Mem. Fac. Fish., Kagoshima Univ.
Vol. 20, No. 1, pp. 91~97 (1971)

Diurnal Rhythm of the Swimming Activity of the Juvenile Spotted Mackerel

Pneumatophorus tapejnocephalus (BLEEKER)

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The rhythm of fish behaviour is very interesting for biologists and fishermen. Studies on it can give informations that could help us to operate the suitable fishing gear and to catch fish more effectively. Hitherto many investigations have been carried out on marine animals,[1)-6)] but a few have been done on the migratory fishes.[7)-9)] In this paper the author describes an experimental observation of the diurnal rhythm of the swimming activity of the juvenile spotted mackerel.

Material and Method

The fish used were juveniles of spotted mackerel *Pneumatophorus tapeinocephalus* (BLEEKER) with 11.7 to 21.4 cm. length, caught in Odomari Bay on 31 May 1970, and kept in a fish-stock-preserve in the sea water pond of Sakura Jima Aquarium. Food used was cold *Stolephorus japonicus* (HOUTTUYN). A wooden experimental tank of 170 cm. length 70 cm. width and 50 cm. depth, with two of its opposing side walls replaced with net, a white plastic board with lines marked at 5 cm. intervals with black paint constituting the bottom was used (Fig. 1).

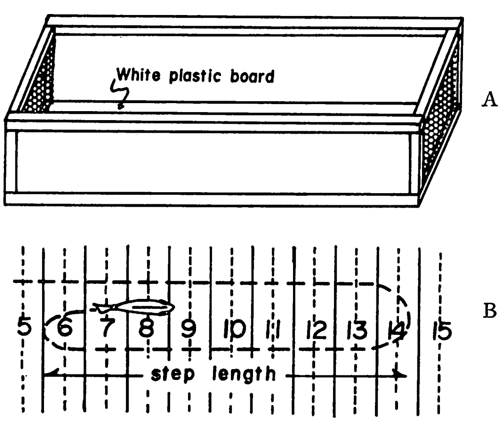

Fig. 1. Wooden experimental tank of 170 cm. length, by 70 cm. width and 50 cm. depth (A), and the bottom of the tank made by white plastic with lines marked at 5 cm. intervals to facilitate measurement of step length (B).

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Five fish given no food for two days before the experiment, one of them being much larger than the others, were picked up from the fish-stock-preserve, and placed in the experimental floating tank in the pond. These fish forming themselves into a group continued to swim taking a rather fixed course around a fixed area. After a few hours, the time taken by the largest fish to repeat 50 turnes was recorded and each step length was measured. Illumination and water temperature were also measured simultaniously.

Actual data for this paper were collected after four days of training on taking measurements in day as well as night to minimize error. Measurements of each observation were repeated for 24-34 hours, and five observations were carried out 27-28 July (I), 20-21 August (II), 2-3 September (III), 19-20 October (IV) and 31 October-1 November (V).

Swimming activity is expressed by the swimming speed and the number of frequencies of the turns and is estimated by using the following formula

$$(\sum S/t) \cdot (T/t) \times 10^{-4}$$

in which S is the step length (cm.), T is the number of frequencies of the turns and t is time in minutes.

Result and Discussion

Results are shown in Fig. 2.

Sea water flow into the pond when tide rises and flow out from it when tide falls, so the daily changes in water temperature in the pond is irregular, but it shows the tendency that the water temperature is high during the day and low in the night. Average water tempeerature in each observation gradually decreased, *viz.* 28.9, 26.4, 28.5 23.0, 21.7°C.

Illumination decreased gradually until one or two hour before the sunset and thereafter rapidly and increased rapidly from one hour before sunrise. But in the daytime the illumination changed variably due to cloudiness.

In the daytime fish forming a group swam in the tank actively, and the swimming activity changed variably and started to decrease just before the sunset and increased from one or two hours before sunrise. In the night they swam sluggishly in a mass and sometimes dispersed but immediately getting together again, never stopping swimming. Swimming activity is high in the daytime and low in the night. The difference is remarkable. Ii et. al.[10] observed nocturnal behaviour of 26 kinds of fish and noted that the activity of nocturnal behaviour of mackerel was lower than that of diurnal behaviour. Accordingly, it is clear that mackerel is a diurnal fish.

Hirata and Kobayashi[11] reported that diurnal rhythm of the feeding activity of gold fish was affected by objective enviromental factors such as water temperature, duration of sunshine and dissolved oxygen. And Hirata[12] peported that it was affected by the average temperature and change in water temperature. Nambia et. al.[13] reported that the water temperature was found to be an important

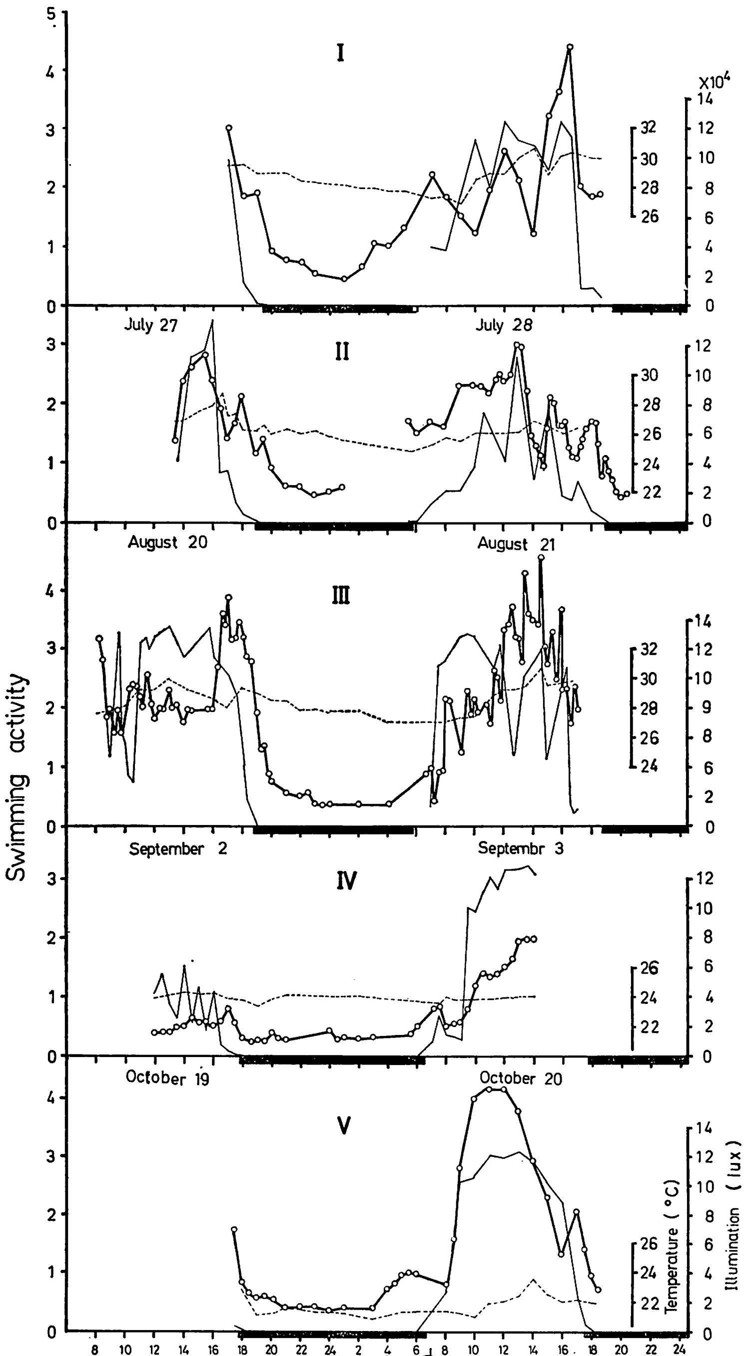

Fig. 2. Diurnal changes of swimming activity of mackerel (open circle and bold line), water temperature (broken line) and illumination (fine line).

factor regulating the swimming speed. In this study the trend of change in water temperature was irregular and did not agree with the trend of the swimming activity (Fig. 3). Furthermore, though the average water teperature in the fifth observation was lower than in the first observation, there was no relation between swimming activity and change in water temperature. As spotted mackerel is found distributed in water of temperature about 30 to 17°C, the swimming activity of it may not be affected by such changes in water temperature that occured in our observations.

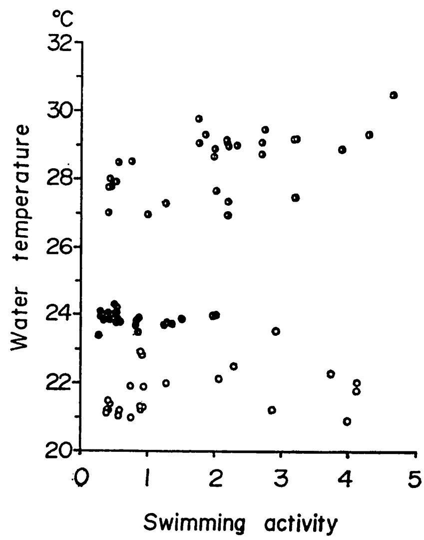

Fig. 3. Relationship between swimming activity and water temperature
semi open circle : III observation 2-3 September
closed circle : IV observation 19-20 October
open circle : V observation 31 October-1 November.

As the diurnal changes of swimming activity agree with that of the illumination it is likely that tha latter affected the former. Tanoue[14] reported that the difference in the illumination-intensity might be one of the important factors to help a good catch of mackerel under the solar eclipse.

The relationship between the change in illumination and the change of swimming activity in the fourth and fifth observations is shown in Fig. 4. Between them, though there is no correlation in the fourth observation there is significant correlation in the fifth observation. In the fourth observation the illumination changed variably due to the effect of cloud between the measurement. Therefore this figure does not explain the relationship between them clearly. In the fifth observation the sky was clear and there was no variable change in the illumination, so the relationship between them could be more reliable.

The relationship between the illumination and the swimming activity is shown in Fig. 5. This figure shows significant correlation between them, and the coef-

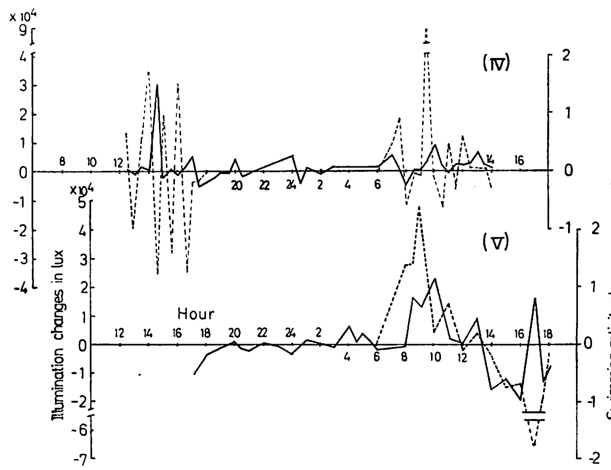

Fig. 4. Relationship between the change in illumination (broken line) and that of swimming activity (solid line).

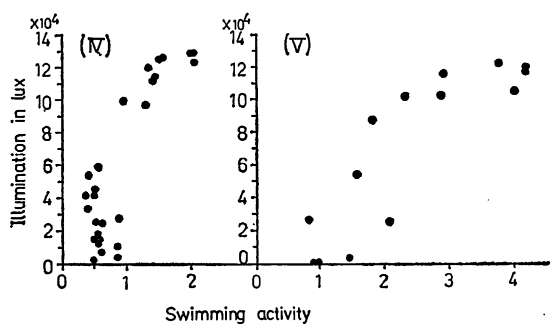

Fig. 5. Relationship between the illumination and the swimming activity.

ficients are $r_4=0.836$ and $r_5=0.772$, in other words the swimming activity increased in proportion to the illumination ($t=7.620$, df : 20, $p<0.001$, $t=4.028$, df : 12, $p<0.005$). When the illumination increased to 80000 lux the swimming activity increased a little and when the former increased above 80000 lux the latter increased with a high rate. There must be some biological critical point at 80000 lux.

According to the reports of Ats[15] and Hunter,[16] fish cannot maintain a school in darkness. Pelagic schooling diurnal fish, such as spotted mackerel, might need a decrease of swimming activity in order to maintain a shool under low illumination. Brock and Riffenbourgh[17] regarded the schooling of fish as a mechanism of protection against predation. And so it can be infered reasonably that the decrease of swimming activity under low illumination may be advantageous to the species by enabling a school to be maintained under dim light and this could protect fish against predation.

Summary

The author observed the diurnal rhythm of swimming activity of juvenile spotted mackerel in the experimental tank floated in the sea water pond. The results were summarized as follows :

1) Swimming activity was high in the daytime and low in the night.

2) Swimming activity was changed in proportion to the illumination and the change in illumination.

Acknowledgments

The author wish to express their appreciation to Captain K. Takahashi and the crews of Nansei Maru, a training ship of Faculty of Fisheries, Kagoshima University for their help in making the catch of fish sample possible and to the staff of the Sakura Jima Apuarium for their kind cooperation in carrying out this work.

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