Journal of Sustainability Science and Management
Volume 10 *Number* 1, June 2015: 107-113
ISSN: 1823-8556

SWIMMING PERFORMANCE OF ASIAN REDTAIL CATFISH (*HEMIBAGRUS NEMURUS*) IN THE SWIMMING CHANNEL OF FLUME TANK

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Abstract: This study aims to enhance the knowledge on endurance swimming capacity and speed of Asian redtail catfish (*Hemibagrus nemurus*)(Body Length (BL)) = 16.13 ± 1.14 cm, Average ± SD) observed in swimming channel of flume tank for development of fishing and aquaculture methods. Swimming speed was negatively correlated to the endurance time. The endurance time decreased when the swimming speed increased. Sustained swimming speed was less than 2.5 BL/s, corresponded to 40.3 cm/s and burst swimming speed was recorded up to 10.5 BL/s, corresponded to 169.4 cm/s, whilst the prolonged speed was recorded at 2.5-10.5 BL/s (40.3-169.4 cm/s). The tail beat frequency of Asian redtail catfish was positive correlation on the swimming speed. The tail beat frequency increased when swimming speed increased. At sustained swimming speed, the tail beat frequency was low at 2-4.5 HZ, and dramatically increased to reach 10 HZ at prolonged swimming speed.

Keywords: Asian redtail catfish, flume tank, Hemibagrus nemurus, swimming speed, swimming endurance.

Introduction

Asian redtail catfish (*Hemibagrus nemurus*) fishing and culture has been increased since almost two decades ago, as this fish is one of the most popular but costly in the local restaurant, however, no study have been conducted on the ethology of the fish, especially its swimming behavior. The knowledge on the fish behavior is required in order to develop sustainable fishing management and optimizing culture practice (Parrish 1999 and Wardle 1993). Studies on the physiological and fishery biology will help the fishing technology, and type of fishing gear to be used as well as aquaculture technique. Hence, studies on the characteristics of fish swimming plays important role on the fishery and aquaculture. Therefore, we should observe the swimming pattern of fish locomotion. The bodies of all fast-swimming fishes taper off at each end. At one end of the body are a caudal fin, which is held vertically and the fish moves forward by sweeping their body from side to side as its principle propulsion. The forward movement of the fish is due to the motion of the tail fin fish through the water supported by the surrounding muscle, and the fin must press backward against the water.

According to Webb (1975) the forward swimming speed of fish can be divided into four categories; namely, sustained speed; it is a fish swimming speed that the fish able and endured for swimming more that 200 minutes continuously. The maximum sustained speed is the fish swimming speed more than the sustained speed. This occurred because of the red muscle and white muscle working together to perform the swimming activities. At such swimming speed, the endurance of the fish drastically decrease due to the fish reached its fatigue (He & Wardle, 1988). The next is at prolonged speed, the swimming speed is even faster; as the fish is able to swim for more than 15 seconds and less than 200 minutes because of fatigue. The last is the maximum swimming speed of burst speed that the fish is only able to swim for less than 15 seconds (Webb, 1975).

Swimming is efficient than other mechanism for movements in the water. One of the important things in studying fish behavior is the fish swimming activities, which is composed of swimming speed and endurance. Whilst in the swimming activities, it can be divided into five patterns of swimming, classified as sustained, maximum sustained, prolonged, burst and backward swimming speed. All swimming speed categories are illustrated in the physiological condition of the fish during swimming (Nofrizal *et al*., 2009). It is useful to determine maximum water current speed for floating cage in the river properly for cage culture industry. Over high current speed can staggering the fish to swim actively, which is a disadvantage in metabolism, process as well for its growth (Nofrizal *et al*., 2011). By knowing the maximum sustained swimming speed and burst swimming speed, we can find out the escape opportunity of Asian redtail catfish during the fishing operation with a certain fishing gear. Whilst, the fish that swim at the prolonged speed can make the fish in completely fatigue (Nofrizal *et al*., 2009; Nofrizal & Arimoto, 2011). Therefore, swimming behavior and its endurance and speed difference characteristics and swimming ability play important role in the development of fishing and aquaculture method. Unfortunately, the swimming performance and its characteristics of Asian redtail catfish still unknown. Unknown behavior of the Asian redtail catfish swimming indicates that further studies on the subject is very important in order to further develop the fish fishery, especially for future sustainable development of fishing technology and aquaculture of Asian redtail catfish.

Methodology

The swimming speed and endurance of Asian redtail catfish of BL = 16.13±1.14 cm examined in the PVC-made flume tank with velocity set at 16.7, 23.3, 36,6, 50.0, 70.0, 76.7, 96.6, 103.3 and 110.0 cm/s. The water temperature in flume tank was 27.2±0.1ºC (Average ± STDEV) during swimming exercise test.

One side of the wall of the test section was covered by a panel where square grids were drawn as visual cues for keeping position in the flow through the optomotor response (Figure 1). When the fish was maintaining its position relative to the oncoming flow, the swimming speed of the fish was considered to be equivalent to the flow speed (Wardle, 1993; He & Wardle, 1988; Xu *et al*., 1993; Nofrizal *et al*., 2008; Nofrizal, 2009; Nofrizal *et al*., 2009; Nofrizal & Arimoto, 2011). In such condition, the swimming speed of fish will be equal to the current speed in the flume tank. At that same condition, the swimming behavior of the fish will be observed and recorded by using a video camera.

In order to understand the relationship in between swimming speed and tail beat frequency it is common to execute linear regression analysis. Whilst on swimming endurance, analysis of swimming curve is

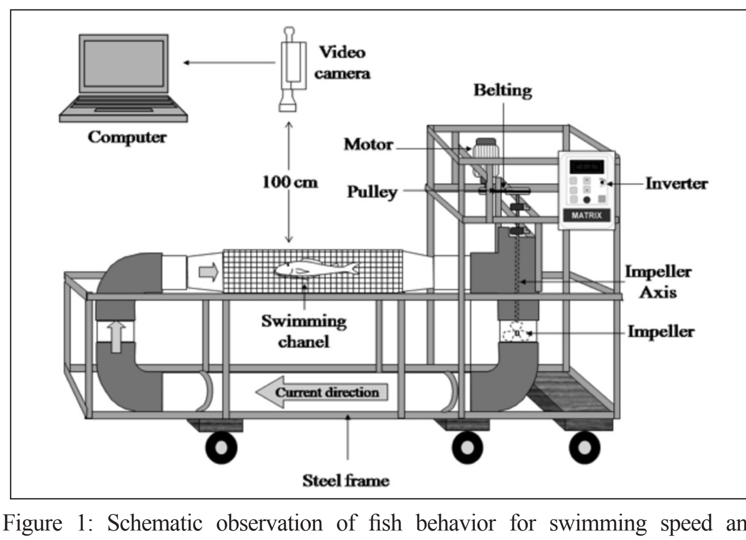

Figure 1: Schematic observation of fish behavior for swimming speed and endurance for asian redtail catfish (*Hemibagrus nemurus*) by PVC-made flume tank

performed at different swimming speed of the fish by using the model of $Te = Log10^{(a+b.U)}$ (Nofrizal *et al*., 2009; Nofrizal 2009). Furthermore to estimate maximum sustained and burst speed, analysis used the substitution of linear regression from the relationship in between swimming speed *U* and swimming endurance (*Te*), which *Log E* is swimming endurance, *a* is intercept of swimming endurance and *b* is slope of the line, so that,

$$U\ max.\ sustained/burst = \frac{LogE - b}{a} \quad (1)$$

Results and Discussion

Based on the experiment we found that the swimming speed has negative correlation to the endurance time. The endurance time decreased when the swimming speed increased. Sustained swimming speed was less than 2.5 BL/s (40.3 cm/s) and burst swimming speed increased to 10.5 BL/s (169.4 cm/s), whilst prolonged swimming speed was recorded between 2.5-10.5 BL/s (40.3-169.4 cm/s) (Figure 2).

Endurance and swimming speed of Asian redtail catfish

Data of swimming endurance at the range of sustained swimming speed was not analyzed to avoid the prediction bias in the sustained, maximum sustained, prolonged and burst swimming speeds. Figure 2 indicates that the endurance and swimming speed has a negative correlation (R^2 = 0.68). Therefore, the endurance swimming time decreased as the swimming speed increased.

Figure 2 shows that the negative correlation between swimming speed and endurance time, the swimming endurance decreased, when swimming speed increased. The sustained swimming speed was less than 2.5 BL/s (40.3 cm/s) and maximum sustained swimming speed was estimated at 2.5 BL/s (40cm/s). The prolonged swimming speed was 2.5-10.5 BL/s (40.3-169.4 cm/s). Meanwhile, the burst swimming speed was higher than 10.5 BL/s (169.4 cm/s). The linear regression equation in Figure 2, can be used to estimate swimming endurance ability of the Asian redtail catfish based on a given swimming speed.

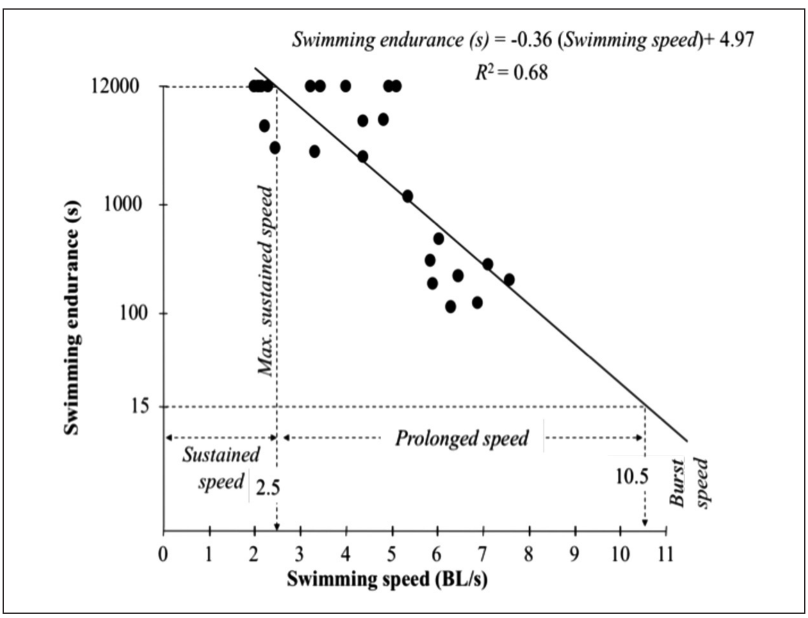

Figure 2: The relationship between swimming endurance and speed (BL/s) in Asian redtail catfish

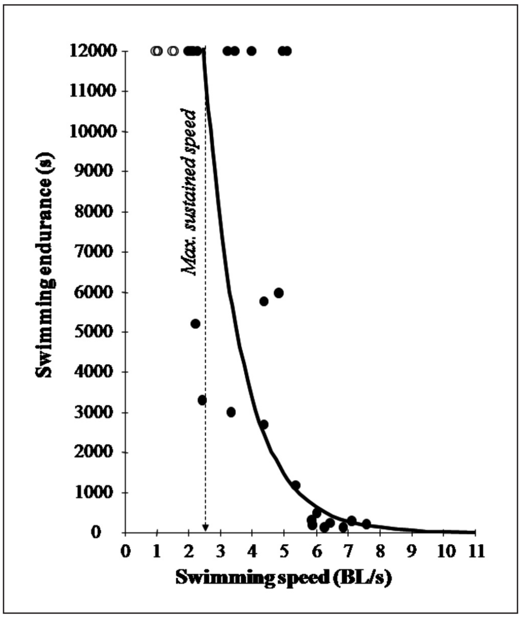

Figure 3: Swimming curve of Asian redtail catfish (*Hemibagrus nemurus*). The asymptote line at the swimming speed of 2.5 BL/s

Swimming curve describes in Figure 3 shows the asymptote line at the swimming speed of 2.5 BL/s. Asymptote line is a sign of the maximum sustained swimming speed. The line also indicates the threshold between sustained and prolonged swimming speed. At sustained swimming speed, the fish swims along its life at this swimming speed. While the tip of curve describes the range of prolonged swimming speed. The swimming curve of the fish presented to show the trend that best fits the data of swimming endurance of fish. At the same time, it also describes the fish swimming ability based on different speed.

Tail Beat Frequency of Asian Redtail Catfish

As the inclined blade of the fish's caudal fin moves through the water it pushes the water away from its surface in a backward and sideways direction relative to the axis of the fish's body. However, inertia of the water resists this movement, and consequently the body of the fish acted upon by a force equal in the opposite to the force that the tail applies to the water. The amount of water that is transferred to the rear and to the side of each sweep of the caudal fin, and consequently the forces applied on the body of a fish, which depend on the same factors by controlling the amount of water displaced by the speed at which the blade tail or fin moves from tail beat. The swimming speed is determined by tail beat frequency, the size and shape of caudal fin. The fin movement is a source of energy to push the body of the fish moving in the water. Figure 4 shows that the positive correlation between tails beat frequency and swimming speed. This describes that the swimming speed was significantly increased, when the tail beat frequency was faster (R^2 = 0.68). The extra energy was required for high swimming speed and consequently the swimming endurance decreased as shown in Figure 2. The extra energy was required to swim at the high speed than lower speed. Therefore, the metabolism rate and respiration process were rather quick and increased at the high speed (Nofrizal *et al*., 2009; Nofrizal and Arimoto 2011). However, the supply of energy in the fish in general is steady and of course, it is arduous to provide the needy high energy in the short time.

The Asian redtail fish is able to sustain swim for 200 minutes (12000 seconds) at swimming speed of < 2.5 BL/s or 40.3 cm/second. During sustained swimming speed involved aerobic metabolism that required high oxygen demand to oxygenate red muscle. Figure 4 indicates that the tail beat frequency at the sustained swimming speed was slow at approximately 2 to 4.5 Hz. and increased from 4.5 to 10 Hz during maximum swimming speed. Whilst data on tail beat frequency for maximum or burst swimming speed approximately up to 10 Hz. The limitation of impeller rotation and the outcome current in the flume tank could not produce the data of caudal fin beat frequency that reflects the maximum or burst swimming speed.

Sustained swimming speed is usually used to study fish activity cultured in the flow water floating cage. Therefore, our results recommend that appropriate water current for floating cage

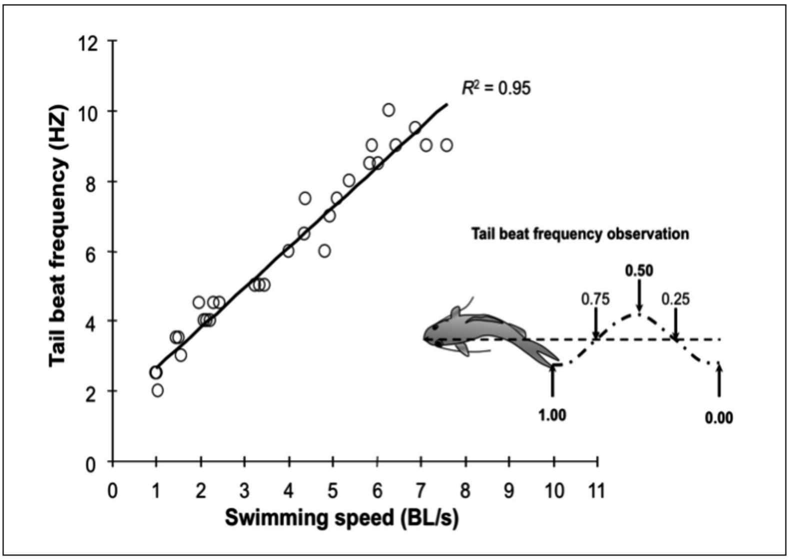

Figure 4: Relationship between swimming speed and tail beat frequency for Asian redtail (*Hemibagrus nemurus*)

should be less than 40.3 cm/s to avoid extra energy expenditure for swimming in the cage. Hence, adjustment of the cage to suitable water current speed in the cage is very important to maintain normal living of the cultured fish in the floating cage.

Metabolism process and respiration increased at around maximum sustained swimming speed, as found in the jack mackerel (*Trachurus japonicus*). Both respiration and metabolism rates were increased during maximum sustained swimming speed shown by the increasing of heart beat (Nofrizal *et al*., 2008; Nofrizal 2009; Nofrizal *et al*., 2009; Nofrizal & Arimoto, 2011). At this maximum sustained swimming speed red and white muscles also working cooperatively to perform the swimming activities. The present experiment showed that the Asian redtail catfish were exhausted at 200 minutes.

Soofiani and Priede (1985) stated that the oxygen consumption at the maximum sustained swimming speed was lower as compared to prolonged swimming speed. It is caused by the aerobic red muscle activities, which is normally not working. Therefore, this swimming speed, is not recommended for cultivating fish in the cage jetted system. Figure 2 shows that the Asian redtail catfish were not able to swim for more than 200 minutes at prolonged swimming speed due to fatigued. In this condition, the Asian redtail catfish is also assumed to be in fatigue. The earlier observation by Nofrizal *et al*., (2009) on jack mackerel found that the fish will be in fatigue at the prolonged swimming speed. Even the fish required time more than nine hours for recovery after achieving such swimming activities. This suggests that such condition should not happen in the aquaculture for fish culture in the floating cage.

Information and data on the maximum swimming speed or also called burst swimming speed are necessary in the fishing technology. This is useful in order to determine the probability of fish to avoid and escape from the fishing gear. Based on this information, the fishermen could determine the exact technique and methods of fishing operation.

The swimming speed ability of Asian redtail catfish is lower than that of jack mackerel's swimming ability, which is able to swim at the speed of 8-10.3 FL/s (Forked Length per-second) or corresponded to 147.2-189.5 cm/s (Nofrizal *et al*., 2009; Nofrizal &

Arimoto, 2011). Whilst the maximum burst swimming speed of the Asian redtail catfish were faster compared to glass catfish at average size of BL = 14.8 cm with speed of 8.0 FL/s (Nofrizal *et al*., 2011). The principle utilized in fishing is the towing speed of the net should be more than the speed of maximum swimming speed of fish. It aims to avoid the fish escape from the gear.

Burst swimming speed is also being used to account kinetics energy force by the fish during endeavors to release from hook and fishing line. This kinetics energy force is able to breakdown the fishing line or yarn at their maximum swimming speed force. Based on this theory, the information can be used to determine the strength of yarn which may use to capture asian redtail catfish by line fishing gear.

Figure 4 shows a significant positive correlation between tail beat frequency and the swimming speed ($R^2 = 0.9$). Consequently, increase of caudal fin beat frequency would eventually cause Asian redtail catfish reach to fatigue stage early and reduce endurance swimming capacity. According to Steinhausen *et al*., (2007) the driving force of the caudal fin beat is related to swimming speed and oxygen consumption during spontaneous activities to sustain aerobic metabolism needs.

Asian redtail catfish fin structure is rather soft and relatively small as compared to jack mackerel (*Trachurus japonicus*). The fin structure and size of the fish body influence to the swimming ability. Jack mackerel has hard and strong caudal fin that is quite similar to tuna, marlin, and other fast swimming fish. With soft and small caudal fin, the asian redtail catfish need to flick their caudal fin faster in order to maintain their swimming performance in swimming channel, subsequently increased energy expenditure that may caused fish fatigue early.

Conclusion

Sustained swimming speed of asian redtail catfish (*Hemibagrus nemurus*) was less than 2.5 BL/s, and maximum swimming speed was 2.5 BL/s. The range of prolonged swimming speed was 2.5-10.5 BL/s and burst swimming speed was recorded more than 10.5 BL/s. Swimming speed and endurance were negative correlations. Whilst, swimming speed and tail beat frequency were positive correlated.

Acknowledgement

We acknowledge the Directorate General of Higher Education, Ministry of National Education with thanks for funding this research through Grant Project for Fundamental Research. Thanks also to Mr. Hesron Ananta for helping us in the research, and the Dean of Fisheries and Marine Science Faculty, University of Riau (Prof. Dr. Bustari Hasan).

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