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Sound and Low Intensity Pulse Ultrasound Stimulation for Aquaculture Oncorhynchus Masou

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1. Introduction

Aquaculture, also known as aquafarming, is the farming of aquatic organisms such as fishes, crustaceans, mollusks and aquatic plants. World aquaculture remains a fast-growing food-producing sector, yielding nearly 60 million metric tons with an estimated value of $120 billion US in 2014[1)]. With the world population has increased to 7.2 billion in 2014, developments of new aquaculture methods to supply enough sea-foods is an important task for world aquaculture researchers. However, conventional aquaculture methods have been limited to feeding, water temperature, quality, stream control of the aquaculture tank, and antibiotic treatment. Ultrasound (US) application for aquaculture field is little known except for fish finder. We reported effects of sonic and 1.0 MHz low intensity pulse ultrasound stimulation (S&LIPUSS) on the survival rate and total fish weight using takifugu rubripes and Japanese flounders.[2)] However, the number of fish were 10 each per a small tank less than 0.2 m^3. In this report, we have developed five types of S&LIPUSS equipment for aquaculture oncorhynchus masou (Sakura Masu) to confirm the effectiveness. The first feasibility study of the S&LIPUSS on the growth and survival rates of 20 fishes using 1 m^3 water tank have been investigated.

2. Experimental method

Fig. 1 illustrates a schematic image of the S&LIPUSS of fishes growing in a fiber reinforced plastic (FRP) aquaculture water tanks. Experimental fishes were 16 months after birth of Sakura masu with an average weight of 73 g. Fig. 2 shows 6 aquaculture FRP tanks of 1.0 m^3 capacity located inside of 6 x 6 x 1 m^3 concrete pond in a warehouse. Six aluminum metal cocking pan container of D33 x T13.5 cm as shown in Fig. 2 were used for the experiment. These S&LIPUSS equipment were designed to float and drift on the water surface to give a uniform S&LIPUS power to the fishes in the water tank.

Two sonic device of pulse 350 Hz and a music were used for the experiment. The music used in this experiment was the Canon in D Pachelbel. The music recorded by a tape recorder were applied to fishes using sound speaker installed bottom of the container.

Fig. 1. Schematic images of S&LIPUSS for Sakura masu in a water tank.

Figure 3 shows the LIPUSS equipment used for #.2 tank. The equipment had 8 PZT transducers with acoustic matching layers in the container.

Figure 4 shows the S&LIPUSS equipment used for #.3 tank. The equipment had one 350 Hz sound device, a music player, and 4 PZT transducers in the container.

The LIPUSS transduce has 500 KHz frequency and 1.0 second pulse repetition frequency with 50% duty cycle (0.5 s. on and 0.5 s. off).

A control circuit was also installed in the container. More details on the S&LIPUSS equipment design and the function will be described in the future.[3)] Five different tanks with different S&LIPUSS experiment groups and a control (placebo) groups, were used. All containers of the same size and weight, five are with the S&LIPUSS function and the other one is without the function for placebo, were put on the water surface of the 1.0 m^3 water tanks at the same time in order to observe the effects of the S&LIPUSS. The S&LIPUSS experiments were carried out for 60 minutes a day,

3 days per week for 14 weeks. Every 7 weeks, the weight of fishes were measured. And every day, the survival rate of the fishes was observed.

Fig. 2. Six FRP 1.0 m^3 water tanks used for S&LIPUSS for Sakura masu experiment in a warehouse.

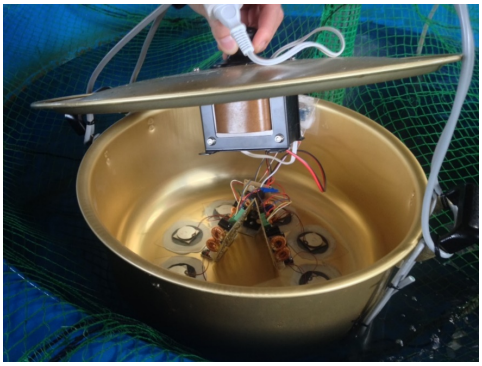

Fig. 3. The S&LIPUSS equipment with eight of 500 kHz PZT transducers used for #2 tanks.

Fig. 4. The S&LIPUSS equipment with a music speaker, 350 Hz sound and four of 500 kHz PZT transducers used for #3 tanks.

3. Result and Discussion

Table I. shows survival rates, average and total fish weighs of each water tanks.

Numbers 2 and 3 tanks showed higher survival rates and total fish weigh after the experiment. This result indicates the S&LIPUSS increases the vital force of aquaculture fishes. The result was similar to those of Takifugu and Japanese flounders using small (0.2 m^3) tanks reported in 2014[2].

Table I. Survival rate, average and total fish harvesting weight of each water tanks.

Tank #	1	2	3	4	5	6
	Ref.	US	Mix	Son	Mod .US	Son
Music	-		Yes			Yes
Freq. 2 (Hz)	-		350	350		-
Freq. 3 (kHz)	-	500	500		500	-
Survival rate (%)	70	85	85	65	60	65
Ave. fish weight (g)	225	231	217	243	211	235
Total fish weight (kg)	3.15	3.93	3.69	3.16	2.53	3.06

4. Conclusion

Five types of moving, floating, drifting sonic and LIPUS stimulation (S&LIPUSS) equipment having a 350 Hz sound, audible music and 500 kHz piezoelectric transducers were manufactured. These S&LIPUSS equipment were applied for 20 of aquaculture oncorhynchus masou and the survival rate and the total weights were compared after 14 weeks operation on sea-water aquaculture tank. Higher survival rate of 85% and total fish weight of 3.93 kg (123%) for the S&LIPUSS group to those of the control group of 70% and 3.15 kg (100%) were observed by the experiment.

The S&LIPUSS equipment has a potential to contribute to the world food shortage issue by increasing the survival rate and a total harvesting weight of various sea-foods in the future.

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