# Effects of Spanwise Width of Expansion Area in Open-channel Flow on Resting Characteristics of Oikawa, *Zacco platypus*

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## ABSTRACT

## 1. INTRODUCTION

Conditions for fish to live in the river are to secure the flow of a river, water quality, feed, spawning ground, circular path, refuge, and to protect from natural enemies [1]. Even among them, this study focuses on securing the refuge. Fish has the red and ordinary muscle. Fish usually uses the red muscle and doesn't use the ordinary muscle because fish gets tired [1]. However, when the flow velocity in a river increases and there is a risk of being preyed, fish uses the ordinary muscle, so it is important to supply the refuge of low-velocity in order to rest. Some researchers investigated how to use the refuge for fish in such as floods and the calm water. In the case of floods, it was confirmed that when water in a river rises, fishes take refuge in the wand [2]. Also, it is observed that when the artificial flood accrues in the experimental river, larva fish takes refuge in wand [3]. On the other hand, in the case of calm water, it was found that when there are concave areas such as the groyne, the wand, and the vegetation in a side riverbank, low velocity area occurs, so fishes use there as refuges and spawning ground [4-7]. Therefore, fishes rest in low velocity area in the river. However, hydraulic quantity such as velocity in low velocity area has not been investigated. Also, suitable geometric shape of the rest area has not been investigated. In this study, resting characteristics of Oikawa (*Zacco platypus*) with changing spanwise width of expansion area and the flow velocity was researched. Furthermore, deep pools and rapids are also resting area for fish, however, the purpose of this study is to research resting characteristics of Oikawa which use the low velocity area caused by river structures such as groyne.

## 2. MATERIALS AND METHODS

**Figure 1** shows the open-channel. It was designed as the following. Pool length ($L$) was 2.0m and width ($B$) was 0.8m. $x$ and $z$ are the coordinates of the streamwise vertical and the spanwise directions, respectively. In expansion area, length of streamwise ($L_s$) is 1.2m and width is $B_s$. This channel is three areas composed of "upstream area", "main channel", and "expanded area". "upstream area" is the area above main channel ($-0.8<x<0.0$m, $0<z<0.4$m) , and "expanded area" is the area of the right bank from main channel ($0.0<x<1.2$m, $z<0$m).

**Table 1** shows experimental case. Flow velocity divided by averaged body length of Oikawa ($U_m/\overline{B_L}$) was set to four patterns within the range from 2 to 10 (1/s). Spanwise width of expansion area was set to three patterns within the range from 0.2 to 0.4 (m). The depth of water in this open-channel was about 0.07m in all area. Also, the water temperature was about 20°C in all cases. The recording has been carried out 20 cases in each pattern and 240 cases in total. Averaged body length was about 70mm. A circular wire net of 0.25m in diameter is set up the boundary line ($x$=1.0m) between main channel and expanded area and 10 fishes are inserted. After it is confirmed that Oikawa settled down for 5~10s, the circular wire net is taken up. Further, trajectory of Oikawa was recorded for 120s with a digital video camera set up the upside of the open-channel. The number of pixel of the digital video camera is 1440×1080, and recording speed is 30fps. The swimming positions of Oikawa were obtained with the aid of the digital video camera. Also, the velocity is measured by three dimensional electromagnetic flowmeter in this open-channel.

## 3. RESULT AND DISCUSSION

The ground speed was defined as swimming speed of fish school to the ground and $\overline{V_E}/\overline{B_L}$ is that ground speed divided by averaged body length of Oikawa. **Figure 2** shows averaged ground speed of fish school ($\overline{V_E}/\overline{B_L}$) in expanded area. When

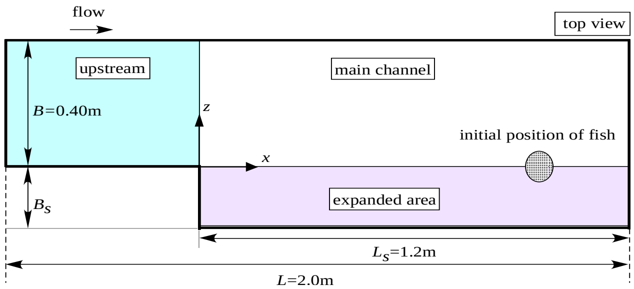


**Figure 1** Open-channel

**Table 1** Experimental case

| | | $U_m/\overline{B_L}$ (1/s) | | | |
|---|---|---|---|---|---|
| | | 2 | 4 | 8 | 10 |
| $B_s$ (m) | 0.2 | C02-2 | C02-4 | C02-8 | C02-10 |
| | 0.3 | C03-2 | C03-4 | C03-8 | C03-10 |
| | 0.4 | C04-2 | C04-4 | C04-8 | C04-10 |

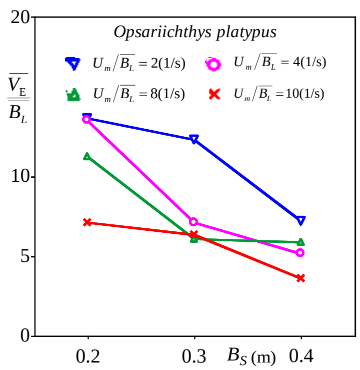


**Figure 2** Averaged ground speed of fish school in expanded area

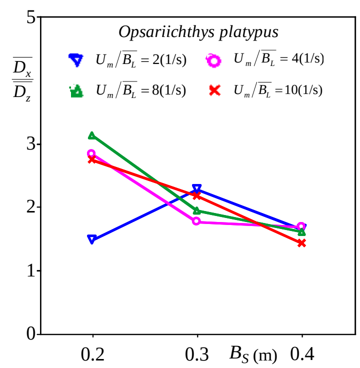


**Figure 3** Fish school length ratio in expanded area

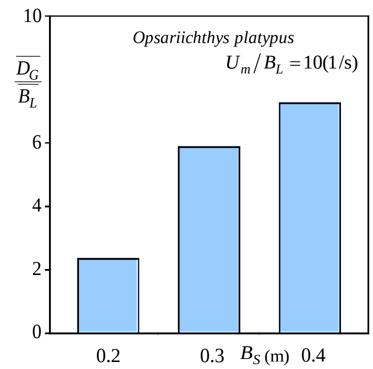


**Figure 4** Averaged distance between the upstream wall at expanded area and fish school

spanwise width of expanded area ($B_S$) or low velocity increases, ground speed of fish school in expanded area decreases. This is suspected that Oikawa rests in expanded area. Fish school length ratio ($\overline{D_x}/\overline{D_z}$) is defined as that averaged fish school of $x$ direction divided by averaged fish school of $y$ direction. **Figure 3** shows fish school length ratio ($\overline{D_x}/\overline{D_z}$) in expanded area. In case of narrow expansion width, the form of fish school in expanded area is long and narrow form, however, when spanwise width of expanded area increases, the form becomes nearly circular form. **Figure 4** shows averaged distance between the upstream wall at expanded area and the center of gravity of fish school. With the increase of expansion width, fish school rests in the downstream of expanded area. Therefore, it was found that when resting area or expansion width is narrow, it requires enough long length of the flowing direction in low velocity area.

## REFERENCES

[1] Nakamura S "Gyodou no Hanashi" Sankaido (1995)

[2] Aya S, Kawai N, Ogawa R, Kihira H, Nakanishi F, and Ryumon S "Change of Water Level and Fish Spawning in the Yodo River " Advances in river engineering Vol.10 (2004) pp.340-358

[3] Sagawa S, Kayaba Y, Arai H, and Amano K "Habitat Selection by Larval Cyprinid Fishes : Relationship Between Larval Habitat and Experimental Flooding" Ecol. Civil Eng. 7(2) (2005) pp.129-138

[4] Matsunami Y, Aya S, and Yada T "Formation and Decline of "wando" in the Yodo River and Its Ecological Meanings" Advances in river engineering Vol.5 (1999) pp.93-98

[5] Denda M, Yamashita S, Ozawa T, and Shimatani Y "Backwaters and Fish Community : On Environmental Factors Affecting Fish Community in Backwaters" Japanese Journal of Ecology Vol52 (2002) pp.287-294

[6] Grift RE, Buijse AD, Van DWLT, Machiels MAM, Kranenbarg J, Breteler JPGK, and Backx JJGM "Suitable habitats for 0-group fish in rehabilitated floodplains along the lower River Rhine" River Research and Applications Vol.19 (2003) pp.353-374

[7] Kamio A, Watanabe R, Yamasaki K, Shimatani Y, Kawaguchi Y, and Watanabe K "Effects on abundance of fishes by bank protection works in sakuta ditch" Proceedings of hydraulic engineering JSCE Vol53 (2009) pp.1207-1212