環境選好性に基づく河川の魚ののぼりやすさ評価のための実験的研究

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1．Introduction

Recently, river improvement works considering fish migration have become popular. But there are actually a lot of fish ways that do not function. In our laboratory, we have been studying the evaluation method of fish migration path through elevation gaps in rivers based on its environmental preference. The purpose of this research is to verify a formula of "gap area" preference in the river proposed in our former study. We use a pit tag system to track the behavior of the fish while they are ascending. We also test the influence of applying a pit tag on fish behavior. Additionally, we examine the influence of the fishway wall as an attractor of fish by laboratory experiments. Finally we propose a migration path evaluation software to simulate fish movement in rivers.

2．Preference experiments in a river

2－1　Formula based on the environmental preference for gap area

Eq 【1】 express the preference of gap are P_G,

$$P_G = (1 - \delta_{(P_B)}) \times P_B \times W_{swim} + \delta_{(P_B)}(P_J \times W_{jump})$$

$$\delta_{(x)} = \begin{cases} 1 & (x = 0) \\ 0 & (x \neq 0) \end{cases}$$

where P_B is the preference of swimming, P_J is the preference of jumping, W_B and W_J are the weights of preference for swimming and jumping respectively.

2－2　Outline of experiment

The experimental site is a fish way constructed using ecological concrete in the Sawanami River in Ube city, Yamaguchi. Experiments were conducted three times on May 1st, September 27th, and October 17th. Twenty experimental fish (cultured sweet fish) are released in the lower pool of the experiment section, and measured the number of ascending fish to the upper pool are counted. There are three ascending path in the gap of experiment section. The number of fish passed through each path is counted using a video camera and Pit tag Reader. Flow velocity, bubble ratio, turbulence energy in the pool together with flow velocity and depth at the gap area are also measured. The conditions of each experiment are shown in Table -1.

Table-1 conditions of each experiment

Experiment day	1-May	27-Sep	17-Oct
with tag (fish)	20	9	0
no tag (fish)	0	9	20
fry or adult	fly	adult	adult
Wt(℃)	19.0	21.2	19.8
flow(m3/s)	0.010	0.018	0.018

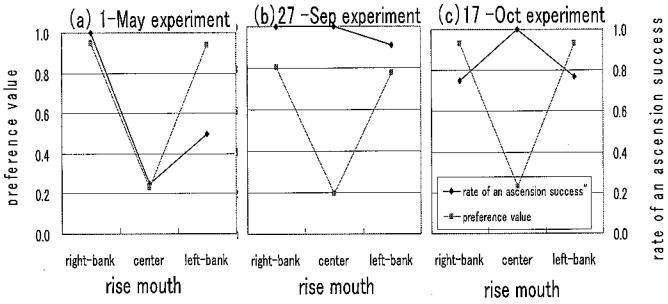

Figure1 relation between the rate of an ascension success, and a preference value

2－3　Results and discussion

Fig. 1 shows the preference value and the number of ascent success. Each preference value is calculated by Eq. [1] from physical environmental values. The preference value and the rate of ascent success show same tendency for larva in Fig. 1 (a). On the other hand, adult fish don't show similar tendency between the preference value and the rate of ascent success (Fig. 1 (b) and (c)).

3．PIT tag affection on fish behavior

3－1　Outline of experiment

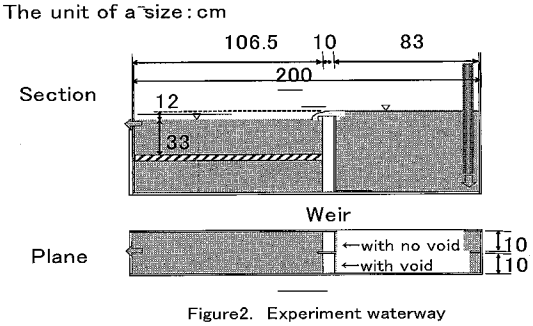

Figure2. Experiment waterway

The influence of a PIT tag to a sweet fish is tested by laboratory experiment. The experiment waterway is shown in Fig. 2. The same number of sweet fish with a tag and without a tag are released in the lower-side pool. The number of ascent successes is counted by using a video camera.

3－2　Results and discussion

The results are shown in Table -3. For adult fish, no influence of a PIT tag can be seen from a result. However, for the fry, the big difference is detected in the ascent number, and it is suggested that a PIT tag affects ascent action.

4．The preference experiment for the attraction of wall

4－1　Outline of experiment

I investigated the influence of the surface of a wall to a sweet fish. A 90×45×45 tank is used for the experiment. One wall of the tank is black representing a wall, and the other sides are white representing an open space. The tank are enclosed in an outer shell to lower a visual stimulus. Experiment period is 3 hours. Experimental fish were four adult sweet fish that length of about 16cm. The tank was divided into nine sections with 10cm section length, and the fish distribution is counted every 10 seconds.

Table-3 Result

(a) fly

pool	with tag(fish)	no tag(fish)
lower side	19	9
uper side	9	19

(b) adult

pool	with tag(fish)	no tag(fish)
lower side	4	4
uper side	5	5

4－2　Results and discussion

The distribution is averaged for every hour and shown in Fig. 3. During the first one hour, fish tend to gather near the wall. Gradually, the distribution moves from the wall side to the center of the tank as time passed. Although a sweet fish shows a preference for a wall in strained situations, it is suggested that the attraction of the wall is not clear in the normal situation.

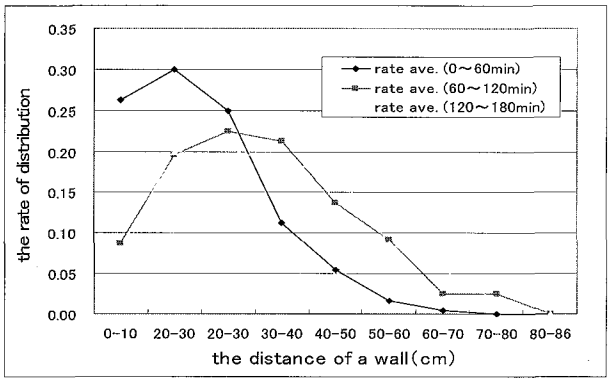

Fig.3 distribution

5．Model　　Simulation

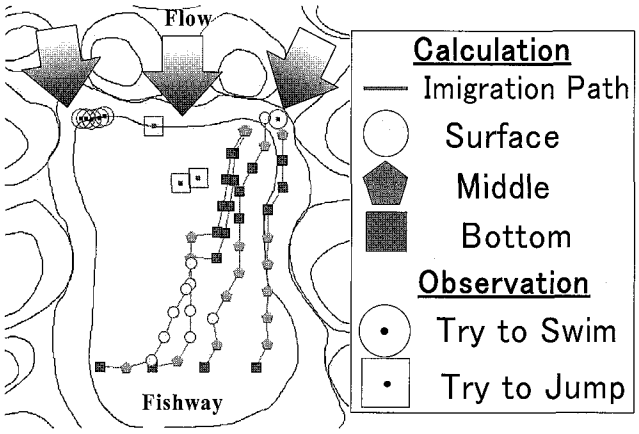

Fig 4 Result on simulation and experiment

For the purpose of abstracting of disagreeable point along the presumed path which fish immigrate in the river, we develop a simulation method of 3 dimensional fish migration on GIS (Geographical Information System). Using the GIS data set on experiments in a river on fly of sweet fish at the 2nd chapter, virtual fish should choice the highest environmental preference point from 3 layers on depth direction about the range of flow direction ±30 degrees. The result is shown by Fig.4. Virtual fish immigrate toward to the direction which preference level is higher, and reached right bank side on fishway on the all calculated path of 4 cases. However, that is different result about observation of experiments. That is caused by the luck of concern about preference on depth and weight between environmental preference and swimming habit toward to the flow direction on fishes. We work to improve this system.