (*Selenotoca multifasciata*) (Class: Actinopterygii, Order: Perciformes, Family: Scatophagidae) is mainly distributed in the southern part of the East China Sea, in the South China Sea, and in some coastal and estuarine areas of several countries including Indonesia, the Philippines, and Thailand. Spotbanded scat is a marine omnivorous fish species, which is mostly herbivorous and demonstrates a wide temperature and salinity tolerance. Its meat is delicate and delicious, highly favored by consumers. As such, it is considered an economically important fish, with both ornamental and food value, as well as economic, social, and ecological benefits [1,2].

Salinity is a crucial environmental factor affecting fish survival and growth, primarily because it directly influences various physiological processes such as metabolism, osmoregulation, appetite, digestive enzyme activity, and reproductive behavior [3]. In an isotonic environment, some fish can use the vast majority of absorbed energy for growth and development because they only need minimal energy on osmoregulation. As such, their metabolic rate reaches the lowest level, and the ingested energy conversion rate reaches the highest level. This characteristic is noted in some salt-tolerant and euryhaline fish [4]. For instance, juvenile largemouth bass (*Micropterus salmoides*) exhibit higher growth performance at a salinity of 5‰ than at a salinity of 10‰ or in freshwater environments [5]. Salinity can promote or inhibit digestive enzyme activity in fish such as the common snook (*Centropomus parallelus*), black porgy (*Onchidium struma*), and olive flounder (*Paralichthys olivaceus*), affecting their digestion and absorption, in turn influencing their growth and development [6–9]. In addition, Choi et al. [10] reported that changes in salinity often lead to reduced reactive oxygen species (ROS) production in *P. olivaceus*. To prevent damage from excessive ROS, organisms have developed an antioxidant enzyme defense system, mainly including superoxide dismutase (SOD), catalase (CAT), and glutathione (GSH) peroxidase (GSH-PX) [11–13]. Malondialdehyde (MDA), a product of free radical attack on membrane unsaturated fatty acids, can interact with the free amino groups of proteins and cause cell damage. MDA contents can be an indicator of the extent of free radical attack on body cells [14,15].

Estuarine areas are the intersections between rivers and oceans. The combined effects of various factors such as water flow, tides, sediment transport, climate change, and human activities render salinity and environmental conditions unpredictable; as a result, aquatic organisms residing in these regions develop complex adaptive processes [16]. The highly unstable environment considerably impedes the survival, growth, development, and physiological status of the juveniles of various fish species. Research thus far on the polystigmatid sciaenid fish spotbanded scat in China and globally has mainly focused on embryonic development [1,17], mitochondrial genomes [18,19], and pathogenic bacteria [2]. However, studies on the effects of salinity on the growth performance, digestive enzyme activity, and antioxidant capacity of spotbanded scat juveniles remain scant. Therefore, in this study, we elucidated the salinity levels required for optimal growth performance, survival rate (SR), and antioxidant capacity of early-stage seedlings of spotbanded scat.

2. Materials and Methods

2.1. Fish Rearing Condition and Experimental Design

Spotbanded scat juveniles used in this study were obtained from artificially fertilized larvae cultivated at the Qionghai Research Center of the East China Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences, China. In total, 720 healthy, disease-free, and undamaged spotbanded scat juveniles with consistent weights (0.5 ± 0.05 g) and consistent body length (24.18 ± 0.14 mm) were randomly selected and divided into eight salinity groups (0‰, 5‰, 10‰, 15‰, 20‰, 25‰, 30‰, and 35‰), with three replicates per group and 30 juveniles per replicate, at the Ganyu Research Base of the East China Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences. Before the experiment began, the subjects were reared in natural seawater with a salinity of 25‰ for one week. Each group was placed in a 120 L white cylindrical tank containing 50 L of water maintained at 24–26 °C. In each group, the initial salinity was set to 25‰ [20], and the salinity was increased or reduced by 5 units daily until it reached the required salinity of each group—at which point the formal experiment commenced. All juveniles were fed twice daily, in the morning and evening, the experimental feed used was the formulated grass shrimp feed from Tongwei Co., Ltd., (Chengdu, China) and the feeding rate (FR) was recorded daily. One-third of the preprepared seawater with various salinities was replaced daily to ensure that the salinity remains unchanged.

2.2. Data Processing and Analysis

The experimental fish were observed daily for their activity, and the water temperature changes and mortality during the rearing process were recorded. On completion of the experiment, various growth data such as body weights and lengths were measured and recorded. The survival rate (SR), weight gain rate (WGR), specific growth rate (SGR), growth rate (GR), feed rate (FR), average daily gain (ADG) and Fulton's condition factor (CF) were then calculated as follows:

$$\text{SR (\%)} = 100\% \times [(N - n)/N]$$

$$\text{WGR (\%)} = 100\% \times [(W_t - W_0)/W_0]$$

$$\text{SGR (\%/d)} = 100\% \times [(\ln W_t - \ln W_0)/t]$$

$$\text{GR (\%)} = 100\% \times [(L_t - L_0)/L_0]$$

$$\text{FR (\%)} = 100\% \times (FI/[t \times (W_t - W_0)/2])$$

$$\text{ADG (g/d)} = (W_t - W_0)/t$$

$$\text{CF (\%)} = 100\% \times (W_t/{L_t}^3)$$

Here, N denotes the total number of fish, n the number of fish deaths, W_t the final wet body weight of the fish (in g), W_0 the initial body weight of the fish (in g), t the number of experimental days (in days), L_t represents the final body length (in cm), L_0 the initial body length (in cm), FI the average food intake per fish (in g), and L_t the total food intake (in g) over t days.

2.3. Sample Collection

Before sample collection, all experimental fish were fasted for 24 h and then anesthetized using a dosage of 30 g/m^3 of Tricaine methanesulfonate (MS-222). Subsequently, all experimental fish were dissected on an ice tray, and their intestines, stomachs, and livers were removed. After content and fat removal, all organ tissue samples were rapidly frozen in liquid nitrogen and stored at −80 °C in an ultralow-temperature freezer.

2.4. Digestive Enzymes Assay

Before measurement, all tissue samples were weighed accurately. To each sample, 0.9% precooled physiological saline was added in a 1:10 ratio of weight (in g) to volume (in mL), followed by homogenization on the European-made Kinematica Brand MB 550 Model high-speed grinder. The resulting homogenate was centrifuged at 4 °C at 2500 rpm for 10 min. The supernatants from the intestinal and stomach tissue homogenates were used for digestive enzyme activity determination; the following definitions were used to measure one unit of digestive enzyme activity:

- Amylase: the amount of enzyme that can hydrolyze 10 mg of starch in 30 min at 37 °C in the presence of 1 mg of tissue protein;
- Lipase: the amount of enzyme that can consume 1 μmol of substrate per minute in a reaction system containing 1 g of tissue protein at 37 °C;
- Trypsin: trypsin contained within 1 mg of tissue protein induced a change in absorbance of 0.003 per minute at pH 8.0 and 37 °C;
- Pepsin: the amount of enzyme that can decompose protein to generate an equivalent of 1 μg of amino acids per minute per 1 mg of tissue protein at 37 °C.

2.5. Antioxidant/Oxidant Assays

Liver tissue homogenates were used for antioxidant enzyme activity and MDA content measurement. SOD activity was measured using the water-soluble tetrazolium (WST-1) method [21], with the absorbance value determined at 450 nm; the activity unit was defined as the amount of enzyme corresponding to a 50% inhibition rate of SOD in this reaction system. CAT activity was measured using a visible light method by determining the amount of H_2O_2 reduced at 450 nm; the activity unit was defined as the amount of enzyme decomposing 1 μmol of H_2O_2 per second per milligram of tissue protein. GSH-PX activity was calculated by measuring GSH consumption at 412 nm; the activity unit was defined as the amount of enzyme reducing the GSH concentration in the reaction system by 1 μmol/L per minute per milligram of tissue protein, excluding the effects of nonenzymatic reactions. The determination of MDA content is based on the measurement of the absorbance of the red product formed from the reaction between MDA and thiobarbituric acid (TBA) at a wavelength of 532 nm, which indirectly reflects the MDA content in the sample.

All enzyme activity and MDA content measurements were performed using kits from Nanjing Jiancheng Bioengineering Institute via spectrophotometry. These kits provide accurate and reliable experimental results, thereby ensuring the accuracy and reproducibility of research data.

All experimental data were subjected to basic processing on Excel 2019 and then analyzed using one-way analysis of variance on SPSS (version 26.0). A p value of <0.05 was considered to indicate statistically significant differences. Multiple comparisons were performed using Duncan's method. All data are expressed as means ± standard deviations (SDs). Graphs were plotted using GraphPad Prism (version 9.5.0).

3. Results

3.1. Effects of Salinity on Juvenile Spotbanded Scat Growth and Survival

3.1.1. Impact of Salinity on Juvenile Spotbanded Scat SR

As shown in Table 1, the SRs did not differ significantly between the 5‰, 10‰, 15‰, and 25‰ salinity groups on experimental days 10, 20, 30, 40, and 50 (all $p > 0.05$); however, in the 5‰, 10‰, and 15‰ salinity groups, but not the 25‰ salinity group, the SRs remained 100% throughout the experimental period. On days 10 and 20, the SRs were significantly lower in the 0‰ and 35‰ salinity groups than in the 5–30‰ salinity groups (all $p < 0.05$). On day 30, the 30‰ and 35‰ salinity groups demonstrated similar SRs. On day 40, sudden death occurred in some 20‰ salinity group fish, which led to significant differences in the 20‰ salinity group compared with the 5‰, 10‰, 15‰, and 25‰ salinity groups (all $p < 0.05$). On day 50, the SRs of the 5‰, 10‰, 15‰, and 25‰ salinity groups did not show significant differences (all $p > 0.05$), but they were significantly different from those in the other groups (all $p < 0.05$).

Table 1. Impact of salinity on spotbanded scat juvenile SR (%).

Salinity (‰)	Experimental Day				
	10	**20**	**30**	**40**	**50**
0	96.11 ± 0.96 ^{c}	96.11 ± 0.96 ^{c}	96.11 ± 0.96 ^{c}	96.11 ± 0.96 ^{c}	92.78 ± 0.96 ^{e}
5	100.00 ^{a}	100.00 ^{a}	100.00 ^{a}	100.00 ^{a}	100.00 ^{a}
10	100.00 ^{a}	100.00 ^{a}	100.00 ^{a}	100.00 ^{a}	100.00 ^{a}
15	100.00 ^{a}	100.00 ^{a}	100.00 ^{a}	100.00 ^{a}	100.00 ^{a}
20	100.00 ^{a}	100.00 ^{a}	100.00 ^{a}	96.39 ± 0.48 ^{c}	96.39 ± 0.48 ^{c}
25	100.00 ^{a}	99.16 ± 0.84 ^{a}	99.16 ± 0.84 ^{a}	99.16 ± 0.84 ^{a}	99.16 ± 0.84 ^{a}
30	100.00 ^{a}	100.00 ^{a}	97.63 ± 0.65 ^{b}	97.63 ± 0.65 ^{b}	97.63 ± 0.65 ^{b}
35	98.05 ± 0.48 ^{b}	98.05 ± 0.48 ^{b}	98.05 ± 0.48 ^{b}	94.72 ± 0.96 ^{d}	94.72 ± 0.96 ^{d}

All values are percentages, presented as means ± SDs. Identical superscript letters within the same column indicate no significant between-group differences ($p > 0.05$), whereas different superscript letters indicate significant between-group differences ($p < 0.05$).

3.1.2. Impact of Salinity on Juvenile Spotbanded Scat Growth Indices

As shown in Table 2, as salinity increased, the W_t, WGR, SGR, GR, and ADG of the spotbanded scat juveniles tended to increase first and then decrease. The highest values were noted in the 5‰ salinity group, and they were significantly different from those in the other groups (all $p < 0.05$). In contrast, the 0‰ salinity group demonstrated the lowest values; only FR in the 0‰ salinity group was significantly different from those in the other groups (all $p < 0.05$), whereas the other values did not differ significantly from those in the other groups (all $p > 0.05$). The CF in the 30‰ salinity group was significantly higher than that in the other groups; however, the differences in CF between other groups were nonsignificant. Taken together, these results indicate that lower salinity has little effect on the feeding rate and condition factor of spotbanded scat larvae, but their overall growth performance is better than that under high salinity.

Table 2. Impact of salinity on spotbanded scat juvenile growth indices.

Salinity (‰)	W_t (g)	WGR (%)	SGR (%·Day^{-1})	FR (%·Day^{-1})	GR (%)	ADG (g·Day^{-1})	CF (%)
0	3.32 ± 1.15 ^{e}	563.20 ± 230.11 ^{e}	4.09 ± 0.73 ^{e}	4.02 ± 0.46 ^{a}	70.84 ± 19.73 ^{e}	0.06 ± 0.03 ^{e}	4.55 ± 0.19 ^{b}
5	12.67 ± 1.80 ^{a}	2433.80 ± 359.21 ^{a}	7.16 ± 0.33 ^{a}	2.63 ± 0.07 ^{b}	172.97 ± 10.63 ^{a}	0.27 ± 0.04 ^{a}	4.53 ± 0.86 ^{b}
10	11.31 ± 2.27 ^{b}	2162.40 ± 453.56 ^{b}	6.89 ± 0.41 ^{ab}	2.83 ± 0.22 ^{b}	161.91 ± 15.26 ^{ab}	0.24 ± 0.05 ^{b}	4.52 ± 1.13 ^{b}
15	11.02 ± 2.01 ^{b}	2104.47 ± 402.57 ^{b}	6.84 ± 0.39 ^{b}	2.55 ± 0.06 ^{b}	155.22 ± 14.80 ^{b}	0.23 ± 0.04 ^{b}	4.93 ± 1.00 ^{b}
20	8.40 ± 2.67 ^{cd}	1580.60 ± 534.75 ^{cd}	6.16 ± 0.71 ^{cd}	2.78 ± 0.41 ^{b}	135.84 ± 21.44 ^{c}	0.18 ± 0.06 ^{cd}	5.23 ± 0.79 ^{b}
25	9.14 ± 1.70 ^{c}	1727.29 ± 340.85 ^{c}	6.42 ± 0.40 ^{c}	2.39 ± 0.23 ^{b}	138.72 ± 18.53 ^{c}	0.19 ± 0.04 ^{c}	4.69 ± 1.16 ^{b}
30	7.33 ± 1.99 ^{d}	1366.00 ± 398.94 ^{d}	5.88 ± 0.66 ^{d}	2.55 ± 0.39 ^{b}	111.82 ± 23.99 ^{d}	0.15 ± 0.04 ^{d}	5.98 ± 1.67 ^{a}
35	8.22 ± 1.87 ^{cd}	1543.07 ± 373.85 ^{cd}	6.16 ± 0.52 ^{cd}	2.78 ± 0.27 ^{b}	135.19 ± 18.25 ^{c}	0.17 ± 0.04 ^{cd}	4.91 ± 0.96 ^{b}

All data are presented as means ± SDs. Final wet body weight (W_t), weight gain rate (WGR), specific growth rate (SGR), growth rate (GR), feed rate (FR), average daily gain (ADG), and Fulton's condition factor (CF). Identical superscript letters within the same column indicate no significant between-group differences ($p > 0.05$), whereas different superscript letters indicate significant between-group differences ($p < 0.05$).

3.2. Effects of Salinity on Digestive Enzyme Activity of Juvenile Spotbanded Scat

3.2.1. Impact of Salinity on Digestive Enzyme Activity in Juvenile Spotbanded Scat Stomach Tissue

As the salinity increased, the stomach amylase specific activity tended to increase initially and then decreased to a relatively stable level (Figure 1a). In particular, the activity reached its maximum at 5‰ salinity; it was significantly higher than in all other groups except the 0‰ salinity group (all $p < 0.05$). However, the groups with salinity ranging from 10‰ to 35‰ demonstrated no significant between-group differences (all $p > 0.05$); the enzyme activity remained stable as salinity increased. The lowest amylase activity was observed in the 20‰ and 25‰ salinity groups.

A trend similar to that for stomach amylase specific activity was noted for stomach lipase activity (Figure 1b): as salinity increased, it increased first and then decreased. The lipase activity peaked in the 5‰ salinity group; it was significantly higher than that in all other groups (all $p < 0.05$). The lowest lipase activity was recorded in the 20‰ salinity group; it was significantly different from that in all other groups except the 25‰ and 30‰ salinity groups (all $p < 0.05$).

Stomach trypsin and pepsin specific activities (Figure 1c,d) were not affected significantly by differences in salinity (all $p > 0.05$). However, stomach trypsin and pepsin activities were the lowest in the 20‰ and 25‰ salinity groups, respectively.

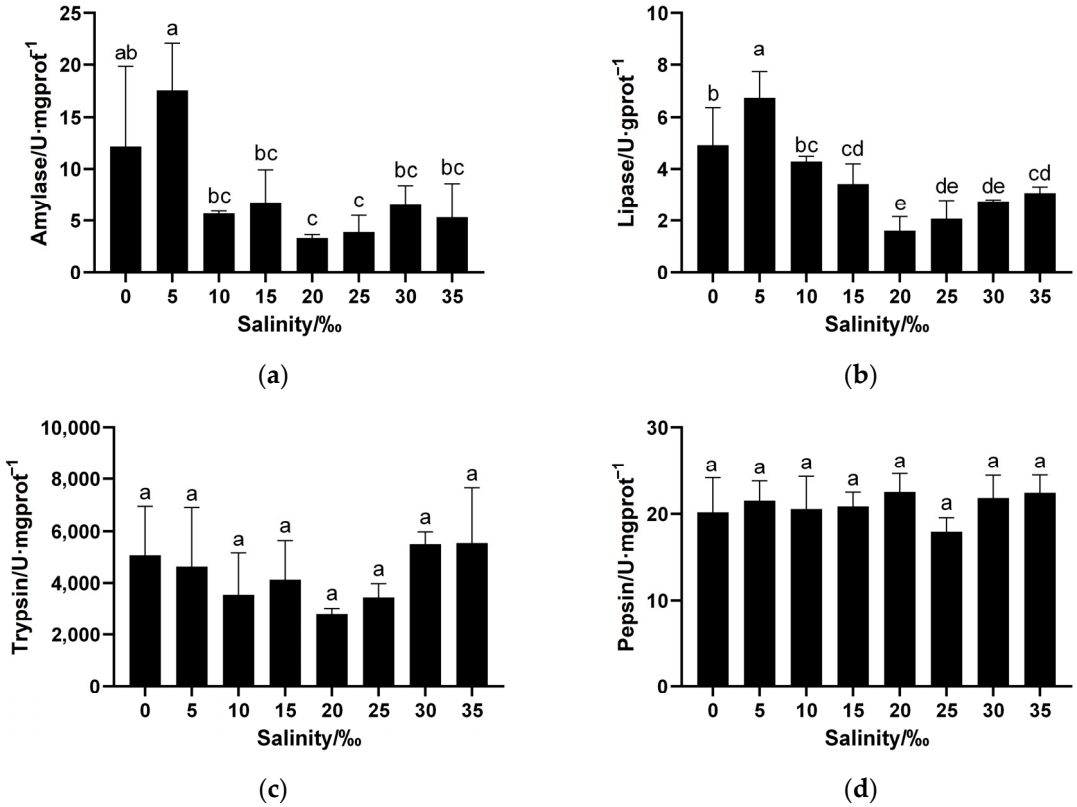

Figure 1. Impact of salinity on (**a**) amylase, (**b**) lipase, (**c**) trypsin, and (**d**) pepsin specific enzyme activities in stomach tissues of spotbanded scat juveniles. The lowercase letters are statistically significant.

3.2.2. Impact of Salinity on Digestive Enzyme Activity in Juvenile Spotbanded Scat Intestinal Tissue

As salinity increased, intestinal amylase, lipase, trypsin, and pepsin specific activities increased first and then decreased (Figure 2a–d). Specifically, all the activities were the highest in the 5‰ salinity group; they were significantly higher than those in all other groups (all $p < 0.05$). In contrast, the lowest amylase, lipase, and pepsin activities were recorded in the 35‰ salinity group, whereas the lowest trypsin activity was noted in the 25‰ salinity group. However, the groups with salinity ranging from 10‰ to 35‰ demonstrated no significant between-group differences in intestinal amylase, lipase, and trypsin activities (all $p > 0.05$).

3.3. Effects of Salinity on Antioxidant Enzyme Activities and MDA Contents in Juvenile Spotbanded Scat Liver

As salinity increased, liver SOD, CAT, and GSH-PX specific activities and MDA contents tended to decrease initially, then increase, and decrease again (Figure 3a–d).

Liver SOD and GSH-PX activities were the highest in the 25‰ salinity group; they were significantly higher than those in other groups except the 20‰ and 30‰ salinity groups (all $p < 0.05$). In contrast, they were the lowest in the 10‰ salinity group. Moreover, SOD activity was significantly lower in the 10‰ salinity group than in other groups except for the 5‰, 15‰, and 35‰ salinity groups, whereas GSH-PX activity was significantly lower in the 10‰ salinity group than in only the 20‰, 25‰, and 30‰ salinity groups (all $p < 0.05$).

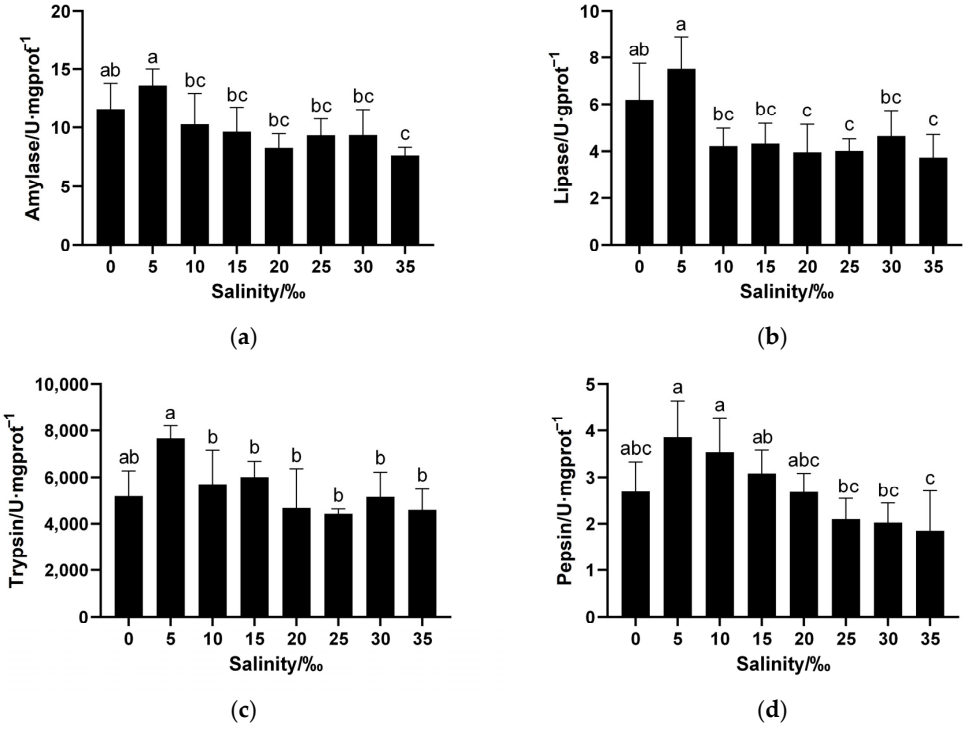

Figure 2. Impact of salinity on (**a**) amylase, (**b**) lipase, (**c**) trypsin, and (**d**) pepsin specific enzyme activities in intestinal tissues of spotbanded scat juveniles. The lowercase letters are statistically significant.

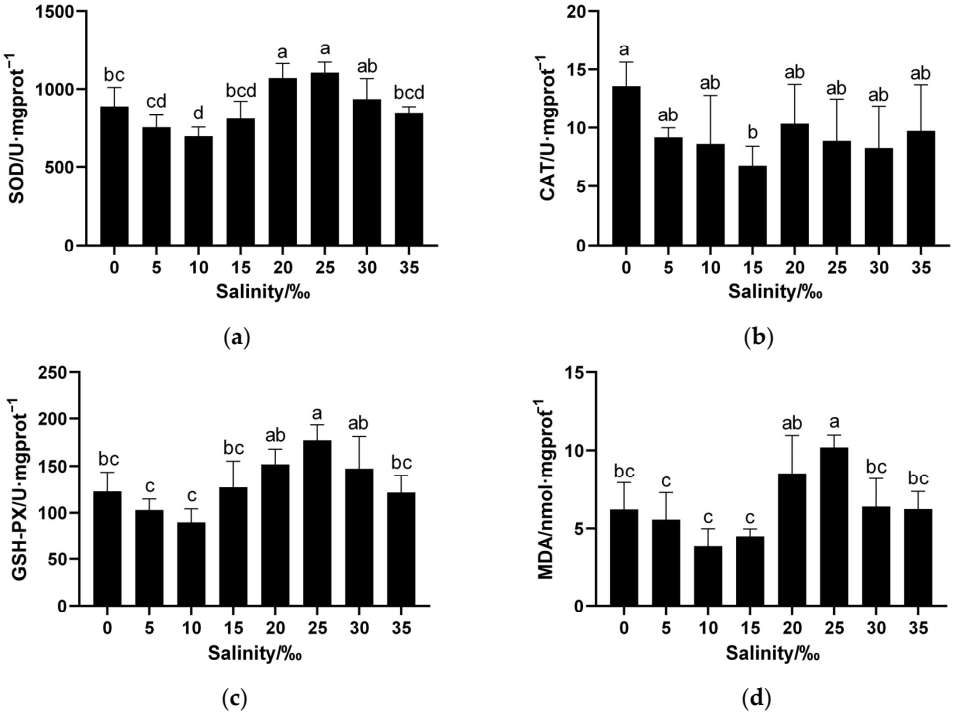

Figure 3. Impact of salinity on (**a**) SOD specific activity, (**b**) CAT specific activity, (**c**) GSH-PX specific activity, and (**d**) MDA content in liver tissues of spotbanded scat juveniles. The lowercase letters are statistically significant.

CAT activity was the highest in the 20‰ salinity group; however, it did not differ significantly from that in all the other groups except the 15‰ salinity group (all $p > 0.05$). In contrast, it was the lowest value in the 15‰ salinity group; however, it did not differ significantly from that in all the other groups except the 0‰ salinity group (all $p > 0.05$).

Finally, liver MDA content was the highest in the 25‰ salinity group; it was significantly higher than that in all the other groups except for the 20‰ salinity group (all $p < 0.05$). In contrast, liver MDA content was the lowest in the 10‰ salinity group; however, it did not significantly differ from that in all the other groups except the 20‰ and 25‰ salinity groups (all $p > 0.05$).

4. Discussion

Fish growth and development are closely related to the living environment, with salinity being a critical environmental factor. Changes in their water body's salinity can affect the physiological activities of fish, including survival, growth, reproduction, digestion, absorption, and immune function [22,23]. Salinity significantly affects the survival and growth rates and overall health of fish juveniles by regulating osmotic balance, thus influencing their metabolic capacity, altering their enzyme specific activity and hormone secretion, and affecting feeding behavior and physiological activities [24,25]. An increase in water salinity increases the osmotic pressure in Nile tilapia juveniles. To maintain the stability of the internal environment and regulate osmotic pressure, a juvenile fish body consumes a considerable amount of energy, directly affecting the growth, development, and survival of the fish [24,26,27]. Moreover, salinity in their environment can influence the growth rates of juvenile fish by affecting their food intake, food conversion, and hormone secretion [28].

The optimal salinity range for the growth of different fish larvae varies significantly. For instance, *Platichthys stellatus* juveniles demonstrate the highest SGR and WGR at 8‰ salinity [29]; moreover, *Pseudosciaena crocea* demonstrates a high growth rate and low FC at 13.6–14.1‰ salinity [30], and the optimal salinity range for *Epinehelus moara* juvenile growth is 14–19‰ [31]. In this study, spotbanded scat juveniles achieved high WGR, SGR, GR, and ADG at 5–15‰ salinity—similar to the findings of Xin et al. for juvenile *Pl. stellatus* [29]. Similarly, Mookkan et al. [32] reported that *Sc. argus* juveniles achieved the highest SGR at a salinity of 5‰. However, our spotbanded scat juvenile demonstrated the lowest at 0‰ salinity. In contrast, 35‰ salinity was noted to result in the lowest SGR among *Sc. argus*. This difference may be related to the differences in the species and size of the fish or in the seawater used. At 0‰ salinity, our spotbanded scat juveniles exhibited significantly higher FR but lower values for other indicators than in other salinity groups (all $p < 0.05$). This may be related to the fact that a low-osmolarity environment similarly requires the organism to expend a significant amount of energy to regulate its osmotic pressure. The observation of a higher feeding rate under low-osmolarity conditions, which deviates from the common perception that marine fish generally exhibit poor adaptability to low-salinity environments, necessitates further inquiry into the underlying mechanisms. FRs did not differ between the 20‰, 25‰, 30‰, and 35‰ salinity groups (all $p > 0.05$); however, other indicators decreased as salinity increased. These results are consistent with those of Li et al. for *M. salmoides* juveniles [33]. This phenomenon may be related to the fish using additional energy to regulate osmotic pressure, thereby reducing the energy available for growth. As such, fish growth performance will be the highest under optimal salinity conditions. In general, a salinity of 5–15‰ may lead to expend less energy in adapting to the environment, and their growth is not hindered by low salinity. Furthermore, lower salinity activates the digestive enzyme activity in spotbanded scat juveniles, enhancing their digestive and absorptive capabilities. Consequently, increasing feed supplementation during production is recommended, providing valuable insights for aquaculture practices.

In fish, digestive enzymes, secreted by digestive system organs, directly catalyze nutrient absorption and conversion, promoting digestion. Salinity can affect the specific activities of these enzymes in fish. In particular, salinity alters the osmotic pressure of the body of a fish, affecting its gastrointestinal digestive enzyme activity [11,34–36]. Gheisvandi et al. [37] reported that salinity can significantly affect digestive enzyme specific activities and efficiency. Based on their digestion targets, digestive enzymes can be broadly divided into proteases, amylases, and lipases. Low salinity can inhibit the specific activities of proteases, amylases,

and lipases in the gastrointestinal tract of marine fish, which prevents digestion and absorption of food, thereby affecting their growth and survival [38,39]. However, some euryhaline fish species exhibit an increase in digestive enzyme specific activity as salinity decreases to within a certain low-salinity range, demonstrating the strong adaptability of the fish [40]. Therefore, digestive enzyme specific activity alterations can be used to monitor the digestive status of fish under different salinity conditions. For instance, changes in amylase, protease, and lipase specific activities in the gastrointestinal tract of Red seabream (*Pagrosomus major*) juveniles tend to be consistent under different salinity levels, reaching their maxima at 25‰ salinity. Increases or decreases in salinity can be associated with corresponding decreases in enzyme activities, particularly lipase specific activity [35].

In the current study, amylase and lipase specific activities in the stomach and intestinal tissues of spotbanded scat juveniles tended to increase first and then decrease as salinity increased; both activities reached their maxima at 5‰ salinity—significantly higher than those in all the other groups (all $p < 0.05$). However, stomach trypsin and pepsin activities did not differ significantly among different salinity groups (all $p > 0.05$). This is consistent with the findings of Luo et al. [41]: increasing salinity inhibits amylase and lipase activities but does not affect protease activity in Marbled eel (*Anguilla marmorata*). In this study, trypsin and pepsin activities in the intestinal tissue demonstrated identical trends as stomach amylase and lipase activities: as salinity increased, both increased first and then decreased; the differences among different salinity groups were significant (all $p < 0.05$). Thus, the specific digestive enzyme activity in the gastrointestinal tissues of spotbanded scat juveniles is relatively high at 5‰ salinity. Furthermore, based on the findings of this study, it is hypothesized that the total enzyme activity in the gastrointestinal tissues of spotbanded scat juveniles may initially increase and then decrease with increasing salinity, peaking at a salinity of 5‰, though further experimental validation is required.

In environments with salinities higher or lower than the isotonic point of a fish's body, some energy is used to maintain the osmotic pressure balance of the fish's body; this leads to reduced utilization efficiency of nutrients present in the food, which affects its growth and development [42,43]. In the current study, digestive enzyme specific activities in the stomach and intestinal tissues of spotbanded scat juveniles were the highest at 5‰ salinity, possibly because this salinity level of 5‰ activates the digestive enzyme activity of spotbanded scat juveniles [44]. Under an environment with salinity close to its isotonic point, the energy a fish consumes for osmotic regulation is less, while digestive enzyme activities correspondingly increase, accelerating food digestion. This results in an enhanced efficiency of food digestion and absorption, allowing for the full utilization of nutrients present in the food. Xu et al. [45] studied the effects of salinity on the growth, body composition, oxygen consumption rate, and ammonia excretion rate of *Sc. argus*; the authors concluded that *Sc. argus* is more suitable for culture under 5–10‰ salinity, consistent with the current results. At 25–35‰ salinity, stomach and intestinal digestive enzyme specific activities in juvenile spotbanded scat were significantly lower than at other salinity levels. This is possibly due to metabolic dysfunction of the digestive organs under long-term high-salinity stress, resulting in an inability to maintain normal digestive function through enzyme activity, or due to the inhibitory effect resulting from ingestion of a large amount of seawater with excessively high ion concentration on digestive enzymes. Studies have shown that many inorganic ions can be digestive enzyme activators or inhibitors [44,46].

On exposure to adverse environmental stimuli, fish bodies produce large amounts of ROS, which leads to oxidative damage to proteins, lipids, enzymes, and nucleic acids. However, fish can effectively remove ROS and prevent damage to their bodies; this mechanism enhances their resistance to oxidative stress but depends on their antioxidant capacity [47,48]. As the most crucial metabolic organ in fish, the liver is the primary site for antioxidant reactions; thus, it harbors numerous antioxidant enzymes, such as SOD, CAT, and GSH-PX [49,50]. In fish liver tissue, SOD converts ROS into H_2O_2 and O_2; CAT further decomposes the generated H_2O_2 into H_2O and O_2, and GSH-PX removes H_2O_2 by

catalyzing the oxidative coupling of GSH. These three antioxidant enzymes can protect the cells of a fish's body from damage to a certain extent [51].

In the present study, as salinity increased, SOD, CAT, and GSH-PX specific activities in the liver tissue of spotbanded scat juveniles decreased initially, then increased, and finally decreased again; the activities reached their highest values in a salinity range of 20–25‰. Thus, in the salinity range of 0–35‰, the antioxidant capacity of spotbanded scat juveniles was activated under low and high salinity levels. However, when salinity exceeded 25‰, antioxidant enzyme activities demonstrated a downward trend, possibly because salinity exceeded the tolerable range of spotbanded scat juveniles, causing some damage to the body. Similar trends of initial increase and subsequent decrease in SOD activity have been observed in *Takifugu obscurus* [52] and *Oplegnathus fasciatus* [13] exposed to different levels of salinity. At low salinity levels (5–15‰), antioxidant enzyme activities were relatively low in our spotbanded scat juveniles, possibly because the environment was suitable for their survival, which resulted in decreased ROS production and therefore partial SOD, CAT, and GSH-PX activation. The nonsignificant difference in CAT activities among different salinity groups may be related to the antagonistic effects between CAT and GSH-PX during their functional execution—a phenomenon also observed in aquatic animals such as *Penaeus monodon* [53] and *Coilia nasus* [11].

MDA is produced via lipid peroxidation due to the action of free radicals. In biological systems, it can lead to a cytotoxic effect via cross-linking and polymerization of proteins, nucleic acids, and other biological macromolecules. As such, MDA content indirectly reflects the severity of free radical attacks on cells [54]. In the current study, as salinity increased, liver MDA content in spotbanded scat juveniles increased initially and then decreased. Therefore, an increase in lipid peroxidation caused by increasing salinity can lead to an increase in MDA degradation. Changes in MDA content in the liver tissue of spotbanded scat juveniles were generally consistent with the changes in SOD and CAT activities. In the 30‰ or 35‰ salinity groups, spotbanded scat juveniles may have exceeded their salt tolerance limits, manifesting in poor growth indices, reduced enzymatic activities, and significant declines in SOD, CAT, GSH-PX antioxidant enzyme activities, along with MDA content in liver tissues. This cumulative effect indicates impairment to the antioxidant system and potentially the organism of spotbanded scat juveniles [55].

5. Conclusions

In this study, we investigated the growth performance, digestive enzyme activity, and antioxidant capacity of spotbanded scat juveniles under different salinity levels. The results demonstrated that under experimental conditions, spotbanded scat juveniles exhibited strong acclimation and high SRs at salinity ranging from 0‰ to 35‰. In particular, the SR was 100% under 5–15‰ salinity. Moreover, the digestive enzyme activity and growth performance peaked at 5‰ salinity. However, at 25‰ salinity, spotbanded scat juveniles exhibited a strong oxidative stress response; specifically, the antioxidant systems of the fish resisted oxidative stress by increasing antioxidant enzyme activity to maintain normal body functions. Contrary to prevalent understanding, *Spotbanded scat*, an oceanic fish species, has demonstrated remarkable survival capacity in low-salinity environments. This phenomenon underscores the urgent need for further investigation into the underlying mechanisms, with the aim of elucidating its unique physiological adaptation strategies. Therefore, for optimal culture of spotbanded scat juveniles, salinity should be maintained between 5‰ and 15‰. The results may aid in further improving the practical production of spotbanded scat, enhancing its economic benefits to farmers, and exploring its cultivation in saline–alkali lands.

Author Contributions: Conceptualization, J.L.; data curation, J.Y. and N.Z.; formal analysis, T.A. and W.J.; investigation, M.S. and J.Y.; methodology, J.L. and T.A.; software, L.G. and Y.Y.; supervision, K.J. and B.Q.; validation, T.A. and J.Y.; visualization, T.A. and J.J.; writing—original draft preparation, J.L. and T.A.; writing—review and editing, J.Y. and M.S. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the National Key R&D Program of China (2019YFD0900405); Central Key Projects Plan of Basic Scientific Research Business Expenses (2019Z01).

Institutional Review Board Statement: The handling procedures for all experimental spotbanded scat juveniles were in accordance with the relevant guidelines and regulations approved by the Experimental Animal Research Committee of the Shanghai Ocean University (SHOU-DW-2022-378).

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are available upon request from the corresponding author.

Acknowledgments: We gratefully acknowledge the help of our colleagues in the Lab of East China Sea Fisheries Research Institute, Chinese Academy of Fishery Science, and the colleagues from the Jiangsu Ganyu Research Center of East China Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences. We would like to thank all the reviewers for their valuable comments and advice.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Liu, J.; Li, Q.; Sun, Y.; Zhuang, P.; Feng, G.; Zou, X.; Zhao, F.; Yu, Y.; Sun, X.; Yang, J.; et al. Embryonic and post-embryonic development of *Selenotoca multifasciata*. *J. Fish. Sci. China* **2021**, *28*, 978–987.
2. Luo, Z.; Xu, J.; Han, J.; Xu, Y.; Ma, W.; Feng, S. Isolation and identification of pathogenetic *Streptococcus iniae* from *Selenotoca multifasciata*. *J. Huazhong Agric. Univ.* **2012**, *31*, 95–99.
3. Rhee, J.; Kim, B.; Seo, J.; Kim, I.; Lee, Y.; Lee, J. Cloning of growth hormone, somatolactin, and their receptor mRNAs, their expression in organs, during development, and on salinity stress in the hermaphroditic fish, *Kryptolebias marmoratus*. *Comp. Biochem. Physiol. Part A Mol. Integr. Physiol.* **2012**, *161*, 436–442. [CrossRef] [PubMed]
4. Wang, Y.; Zhu, X. A review on impact of salinity on pactterns of fish ecophysiology. *Stud. Mar. Sin.* **2002**, *41*, 151–158.
5. Yi, H.; Chen, X.; Liu, S.; Han, L.; Li, G. Growth, osmoregulatory and hypothalamic–pituitary–somatotropic (HPS) axis response of the juvenile largemouth bass (*Micropterus salmoides*), reared under different salinities. *Aquac. Rep.* **2021**, *20*, 100727. [CrossRef]
6. Tsuzuki, M.N.Y.; Sugai, J.K.; Maciel, J.C.; Francisco, C.J.; Vinícius, R.C. Survival, growth and digestive enzyme activity of juveniles of the fat snook (*Centropomus parallelus*) reared at different salinities. *Aquaculture* **2007**, *271*, 319–325. [CrossRef]
7. Sheng, Y.L.; Ge, X.P.; Huang, J.T.; Wang, A.M.; Lv, F. Effects of Salinity on Digestive Enzyme Activities of *Onchidium struma*. *Chin. J. Anim. Nutr.* **2012**, *24*, 1839–1846.
8. Na, Y. Effects of Salinity on Digestive Physiology and Osmoregulation Physiology in Grey Mullet *Mugil cephalus*. Master's Thesis, Shanghai Ocean University, Shanghai, China, 2011.
9. Bolasina, S.N.; Tagawa, M.; Yamashita, Y. Changes on cortisol level and digestive enzyme activity in juveniles of Japanese flounder, *Paralichthys olivaceus*, exposed to different salinity regimes. *Aquaculture* **2007**, *266*, 255–261. [CrossRef]
10. Choi, C.Y.; An, K.W.; An, M.I. Molecular characterization and mRNA expression of glutathione peroxidase and glutathione S-transferase during osmotic stress in olive flounder (*Paralichthys olivaceus*). *Comp. Biochem. Physiol. Part A Mol. Integr. Physiol.* **2008**, *149*, 330–337. [CrossRef]
11. Deng, P.P.; Shi, Y.H.; Wang, Y.; Jia-Bo, X.U.; Xie, Y.D.; Liu, Y.S.; Shui, C. Effects of salinity on activities of non-specific immune and digestive enzymes in juvenile estuarine tapertail anchovy *Coilia nasus*. *J. Dalian Ocean. Univ.* **2016**, *31*, 533–537.
12. Yin, F.; Sun, P.; Peng, S.-M.; Shi, Z.H. Effects of low salinity stress on the antioxidant enzyme activities in juvenile *Pampus argenteus* liver and the APTase activities in its gill and kidney. *Chin. J. Appl. Ecol.* **2011**, *22*, 1059–1066.
13. Sun, P.; Yin, F.; Peng, S.-M.; Shi, Z.H. Effects of salinity on the activity of antioxidant enzymes in livers of juvenile *Oplegnathus fasciatus*. *Mar. Fish.* **2010**, *32*, 154–159.
14. Papadimitriou, E.; Loumbourdis, N. Exposure of the frog *Rana ridibunda* to copper: Impact on two biomarkers, lipid peroxidation, and glutathione. *Bull. Environ. Contam. Toxicol.* **2002**, *69*, 885–891. [CrossRef] [PubMed]
15. Wang, Q.; Fan, C.; He, X.; Cheng, K. Effects of three typical sulfonamides on GST activity and MDA content in liver tissue of *Oreochromis niloticus*. *Ecol. Environ. Sci.* **2010**, *19*, 1014–1019.
16. Brocker, C.; Thompson, D.C.; Vasiliou, V. The role of hyperosmotic stress in inflammation and disease. *Biomol. Concepts* **2012**, *3*, 345–364. [CrossRef]
17. Sun, Y.; Liu, J.; Zhang, P.; Li, Q.; Zou, X.; Feng, G.; Zhao, F.; Yu, Y.; Sun, X.; Yang, J. Effects of water temperature, salinity and pH on embryonic development of *Selenotoca multifasciata*. *South China Fish. Sci.* **2021**, *17*, 122–129.

18. Suzuki, A.C.; Takeda, M.; Tanaka, H.; Yoo, M.S. Chromosomes of *Scatophagus argus* and *Selenotoca multifasciata* (Scatophagidae). *Jpn. J. Ichthyol.* **1988**, *35*, 102–104. [CrossRef]
19. Liu, Z.; Mu, X.; Li, H.; Gui, L.; Zeng, W.; Zhang, J. Complete mitochondrial genome of the striped scat *Selenotoca multifasciata* (Perciformes: Scatophagidae). *Mitochondrial DNA Part A DNA Mapp. Seq. Anal.* **2016**, *27*, 2691–2692. [CrossRef]
20. Sun, R.Z.; Liang, H.F.; Wen, C.Q.; Wang, P.S.; Huang, J.Y. Effect of Salinity on the Growth of *Selenotoca multifasciata*. *Anhui Agric. Sci.* **2023**, *51*, 109–111.
21. Peskin, A.V.; Winterbourn, C.C. Assay of superoxide dismutase activity in a plate assay using WST-1. *Free Radic. Biol. Med.* **2017**, *103*, 188–191. [CrossRef]
22. Hoar, W.S.; Randall, D.J. Fish Physiology. Volume VI. In *Environmental Relations and Behavior*; Academic Press: New York, NY, USA; London, UK, 1971; pp. 289–290.
23. Imsland, A.K.; Gústavsson, A.; Gunnarsson, S.; Foss, A.; Árnason, J.; Arnarson, I.; Jónsson, A.F.; Smáradóttir, H.; Thorarensen, H. Effects of reduced salinities on growth, feed conversion efficiency and blood physiology of juvenile *Atlantic halibut* (*Hippoglossus hippoglossus* L.). *Aquaculture* **2008**, *274*, 254–259. [CrossRef]
24. Varsamos, S.; Nebel, C.; Charmantier, G. Ontogeny of osmoregulation in postembryonic fish: A review. *Comp. Biochem. Physiol. Part A Mol. Integr. Physiol.* **2005**, *141*, 401–429. [CrossRef] [PubMed]
25. Alderdice, D.F. *3 Osmotic and Ionic Regulation in Teleost Eggs and Larvae. Fish Physiology*; Elsevier: Amsterdam, The Netherlands, 1988; pp. 163–251.
26. Fridman, S.; Bron, J.; Rana, K. Ontogenic changes in the osmoregulatory capacity of the Nile tilapia *Oreochromis niloticus* and implications for aquaculture. *Aquaculture* **2012**, *356*, 243–249. [CrossRef]
27. Duston, J. Effect of salinity on survival and growth of Atlantic salmon (*Salmo salar*) parr and smolts. *Aquaculture* **1994**, *121*, 115–124. [CrossRef]
28. Bœuf, G.; Payan, P. How should salinity influence fish growth? *Comp. Biochem. Physiol. Part C Toxicol. Pharmacol.* **2001**, *130*, 411–423. [CrossRef]
29. Feng, X.; Liu, J.; Dong, Y.; You, H.; Jiang, Z.; Ge, Y. Effect of different salinity on food intake and growth for platichthys stellatus juveniles. *Feed. Ind.* **2008**, *29*, 22–25.
30. Chen, J.; Yuan, C.G.; Ruan, C.X. Combined effect of temperature and salinity on the growth of *Pseudosciaena crocea*. *J. Guangzhou Univ. (Nat. Sci. Ed.)* **2013**, *12*, 35–39.
31. Hua, L.Y.; Ping, Z.Y.; Min, Z.Q.; Jun, L.I.; Jie, X.Y.; Cai, H.J.; Zhi, Z.Y. Effects of Temperature and Salinity on the Growth and Survivability of Young *Epinephelus moara*. *J. Jimei Univ.* **2014**, *19*, 241–246.
32. Mookkan, M.; Muniyandi, K.; Ramasubbu, S.; Raman, V.; Govindarajan, T. Influence of Salinity on Survival and Growth of Early Juveniles of Spotted Scat *Scatophagus argus* (Linnaeus, 1766). *Indian J. Innov. Dev.* **2014**, *3*, 23–29.
33. An, L.; Zhu, S.R.; Dong, X.S.; Wang, C.; Zhang, Z.S.; Zhang, L.G.; Zhu, Y.A.; Meng, Q.L. Effects of salinity on growth, flesh quality and antioxidant capacity of juveniles *Micropterus salmoides*. *Freshw. Fish.* **2023**, *53*, 34–43.
34. Pan, L.; Tang, X.; Liu, H.; Tian, J. Effects of salinity on plasma osmolality and gill na~+-k~+-atpase activity of juvinile japanese flounder *Paralichthys olivaceus*. *Oceanol. Limnol. Sin.* **2006**, *37*, 1–6.
35. Chen, P.J.; Wang, C.G.; Zheng, S.L. Effects of Salinity on Digestive Enzyme Activity of *Pagrosomus* Major Young Fish. *J. Xiamen Univ.* **1998**, *37*, 754–756.
36. Wang, G.; Tian, X.; Dong, S.; Gong, Q. Effects of Different Salinities on the Growth, Osmoregulation and Energy Budget of the Bester(*Huso huso* × *Acipenser ruthenus*). *Period. Ocean. Univ. China* **2007**, *13*, 189–194.
37. Gheisvandi, N.; Hajimoradloo, A.; Ghorbani, R.; Hoseinifar, S.H. The effects of gradual or abrupt changes in salinity on digestive enzymes activity of Caspian kutum, *Rutilus kutum* (Kamensky, 1901) larvae. *J. Appl. Ichthyol.* **2015**, *31*, 1107–1112. [CrossRef]
38. Hieu, D.Q.; Hang, B.T.B.; Huong, D.T.T.; Kertaoui, N.E.; Farnir, F.; Phuong, N.T.; Kestemont, P. Salinity affects growth performance, physiology, immune responses and temperature resistance in striped catfish (*Pangasianodon hypophthalmus*) during its early life stages. *Fish Physiol. Biochem.* **2021**, *47*, 1995–2013. [CrossRef] [PubMed]
39. Liu, Z.F.; Gao, X.Q.; Yu, J.X.; Qian, X.M.; Xue, G.P.; Zhang, Q.Y.; Liu, B.L.; Hong, L. Effects of different salinities on growth performance, survival, digestive enzyme activity, immune response, and muscle fatty acid composition in juvenile American shad (*Alosa sapidissima*). *Fish Physiol. Biochem.* **2016**, *43*, 761–773. [CrossRef] [PubMed]
40. Hamed, S.S.; Jiddawi, N.S.; Poj, B. Effect of salinity levels on growth, feed utilization, body composition and digestive enzymes activities of juvenile silver pompano *Trachinotus blochii*. *Int. J. Fish. Aquat. Stud.* **2016**, *4*, 279–283.
41. Luo, M.; Guan, R.; Jin, H. Effects of the salinity on the growth performance and digestive enzyme activities of *Anguilla marmorata* elver and *A. bicolor* pacifica elver. *Acta Hydrobiol. Sin.* **2015**, *39*, 653–660.
42. Hu, L.; Yan, M.; Zheng, J.; Li, X.; Huang, X.; Wang, K.; Zhou, C. Effects of salinity on growth and nonspecific immune enzyme activities of *Anguilla japonica*. *J. Oceanogr. Taiwan Strait* **2011**, *30*, 528–532.
43. Zhang, L.; Luo, J.; Zhao, F. Influence of salinity on serum osmolarity, ion content and gill Na+, K+-ATPase activity of *Siganus guttatas*. *Mar. Fish.* **2015**, *37*, 449–456.
44. Sánchez-Chiang, L.; Cisternas, E.; Ponce, O. Partial purification of pepsins from adult and juvenile salmon fish *Oncorhynchus keta*. Effect of NaCl on proteolytic activities. *Comp. Biochem. Physiol. Part B Comp. Biochem.* **1987**, *87*, 793–797. [CrossRef] [PubMed]
45. Xu, J.; Shui, C.; Shi, Y.; Yuan, X.; Liu, Y.; Xie, Y. Effect of salinity on survival, growth, body composition, oxygen consumption, and ammonia excretion of juvenile spotted scat. *N. Am. J. Aquac.* **2020**, *82*, 54–62. [CrossRef]

46. Squires, E.J.; Haard, N.; Feltham, L. Gastric proteases of the Greenland cod *Gadus ogac*. I. Isolation and kinetic properties. *Biochem. Cell Biol.* **1986**, *64*, 205–214. [CrossRef]
47. Saoud, I.P.; Kreydiyyeh, S.; Chalfoun, A.; Fakih, M. Influence of salinity on survival, growth, plasma osmolality and gill Na+–K+–ATPase activity in the rabbitfish *Siganus rivulatus*. *J. Exp. Mar. Biol. Ecol.* **2007**, *348*, 183–190. [CrossRef]
48. Gonzalez, P.; Dominique, Y.; Massabuau, J.; Boudou, A.; Bourdineaud, J. Comparative effects of dietary methylmercury on gene expression in liver, skeletal muscle, and brain of the zebrafish (*Danio rerio*). *Environ. Sci. Technol.* **2005**, *39*, 3972–3980. [CrossRef] [PubMed]
49. Cui, Q.; Chen, B.; Qiu, L.; Fu, X.; Yang, B.; Han, Y. Influence of low salinity stress on the gill Na+/K+-ATPase, liver antioxidase and non-specific immune enzyme in juvenile *Pleuronectes yokohama*. *J. Guangdong Ocean. Univ.* **2017**, *37*, 26–32.
50. Rahman AN, A.; Mohamed, A.A.-R.; Dahran, N.; Farag, M.F.M.; Alqahtani, L.S.; Nassan, M.A.; AlThobaiti, S.A.; El-Naseery, N.I. Appraisal of sub-chronic exposure to lambada-cyhalothrin and/or methomyl on the behavior and hepato-renal functioning in *Oreochromis niloticus*: Supportive role of taurine-supplemented feed. *Aquat. Toxicol.* **2022**, *250*, 106257. [CrossRef] [PubMed]
51. Ansaldo, M.; Luquet, C.M.; Evelson, P.A.; Polo, J.M.; Llesuy, S. Antioxidant levels from different Antarctic fish caught around South Georgia Island and Shag Rocks. *Polar Biol.* **2000**, *23*, 160–165. [CrossRef]
52. Bian, P.-J.; Qiu, C.-G.; Xu, S.-L.; LIN, S.-Z. Effects of salinity on growth, activity of non-specific immune and antioxidant enzymes in obscure puffer *Takifugu obscures*. *Acta Hydrobiol. Sin.* **2014**, *38*, 108–114.
53. Wang, W.-N.; Wu, J.; Su, S.-J. Effects of salinity stress on antioxidant enzymes of *Penaeus monodon* of two different life stages. *Comp. Biochem. Physiol. Part C* **2008**, *4*, 466. [CrossRef]
54. Gaweł, S.; Wardas, M.; Niedworok, E.; Wardas, P. Malondialdehyde (MDA) as a lipid peroxidation marker. *Wiad. Lek.* **2004**, *57*, 453–455. [PubMed]
55. Gao, L.; Ma, A.J.; Wang, X.A.; Huang, Z.H.; Yu, H.; Yang, Z. Effects of temperature and salinity on the activities of antioxidant enzymes of juvenile turbot Scophthalmus maximus. *J. Dalian Fish. Univ.* **2012**, *27*, 422–428.

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.