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Short Paper

Effectiveness of Using a Vinyl Sheet to Reduce Mortality Caused by Collision During Rearing of Pacific Saury *Cololabis saira*

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Abstract: To reduce mass mortality of Pacific saury caused by collision with the tank wall, we examined rearing of saury in a tank with a vinyl sheet attached to the tank wall, and no vinyl sheet tank. We compared survival rate and ratio of the lower jaw length to the knob length of those fish. Survival rate of the former was higher than the latter. No significant difference was recognized for the ratio. These results suggest that the vinyl sheet could not reduce the damage to the lower jaw, but it could reduce the mortality caused by collision.

Key words: Pacific saury; Collision; Reduce mortality; Vinyl sheet

When artificially reared, fish with a high swimming ability such as tuna have a high mortality rate caused by collision with rearing structures (e.g. Miyashita et al. 2000; Ishibashi 2006). Pacific saury *Cololabis saira* are also easily damaged in rearing tanks (Tsuzaki 2000a, 2000b, 2001a, 2001b), and they are difficult to transport because of the ease of removing scales if caught by a scoop net or when touched by hand. Though in fish with a less rapid swimming ability fish like the sunfish *Mola mola*, collision with the wall of water tanks is the main factor causing mortality. Some aquarium adopted a new rearing tank which attach vinyl sheet inside the tank to reduce their collision related mortality (e.g. Aqua world Oarai Ibaraki, Sanshine International Aquarium, Personal communication). In this study, we attached a vinyl sheet inside of the tank to reduce the mortality after reaching the juvenile stage, and the effects monitored were (1) the comparison of survival rate between treatments of tanks with a vinyl sheet (WV) attached along the inside of the tank and with no vinyl sheet (NV) tank, and (2) comparison of the morphology between WV and NV.

Pacific saury were raised artificially in Hokkaido National Fisheries Research Institute, Fisheries Research Agency, Akkeshi, Hokkaido. Only natural light was used and reduced using a covering curtain. Pacific saury were fed to satiation (mix of Otohime A, B1, B2, and Hirame EP1: Marubeni Nisshin Feed Corporation, Tokyo) 10－20 times (depending on demand) a day by using a self feeding machine during 06:00－17:00. Also mince (made of frozen mysid and squid) was fed on Mondays, Wednesdays, and Fridays at 10:00－11:00. Every day from 08:00 to 09:00, we cleaned up the bottom of the tanks and collected any dead individuals, and then measured the water temperature (controlled at 20℃; WV: 20.1±0.31℃ (Mean ±SD); NV: 20.1±0.32℃). The cause of death was determined (injury and morphological defect). All individuals that died after 60 days after hatching (DAH) were observed to determine the cause of death. As a result, 83% of the dead individuals had back injuries (Nakaya et al. 2006). We compared the mortality rate and the morphology among the two tank treatments, one tank with a vinyl sheet (1,500 mm width, 0.16 mm thick, Okamotomoyaresu, OKAMOTO Corporation, Tokyo) attached along the inside of the tank (WV) (No. of stocked individuals: 539, tank volume: 8 m^3, density: 67 inds / m^3), and the other was a normal concrete tank (no vinyl sheet attached (NV)) (No. of stocked individuals: 733, tank volume: 12 m^3, density: 61 inds / m^3) during 90 to 136 DAH (Fig. 1). The samples collected on 90, 100, 110, 120, and 130 DAH were preserved in 80% ethanol after being anesthetized with cold water with ice. The sampling was done at feeding time because the time was easy to catch without inducing strong stress. This time is one when they show the least wariness and swim near the water surface. Knob length (KnL: This is a unit of body length from the edge of the lower jaw to the edge of the meat of silver part which is inside the caudal fin. This part has been shown to have the least measurement bias for Pacific saury (Kimura 1956)), and body weight in wet weight (BW) of Pacific saury were measured to the nearest 0.1 mm and 0.01 g. For statistical analysis, one-way ANOVA was used to detect the BW, KnL, and the

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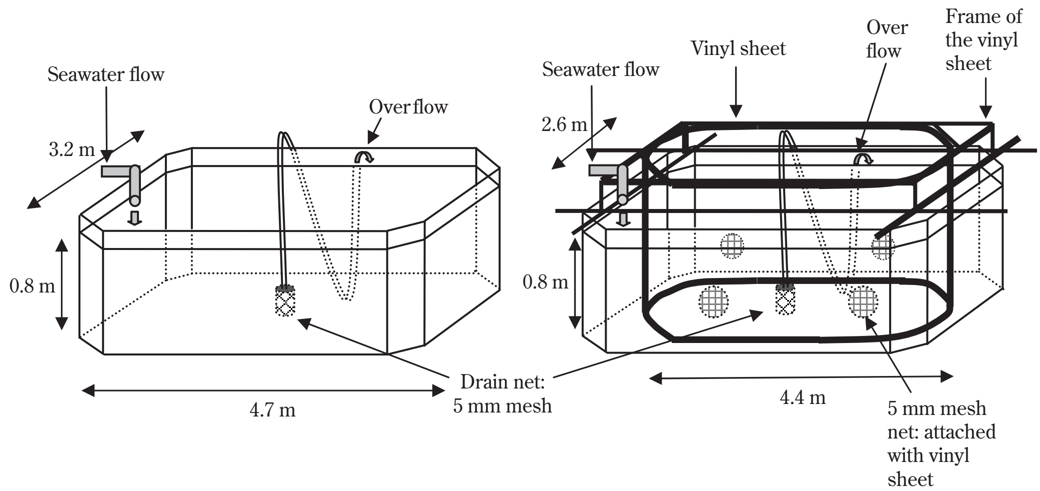

Fig. 1. Two types of rearing tanks (left: no vinyl sheet attached tank (NV), right: with a vinyl sheet attached surrounding the tank (WV)).

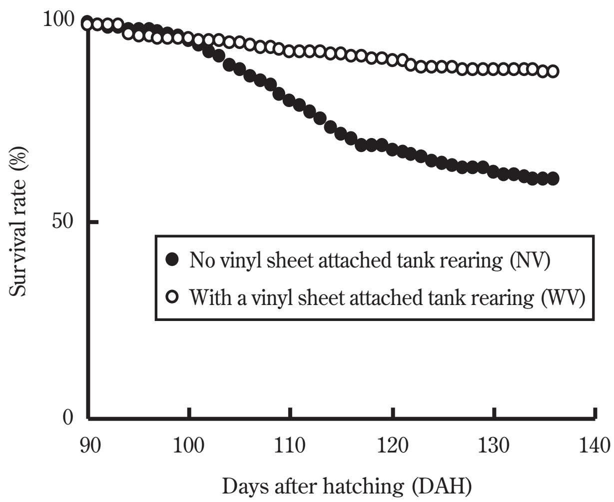

Fig. 2. Comparison of the mortality between with a vinyl sheet attached surrounding the tank (WV) rearing and no vinyl sheet attached tank (NV) rearing.

ratio of lower jaw length to KnL (LJL / KnL) difference among environmental conditions. If the variances determined were heteroscedastic as shown by a F_{max}-test, the values were log transformed. Chi square test was used to compare the ratio of died and survival individuals during the period between WV rearing and NV rearing. Values were considered significant at the 5% level.

We compared their survival rate from 90 to 136 DAH among the two kinds of tank (WV and NV). As a result, there was a significant difference the ratio of dead and survival individuals between WV rearing and NV rearing (Chi square test, $P<0.05$). The WV rearing showed a higher survival rate (88%) than NV rearing (61%) (Fig. 2). Lower jaw damage of Pacific saury has been reported when reared in tanks after becoming juveniles (Kawamura 1990). In this rearing, plenty of such damaged individuals were observed. Body weight, KnL, and ratio of LJL / KnL were compared among WV rearing and NV rearing. For the BW, KnL, and ratio of LJL / KnL when the experiment was started (90 DAH), there were no significant differences (Table 1). And also there were no significant difference through this experiment between WV rearing and NV rearing, except for KnL of 120DAH (Table 1). Moreover the ratio of LJL / KnL that died individuals during the experiment period were no significant difference among WV rearing (7.4 ± 0.60% (Mean ± SD), $n=27$) and NV rearing (7.2 ± 0.60%, $n=29$) (one-way ANOVA, $P=0.29$). These results suggest that the mortality caused by collision damage were not the effect of cumulative delayed growth, but of direct death soon after being injured.

In the daytime, collisions with the wall by individuals were seldom observed unless they were exposed to some unexpected stimulus causing an escape response. While from sunset to sunrise (in the night time), they were injured by colliding with the wall. Tsuzaki (2000a, 2000b, 2001a, 2001b) report that using lighting during the night time is effective for Pacific saury rearing to reduce collisions with the wall. However, some studies suggest that the construction of otolith daily growth rings and illumination are closely related (Tanaka et al. 1981; Tanabe et al. 2003; Nakaya et al. 2008). The illumination will have a major effect on their circadian rhythm. In addition, using lighting during the night time will produce physiological stress. In this study, death related to collision was reduced by attaching a vinyl sheet to the rearing tanks, though the damage to the lower jaw could not be avoided. Vinyl sheet attached surrounding the tank would contribute to the improvement of rearing methods for fish with a high swimming ability.

Table 1. Body weight (BW), Knob length (KnL) and ratio of lower jaw length (LJL) per KnL of Pacific saury for different rearing (with a vinyl sheet attached tank rearing (WV), no vinyl sheet attached tank rearing (NV))

Days after hatching (DAH)		Mean ± SD		One way ANOVA
		WV	NV	*P*
90	(1) BW (g)	5.4 ± 1.12	5.6 ± 1.97	0.70
	(2) KnL (mm)	113.8 ± 8.97	114.4 ± 13.79	0.88
	(3) 100x (LJL/ KnL) (%)	7.1 ± 0.62	7.0 ± 0.43	0.89
	(4) Number of samples	23	23	
100	(1)	7.1 ± 2.17	7.7 ± 2.47	0.45
	(2)	127.2 ± 13.45	129.7 ± 13.41	0.58
	(3)	7.2 ± 0.85	6.9 ± 0.57	0.21
	(4)	20	20	
110	(1)	9.4 ± 1.94	10.9 ± 4.66	0.12
	(2)	137.6 ± 10.37	140.8 ± 23.82	0.54
	(3)	7.1 ± 0.56	7.3 ± 0.69	0.21
	(4)	24	18	
120	(1)	14.3 ± 2.94	15.6 ± 3.67	0.21
	(2)	155.2 ± 9.84	161.4 ± 11.11	0.04
	(3)	7.1 ± 0.45	7.3 ± 0.47	0.38
	(4)	20	20	
130	(1)	19.2 ± 5.07	21.1 ± 6.93	0.28
	(2)	165.9 ± 13.82	171.0 ± 14.59	0.21
	(3)	6.8 ± 0.65	7.0 ± 0.41	0.23
	(4)	22	21	

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