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Experimental Study of Swimming Characteristics of Japanese Rice Fish (*Oryzias latipes*) for paddy-field Fishway Design

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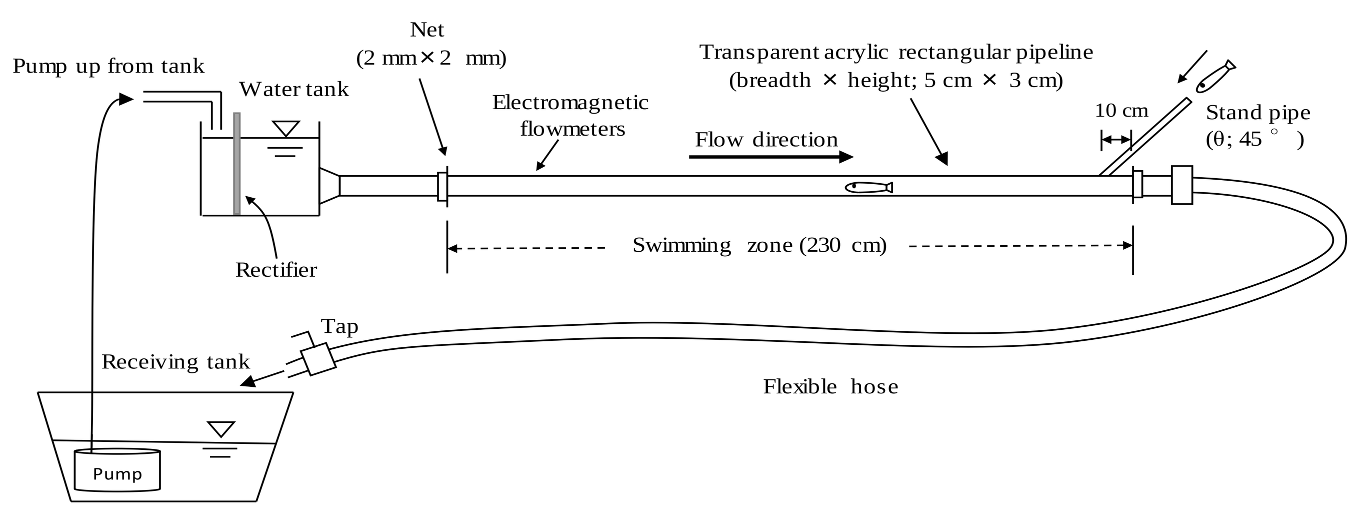
Abstract

Recently, paddy-field fishways that aim to conserve fish living in paddy fields have been developed in Japan. The Japanese rice fish, the minami medaka (Oryzias latipes) living in paddy fields uses paddy fishways. The swimming ability of the minami medaka is low, and the burst ability and swimming method is unknown.
We conducted an indoor experiment on wild minami medaka to study its burst swimming speed for paddy-field fishway design. The experiment was conducted in a small channel with a rectangular cross-section and a waterway system for circulation. It was installed in an indoor laboratory. The experiment was conducted under an average cross-sectional water flow velocity of about 24 cm/s. The body length of the minami medaka ranged from 1.6 to 3.0 cm. The water temperature was maintained at about 23°C, so that this factor did not impact swimming behavior.
The minami medaka swam at the speed of 44 cm/s in a flow velocity of 24 cm/s in the pipeline by repeated burst behavior. As the burst speed of one-time burst behavior increased, the burst time decreased. The swimming behavior of minami medaka can be characterized by repeated burst behavior to quickly move forward in high flow velocity. The burst speed of small fish, which should determine fishway design, has not previously been clearly described. The current information can be used to design fishways to protect local ecosystems.

Material and Method

Fig. 1 shows the schematic view of the experimental equipment (Stamina tunnel). Sample fish were inserted via the standpipe and could swim in the measurement section between two nets of 2 mm mesh size. City water with chlorine removed was supplied to the water tank by an underwater pump. While keeping the water level constant at the spillway, the water ran through the pipeline, flexible hose, and the drainage outlet, and it was then discharged to the receiving tank again. The Stamina tunnel is a transparent acrylic rectangular pipeline, with internal dimensions of 230 cm (or 47 cm) × 5 cm × 3 cm (length × breadth × height). The water tank and the pipeline were placed horizontally. A scaled whiteboard was attached to the floor of the pipeline. For the measurement of swimming speed of the sample fish, two digital video cameras (Sony: HDR-CX170, HDR-CX80) were set above and to the side of the pipeline to record the swimming behavior of the sample fish two-dimensionally. The temperature of the water was controlled at about 23°C.

Fig.1 Schematic view of experimental equipment



Swimming curve; relationship between swimming speed and swimming time

The mean body length of 22 fish sampled was 2.5 cm. Fig. 2 shows the relationship between swimming speed and time in a double logarithmic chart. The flow velocity in the pipeline ranged from 20 to 35 cm/s. The formula for the swimming curve was V = 38 t-0.12 (V: swimming speed [cm/s], t: swimming time [s]).

Burst speed

The mean body length of 76 fish sampled was 2.4 cm. The flow velocity in the pipeline ranged from 5 to 40 cm/s. There were 246 actions recorded for analysis. Fig. 3 shows the schematic diagram of a series of the burst behavior of the minami medaka. 36 samples were used the pipeline of 47 cm of swimming zone. The fish advanced by repeated burst behavior because the swimming stamina was low. The swimming distance and time at one-time burst behavior was analyzed (Figs. 4, 5, and 6).

Fig.3 the schematic diagram of a series of the burst behavior of minami medaka

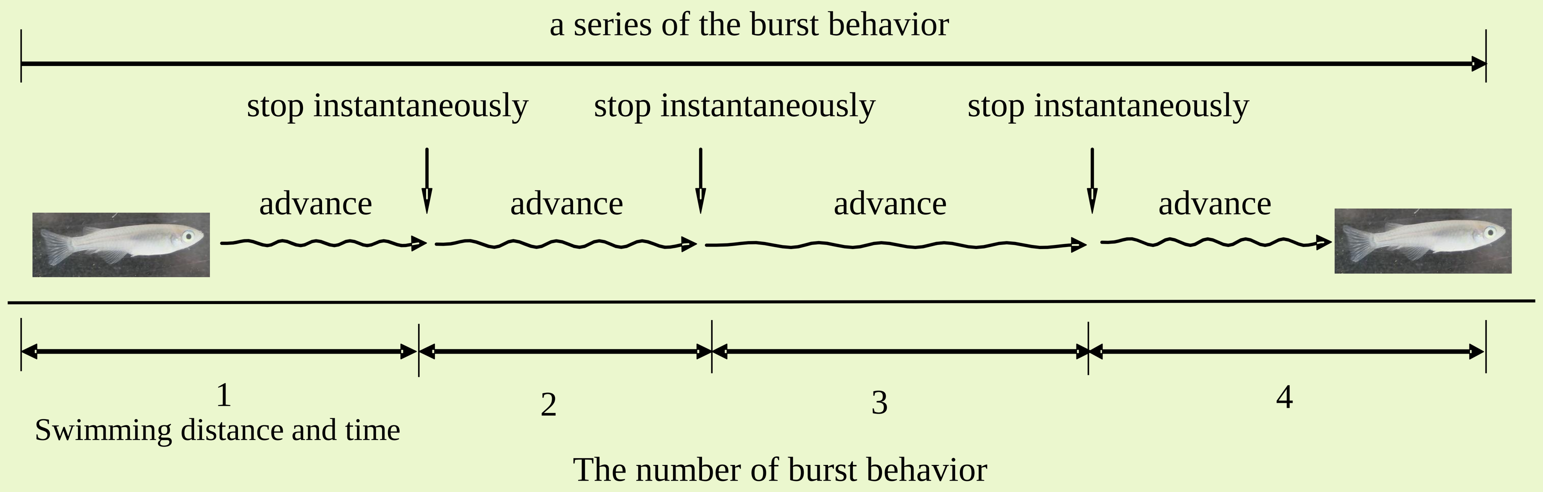


table1 the flow velocity, swimming speed and distance at a series of the burst behavior

	body length (cm)	flow velocity (cm/s)	swimming distance (cm)	time (s)	ground speed (cm/s)	swimming speed (cm/s)
mean	2.5	24	23	1.31	21	44
deviation	0.2	5	30	1.69	9	11

Fig. 4 shows the relationship between burst speed of one-time burst behavior and body length at a series of the burst behavior at both types of the swimming zone.
Fig. 5 shows the relationship between mean burst speed of one-time burst behavior and body length at a series of the burst behavior. There is a proportional relationship between the mean burst speed and body length.
Table 1 shows the mean values of the flow velocity in the pipeline, swimming speed, and distance of the minami medaka at a series of the burst behavior. It shows that the minami medaka swam at a speed of 44 cm/s in the flow velocity of 24 cm/s with repeated burst behavior.
Fig. 6 shows the relationship between the mean burst distance and time of one-time burst behavior at a series of the burst behavior for each speed. According these figures, as the burst speed of one-time burst behavior increased, the burst time decreased. The minami medaka has a characteristic swimming behavior of repeated burst behavior to quickly move forward with high flow velocity.

Fig.2 Relationship between swimming speed and time

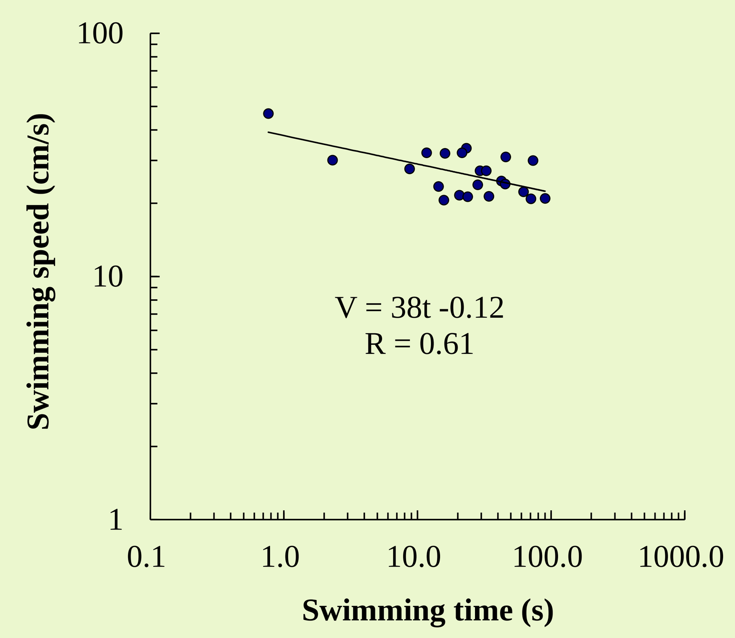


Fig.4 Relationship between burst speed and body length at a series of the burst behavior

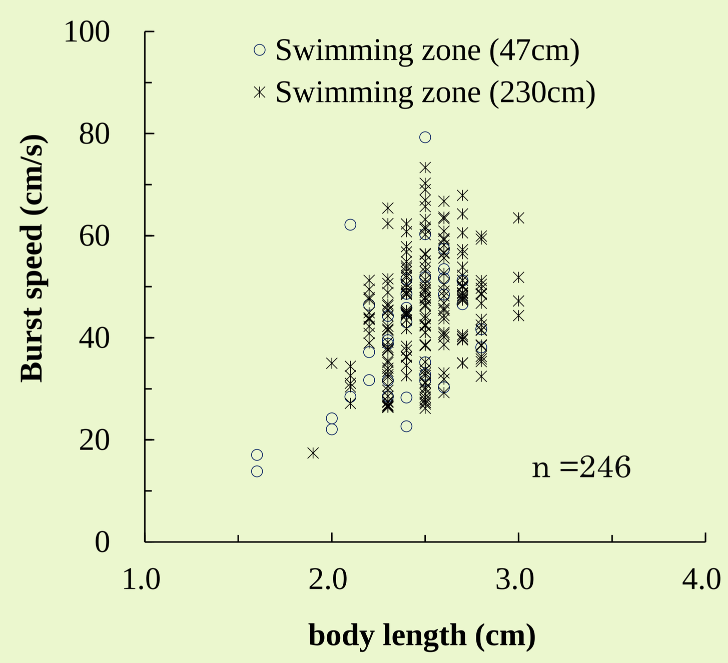


Fig.5 Relationship between mean burst speed and body length at a series of the burst behavior

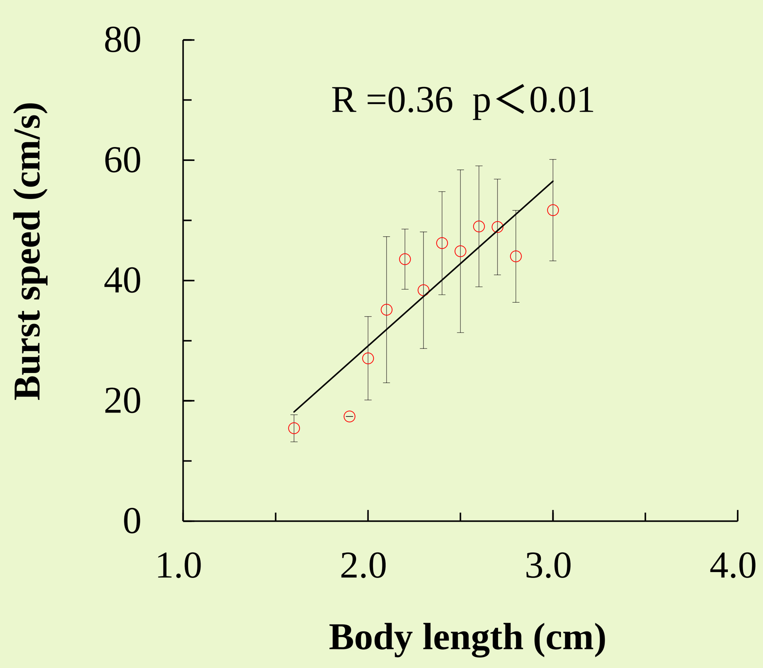
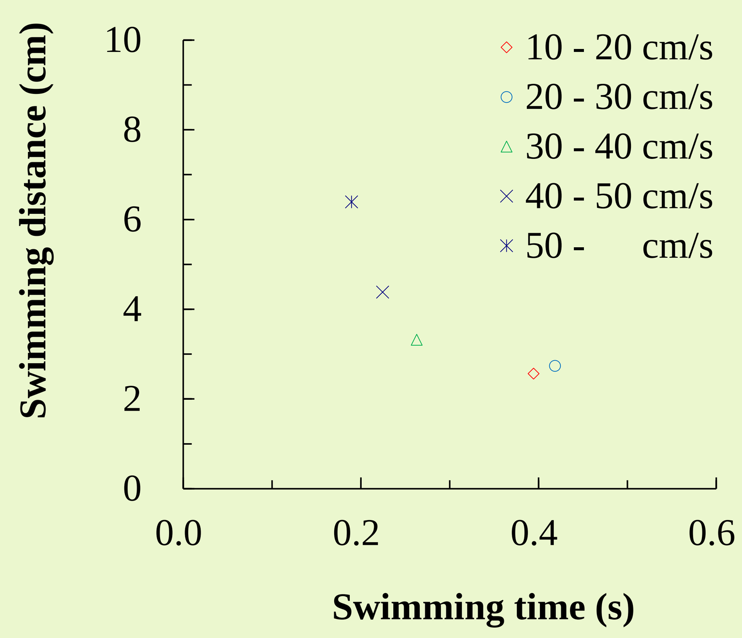


Fig.6 Relationship between burst distance and time at a series of the burst behavior



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