Diel behavioral pattern of hatchery-reared black-spot tuskfish determined by acoustic telemetry in the natural environment and video observation in a fish tank

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ABSTRACT
Diel behavioral pattern of hatchery-reared black-spot tuskfish was examined by acoustic telemetry in the natural environment and video observation in a fish tank. Nine tuskfish were monitored using acoustic telemetry for 150 days; five fish were observed in a fish tank for 2 days. In the acoustic telemetry tracking, tuskfish moved horizontally and vertically during the day; they stayed still at night. The tuskfish tended to utilize depths near the bottom both during the day and night. In the video observation, the tuskfish tended to move actively and sweep sand at bottom during the day; they tended to stay still in the crater they made during the night. These results indicated that tuskfish might make their night-time resting house by sweeping sand near structures and forage benthic preys during the day, and rest in the resting house at night.

KEYWORDS: *Choerodon Schoenleinii*, diurnal, labrid, stock enhancement

INTRODUCTION

Understanding diel behavioral patterns of hatchery-reared fish is essential in order to clarify their basic ecology (Hobson, 1973; Arendt *et al.*, 2001; Kawabata *et al.*, 2007). The knowledge can also be used as an index to examine if the fish are behaviorally healthy or not (Yokota *et al.*, 2006; Kawabata *et al.*, 2007; Yokota *et al.*, 2007a; Yokota *et al.*, 2007b).

Black-spot tuskfish *Choerodon schoenleinii* (Valenciennes) is one of the most highly prized commercial fishes, and is a potential candidate species for stock enhancement in Okinawa Prefecture, Japan (Yoseda *et al.*, 2005). The tuskfish live around coral reefs, ranging from Okinawa Island to the West Pacific (Araga, 1997; Lieske & Myers, 2002). The tuskfish is generally territorial (Lieske & Myers, 2002), utilizing sandy and gravel areas near lagoon and seaward reefs (Araga, 1997; Lieske & Myers, 2002).

In the previous study, (Kawabata *et al.*, 2007) monitored five hatchery-reared tuskfish using acoustic telemetry for about three months in Urasoko Bay, Ishigaki Island, Japan. From the detection pattern, they found that the black-spot tuskfish might show diurnal activity rhythm.

The objective of the study was to further clarify the diel behavioral pattern of the hatchery-reared black-spot tuskfish. In order to achieve the goal, we monitored the hatchery-reared tuskfish for 150 days using acoustic telemetry with built-in depth sensors (Kawabata *et al.*, in press). We also conducted video observation in a fish tank for further investigating the diel behavioral pattern of the tuskfish. In this paper, we introduce the diel behavioral pattern of hatchery-reared tuskfish, revealed by these two experiments.

MATERIALS AND METHODS

Sample fish

We used nine hatchery-reared black-spot tuskfish for acoustic telemetry tracking (TL $\pm$ SD: 261 $\pm$ 30 mm, BW $\pm$ SD: 338 $\pm$ 105 g); five hatchery-reared tuskfish were used for video observation (TL: 350 $\pm$ 21 mm, BW: 532 $\pm$ 119 g). From the TL-fecundity relationships of the fish (Ebisawa *et al.*, 1995), all fish were identified as female. The fish were reared in Yaeyama Station of the Seikai National Fisheries Research Institute, Fisheries Research Agency. The fish were reared in a 2000 L-polycarbonate circular tank up to approximately 20 mm in total length, and then reared in an experimental fish pond (approximately 20 m x 20 m). When the fish were reared in the fish tank, the fish were fed with pellet on some regular basis; while in the fish pond, the fish were fed with squid and manila clam irregularly.

Acoustic telemetry tracking in natural environment

Coded ultrasonic transmitters with built-in depth sensors (V9P-2H, Vemco Ltd., Canada; 9 mm in diameter and 46 mm in length with a weight of 2.9 g in water) were used in this study. The transmitters transmit a signal once every 60 to 180 seconds with an expected battery life of 150 days. The signals from the transmitters were detected using automated monitoring receivers (VR2, Vemco Ltd, Canada). The receivers recorded the ID number, date, time, and depth when a transmitter existed within approximately 100 m from the receiver.

Coded ultrasonic transmitters were surgically implanted into the abdominal cavity of the fish under anesthesia. Surgical procedures were similar to those in (Mitamura *et al.*, 2002). After the surgery, the fish were kept in a black circular polyethylene tank (1000 L in volume) for three days to observe any negative effects of the operation. The fish showed no observable effect of the surgery on their behavior.

The tagged fish were released into the sandy bottom of Urasoko Bay on 22 September 2006 (Fig. 1). After the release, the signals from the tagged fish were monitored using 6 automated monitoring receivers (Fig. 1). The data was downloaded between 23 and 27 April 2007.

Video observation in a fish tank

The experiment was carried out in the Yaeyama Station. The protocol of the video observation was similar to (Yokota *et al.*, 2007a) and (Yokota *et al.*, 2007b). We used an acrylic fish tank (90 cm x 45 cm x 45 cm) under a light bulb connected to a timer (Fig. 2). They were separated from observers by a thick black vinyl sheet. We recorded data using an infrared video camera (DC-NCIRC1, Digital Cowboy, Japan) with a laptop computer and two infrared illuminators (AI18CIR-AFM, HOGA, Japan). The bottom of the tank was covered with sand to a depth of 50 mm. Sea water and air were supplied continuously to the aquarium.

We recorded one fish at a time. Each fish was put into the tank at 12:00 and taken out from the tank at 10:00 two days later. Light was turned on at 5:30 and off at 19:00 to simulate the natural light condition of Urasoko Bay. The data for the first 6 hours after the introduction were not used for analysis, thus eliminating the handling stress of introduction.

Turn numbers and sweep numbers per 30 min were counted in each fish. 'Turn' was defined as the behavior by which the fish changed its orientation by more than 180°. 'Sweep' was defined as the behavior by which the fish swept sand so that the water got turbid. Since the turn number was considerably different among individuals, we calculated the rate of the numbers to the total numbers in each fish.

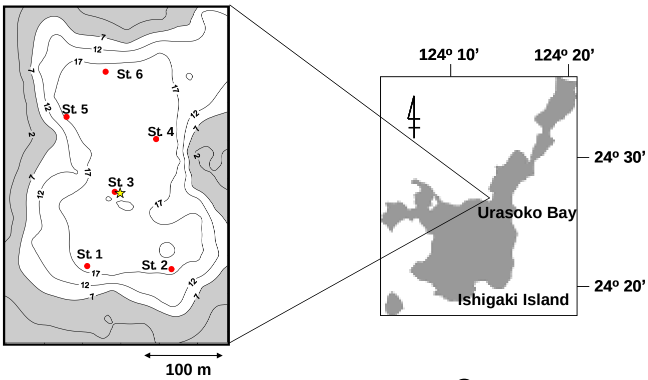

Fig. 1. The study site, receiver locations (●) and fish release point (☆). The lines with numbers in the map indicate the contours of the bottom depth. The shaded area in the map represents the coral reef.

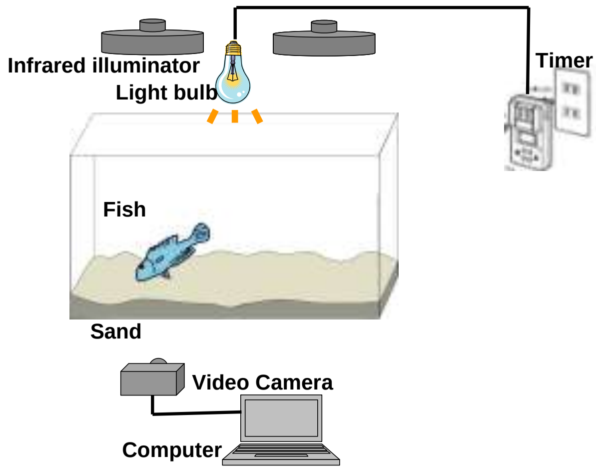

Fig. 2. A schematic drawing of a video observation unit.

RESULTS

Acoustic telemetry tracking (See Kawabata *et al.*, in press for detail)

The tuskfish moved horizontally and vertically during the day and stayed in the same place at night (Fig. 3). The tuskfish utilized depths less than 17 m, which is beyond the sandy bottom (Fig. 1), more frequently during the day (8:00-18:00) than during the night (20:00-6:00) (paired *t*-test, $P<0.02$) (Fig. 4). However, they spent most of the time below 17 m in depth both in the daytime (87.3 $\pm$ 17.3 %) and night-time (92.7 $\pm$ 14.3 %) (Fig. 4). This reveals that the tuskfish spent most of the time near the bottom even though the tuskfish sometimes go up in the water column during the day.

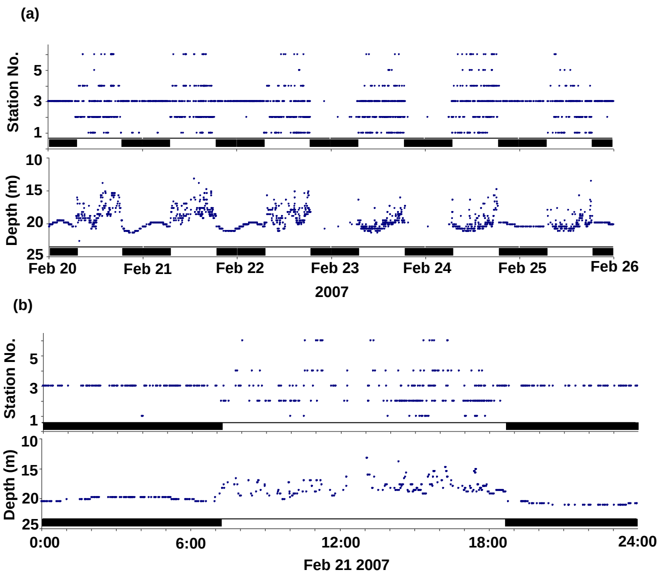

Fig. 3. Typical diel horizontal and vertical movements of black-spot tuskfish. Time series horizontal and vertical movements of one fish from 20 to 26 February 2007 are shown in (a). Close-up time series horizontal and vertical movements on 21 Feb 2007 are shown in (b). Black bars at the bottom of each figure indicate night-time. (Kawabata *et al.*, in press)

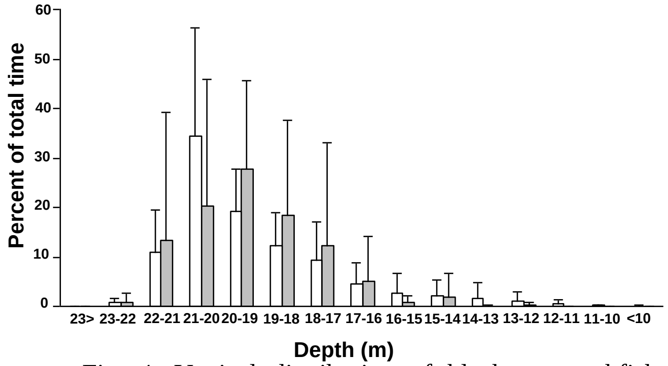

Fig. 4. Vertical distribution of black-spot tuskfish within the monitoring area for over 60 days as percent time (mean + standard deviation) in daytime (☐) and night-time (■). (Kawabata *et al.*, in press)

Video observation

The fish tended to move actively and sweep sand and made a crater in the daytime, and stayed still at the crater at night.

The turn rates were higher in the daytime than night-time (Fig. 5a). There were two trends in sweep rates. The sweep rates were higher in the daytime than night-time (Fig. 5b). The sweep rates gradually became smaller as time elapsed (Fig. 5b).

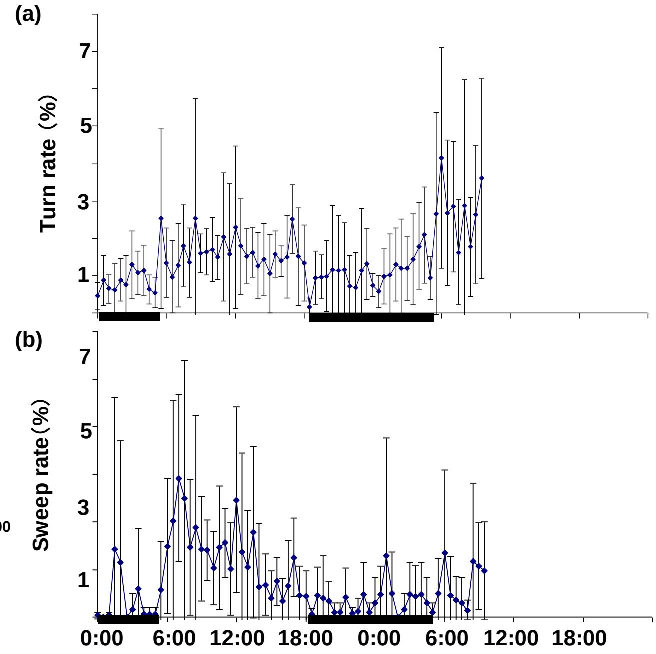

Fig. 5. Time series turn rates (mean + standard deviation) (a) and sweep rates (mean + standard deviation) (b) of black-spot tuskfish in a fish tank. Black bars at the bottom of each figure indicate night-time.

DISCUSSION

The tuskfish showed a strong diurnal movement pattern in both experiments (Fig. 3; Fig. 4; Fig. 5. The decreased detection numbers at night in the acoustic telemetry tracking suggests that the tuskfish were in or near structures at night which could block the transmitter signals (Arendt *et al.*, 2001; Mitamura *et al.*, 2005; Yokota *et al.*, 2006; Kawabata *et al.*, 2007; Yokota *et al.*, 2007a; Yokota *et al.*, 2007b). Since the fish made a crater at the sandy bottom during the day and stayed still at the crater in the fish tank at night, the fish might sweep the sand under or near structures in order to make their own resting house in the natural environment. However, since wild black-spot tuskfish is reported to forage benthic prey in sand (Wainwright and Bellwood, 2002) and under rocks (Lieske & Myers, 2002), it is also possible that the fish searched for benthic prey during the day. Further studies are needed to understand the ecological function of the diurnal behaviour.

ACKNOWLEDGEMENTS

We would like to express our great thanks to the participants in the study for their kind cooperation. We especially thank the staff working at Yaeyama Station, of the Seikai National Fisheries Research Institute, FRA. We thank the staff and students of the Graduate School of Informatics at Kyoto University for their constructive comments. We also thank Dr.

Reiji Masuda at Maizuru Fisheries Research Station at Kyoto University for providing valuable information on a video observation. This study was partly supported by Sasakawa Scientific Research Grant from The Japan Science Society.

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