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Observation on behavior of the large suspension feeding bivalve *Atrina pectinata lisckeana* under natural conditions

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Abstract To evaluate an effect of environmental changes on the pen shell *Atrina pectinata lisckeana*, we conducted research on the valve movement of the pen shell; an indicator of their activity. We developed two types of data logger to measure the valve movement of the pen shells under field conditions. One is a wire-communication type for regions close to the shore while the other is an underwater type for offshore regions. The measurements were performed in a tidal flat and in a subtidal station in Ariake bay in 2004. The measurement in tidal flat revealed a distinct emersion effect, where the pen shells were closing their valves and remaining motionless during the emersion. This type of motionless period did not, however, occur when they were submerged. Measurement in the subtidal station revealed post-transplantation burrowing behavior and unusual single close-open actions during a storm.

Key words: Pen shell, *Atrina pectinata lisckeana*, valve movement, data logger

The pen shell *Atrina pectinata* is a large suspension feeding bivalve and one of the most important species in shell fisheries in Ariake bay Japan. The pen shell is also an important species in terms of its ability to construct benthic fauna. Their filtration and bio-deposition may affect the composition of the benthic fauna and environmental conditions (Cummings *et. al*., 1998; Norkko *et. al*., 2001). Therefore, the pen shell is important as a key species in the benthic community in Ariake bay. However, the pen shell production in Ariake bay has been decreasing since the 1960's. In a recent survey, mass mortality of the pen shells was observed in the fishing grounds (Matsui, 2002, Kawahara and Ito, 2003). Certain factors such as the development of a hypoxic water mass (Matsui, 2002), an increase of the muddy bottom area (Ito, 2004), and predation (Kawahara *et. al*. 2004) have been blamed for its decline. Despite intensive research, the mechanism for the decrease in the pen shell resources remains unclear. In previous studies, the gill activity of the pen shell related to the dissolved oxygen concentration (Yamamoto *et. al*. 1993) and the lethal level of dissolved oxygen (Akimoto *et. al*. 2004) were reported. However, the description of the pen shell activity under natural fishing ground conditions has yet to be produced.

The activity of bivalves has been also studied by measuring valve movement for mussels (Ameyaw-Akumfi 1987, Fujii and Toda 1991), scallops (Fujii and Sugiyama 1991), and short-neck clams (Fujii 1977, Fujii 1979). Most of these studies focused on the rhythmic activity of bivalves but Tyurin demonstrated that the valve movement of scallop and mussel can be a possible bio-monitor for unfavorable environments (Tyurin 1990). He reported that the frequency of valve movement was increased under low oxygen condition in Scallop. We found the valve movement of the pen shell also increases under hypoxic condition by laboratory experiment (Suzuki, unpublished data). Therefore, if the valve movement of the pen shell is monitored *in situ*, it is expected to contribute for understanding the mechanisms of the decrease of the pen shell. In

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the present study, the valve movements of the pen shells under natural conditions were measured and the resulting data revealed typical patterns which are discussed in relation to environmental conditions, as are the devices we developed.

Materials and Methods

The experiment was carried out at the west part of Ariake bay in Kyushu, Japan. One station was situated in the mud flat near Konagai, and the other in the subtidal area off Ohura (Fig. 1). The measurement period was from May 19 to June 30 in the mud flats and from August 24 to September 8 in the subtidal station in 2004, respectively. Pen shells were found to occur naturally in the vicinity of both experimental sites. The station in the mud flats emerged when the tide level went below 60cm in Takesaki. The expected tide level at Takesaki was available from the URL of the Japan Coast Guard. The depth at the subtidal station, meanwhile, was ca. 11m in mean low water level.

The pen shells used were collected from mud flats off Yanagawa about two weeks before the experiment. They were identified as *Atrina pectinata lisckeana*, based on the shell squamation (Yokogawa 1996). The shells were then kept in holding tank without being fed. Eight shells (138-190mm in SL) were used for the experiment. Shells were fitted with a sensor on one side of the valve and a magnet fitted on the opposite side by a plastic clip or cyanoacrylate instant glue. A hall element (THS130, Toshiba Semiconductor Co., Tokyo, Japan) and a magnet (Wilson *et. al*., 2002) was used as sensors for measuring the valve movement. The sensors were molded by Epoxy resin and were connected to

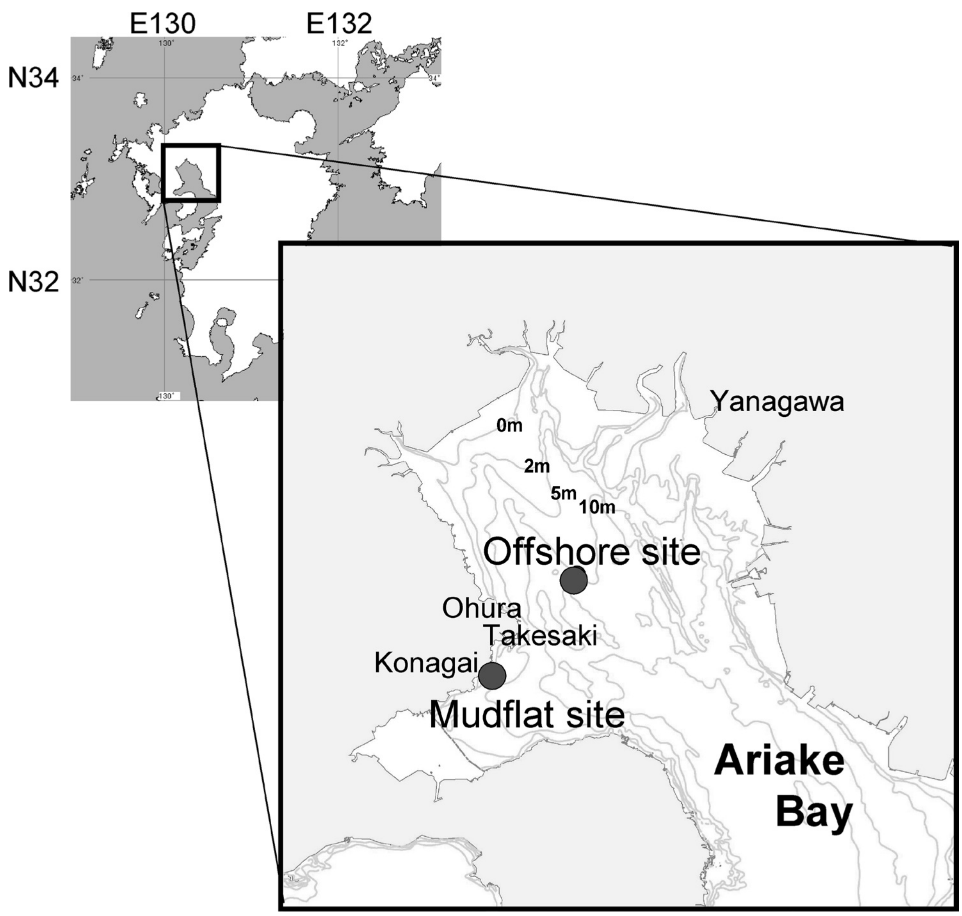

Fig. 1. The map of the study sites.

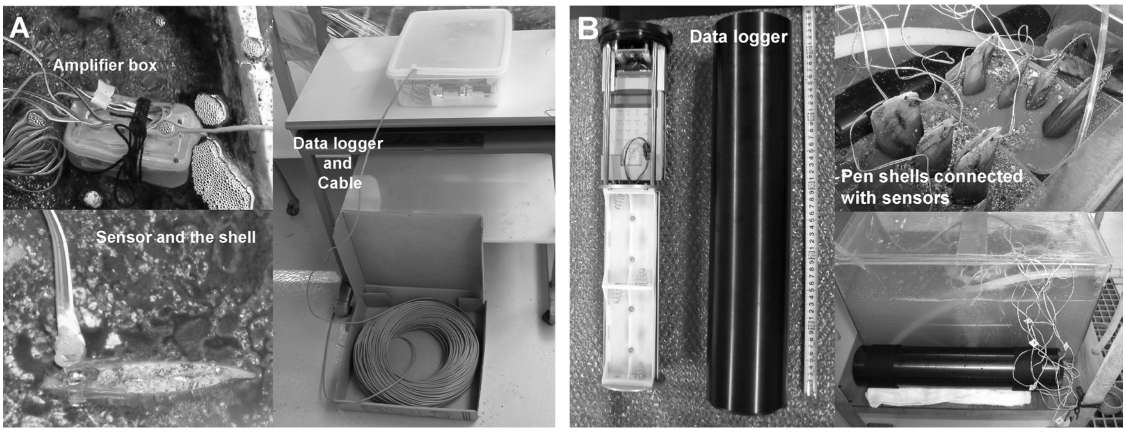

Fig. 2. The wire communication type data logger (A) and the under water type data logger (B).

the amplifier by 1m flat cables. The amplifier circuit, meanwhile, was built based on a gauss meter circuit (Shimada, 2003). When the shell closed their valves, the distance between the hall element and the magnet shortened, causing the output voltage of the hall element to rise.

Two types of data loggers were developed to measure the valve movement of the pen shell. One was of the wire communication type while the other was an underwater type (Fig. 2 (A), (B)). The wire communication type data logger was used for measuring in the mud flat while the underwater type was used in the subtidal station.

The amplifier circuit was molded by Epoxy resin to render it waterproof for the wire communication type. The signal from the amplifier circuit was transmitted to a data storage device using a multi wire cable. The data storage device (LAB-MIC 2A, ROHRM RIKEN. Co. Ltd, Shizuoka, Japan) used for the wire communication type data logger included 32 megabits of flash memory, with a recording period of about 10 days for two channels at intervals of 0.5 seconds.

The underwater model was assembled by Little Leonard Co. Ltd., Tokyo, Japan. The amplifier circuit and data storage device were built in a waterproof casing on the underwater type data logger. The casing was a cylindrical shape (10cm in diameter, 60cm in length) with 8 waterproof sockets used to connect the sensor cables. The data storage device (UL81, Unipulse Co., Tokyo, Japan) used for the underwater type data logger included 512 megabits of flash memory, with a recording period of about two weeks for 8 channels at one second intervals.

Results and Discussion

The measurements in the mud flats were carried out from May 19 to June 30. Unfortunately, the available data was recorded only for the first week because of the transfer cable being damaged by drift wood. The valve movement records of two individuals and the expected tide level at Takesaki are shown in Fig. 3. Two shells opened their valves for most of the recorded period. They also had frequent short term valve closures. The valve movement pattern showed both single and multiple close-open actions. The former is characterized by a close-open action occurring over an interval of more than a few minutes and the latter is characterized by a series of close-open actions repeated at intervals of less than 30 seconds. Our preliminary observation in the aquarium showed that the single close-open action occurred during the vomiting behavior to expel the sand from within the shell. This observation also showed that the multiple close-open action was apparent during burrowing behavior (Suzuki, unpublished data). The valve movement recorded in the mud flats demonstrated that the pen shells remained still, closing their valves during the emersion and they experienced burrowing behavior after they were submerged.

The measurements at the subtidal station were carried out from August 24 to September 8, with

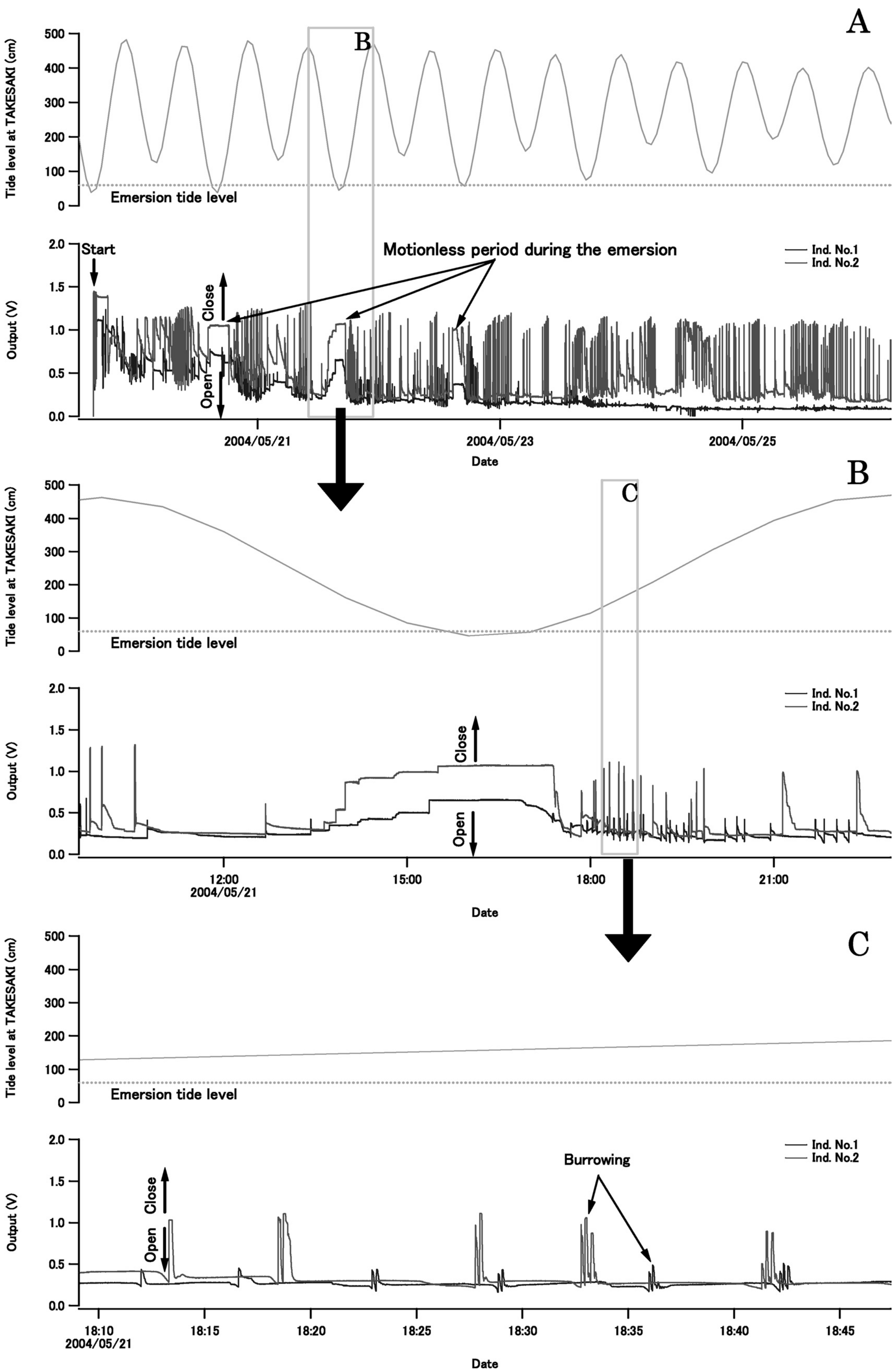

Fig. 3. (A) One week recordings obtained for valve movement of two pen shells on the mud flat. (B) Motionless period during the emersion and (C) multiple close-open action (burrowing) followed the motionless period.

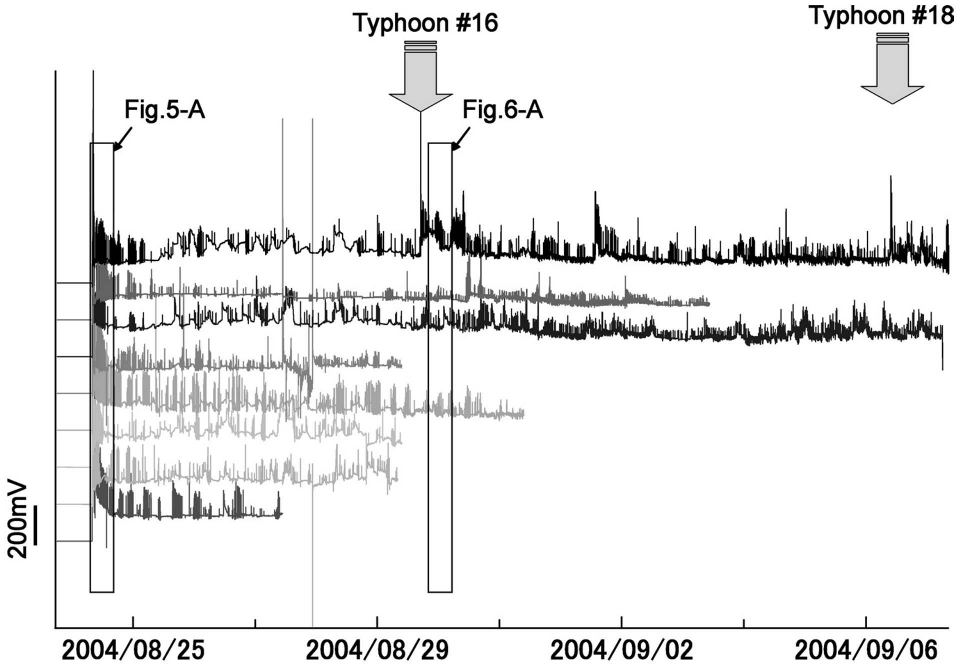

Fig. 4. The recordings obtained for valve movement of eight pen shells at subtidal station.

the records are shown in Fig. 4. Unfortunately there were two typhoons during this period and five shells were lost. Valve movement was most frequent just after the shells were transplanted and also frequently occurred following the encounter of the typhoon #16. By examining the details of the record, we found that the shells experienced multiple close-open actions just after being transplanted (Figs. 5A, B). So the pen shells are considered to have burrowed extensively after being transplanted to fix themselves in position. On the contrary, most of the valve movements during the encounter of the typhoon #16 were single close-open actions (Figs. 6A, B). This type of valve movement is similar to that of vomiting behavior, meaning these actions were thought to be a reaction of the pen shells to high turbidity or since they were covered with sand from heavy waves.

In the present study, the valve movement records assess the change in activity or behavior of the pen shells. This method could also be used to monitor the state of the pen shells within natural fishing grounds. To clarify the effects of environmental conditions such as oxygen deficient water on the pen shells, the activity of the pen shells and prevailing environmental conditions must be monitored at the same time. Further studies under laboratory condition are also required to understand the meanings and causes of change in the patterns of valve movement.

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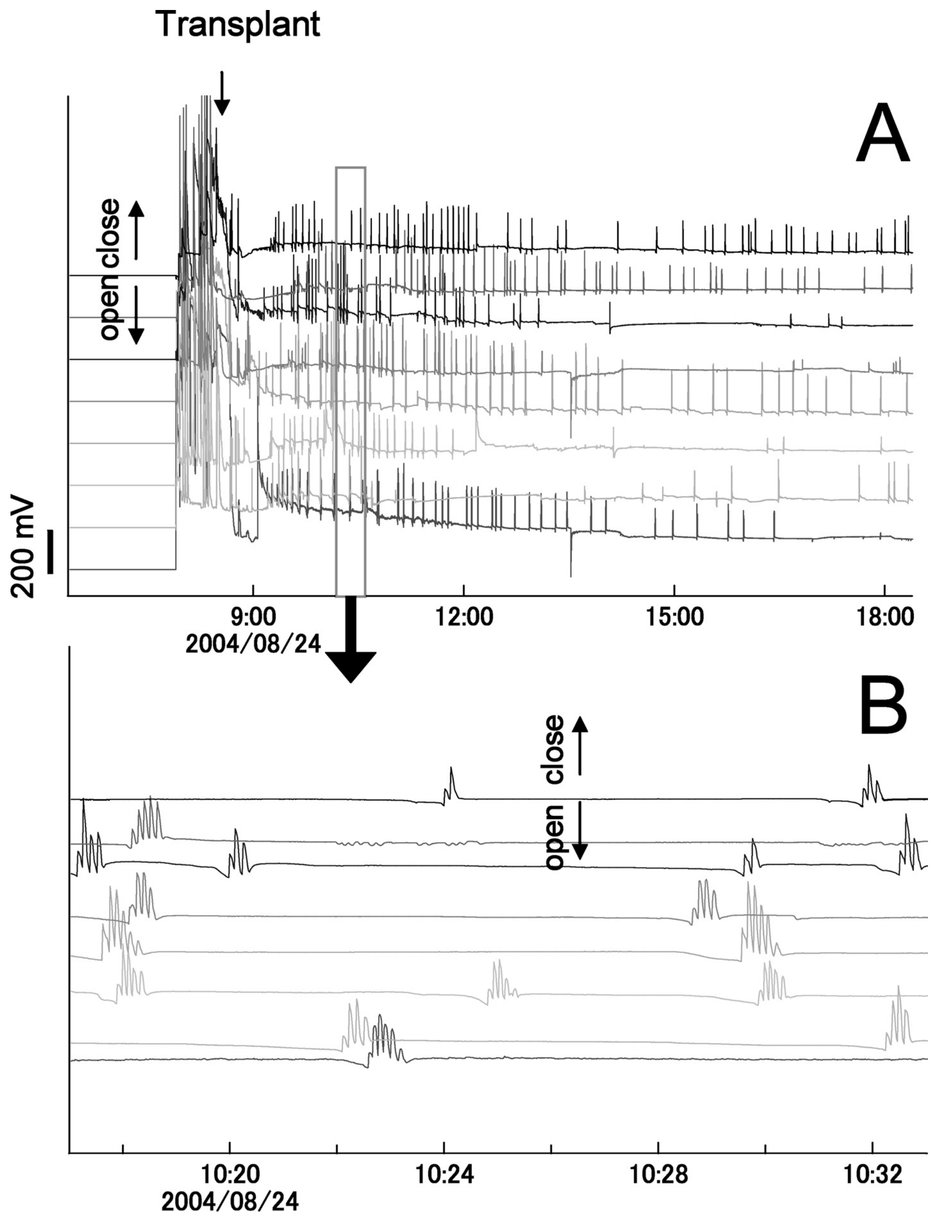

Fig. 5. (A) The recordings obtained for multiple close-open actions appeared just after pen shells were transplanted. (B) A 16-miutes portion of the record. Close-open actions were repeated within a minute.

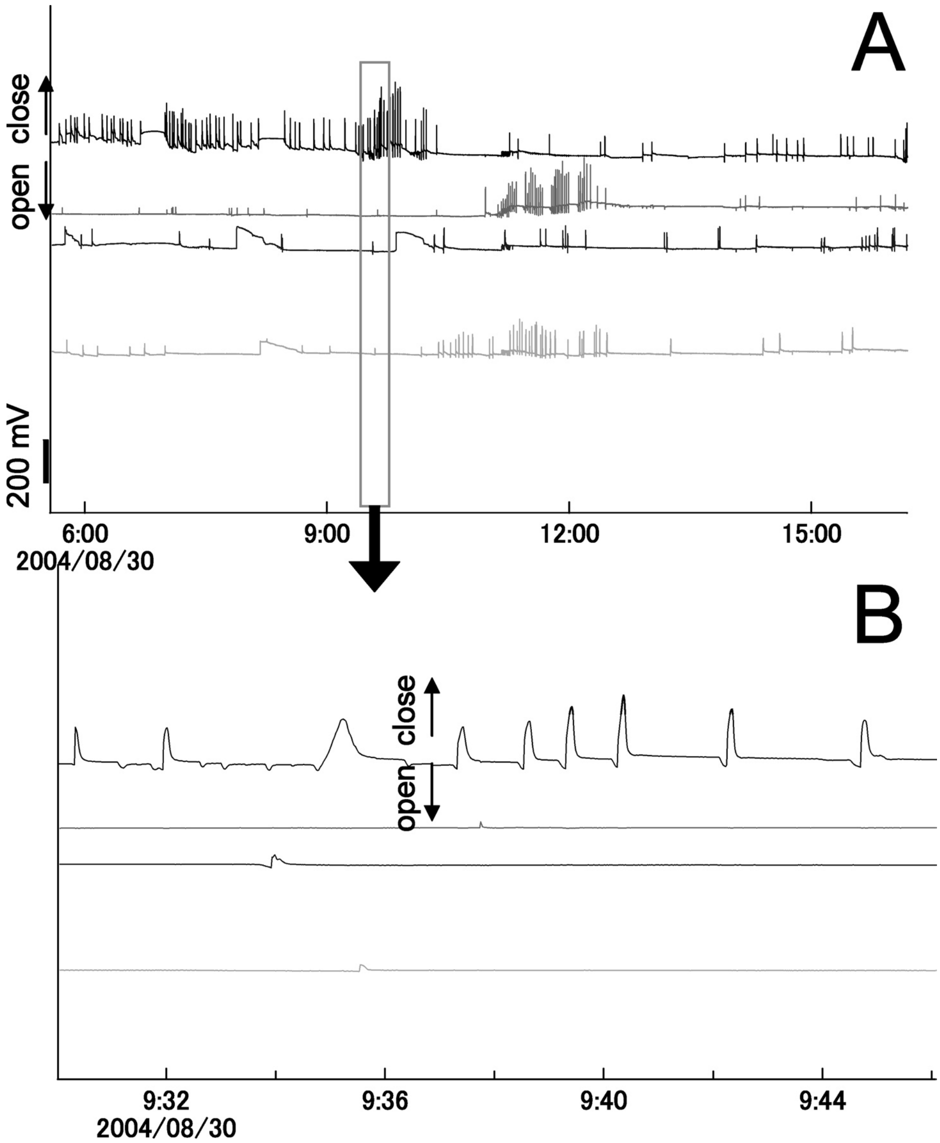

Fig. 6. (A) The recordings obtained for single close-open actions appeared during a storm. (B) A 16-miutes portion of the record. Close-open actions were repeated at least one or more minutes interval.

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和文要旨

環境変化がタイラギの活動に与える影響を把握するため殻体運動を測定する装置を開発し，小長井地先の干潟と大浦沖の潮下帯でタイラギの殻体運動を測定した。干潟上のタイラギは，干出時に殻を閉じて静止しており，潮が満ちると殻体運動が増加した。潮下帯の

タイラギでは移植直後の潜砂行動に伴う連続した殻体運動が記録され，その後殻体運動の頻度は減少したが，台風の接近以降に潜砂行動とは異なる単独の殻体運動が増加した。