AN OBSERVATION ON THE OPENING BIVALVE MOLLUSCS BY STARFISH, *ASTERIAS AMURENSIS*

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In a previous paper (1969) the writer reported that the highest value of electivity index of a same sized prey by the starfish differs specifically. The present paper deals with the feeding of the starfish on some bivalve molluscs in relation to the process of shell opening and its time duration.

Materials and Method

The kymographic method was used in this study. As shown in Fig. 1, a wooden plate (d) was set horizontally in an aquarium at a height of 15 cm and, as food for the starfish, a bivalve mollusc was firmly attached on the plate by one of its valve with a binder named Aron-alpha. The movement of the upper valve was recorded through a thread (c) fixed with Aron-alpha near its midventral margin (a). Lest the threads should be touched by the starfish, it was led down through a hole in the wooden plate to which the lower valve (b) of the bivalve mollusc adhered.

In the present study, the following five species of bivalve molluscs such as *Tapes japonica*, *Crassostrea gigas*, *Scapharca broughtonii*, *Mytilus edulis* and *Patinopecten yessoensis* were used as food for *Asterias amurensis*. All of them were

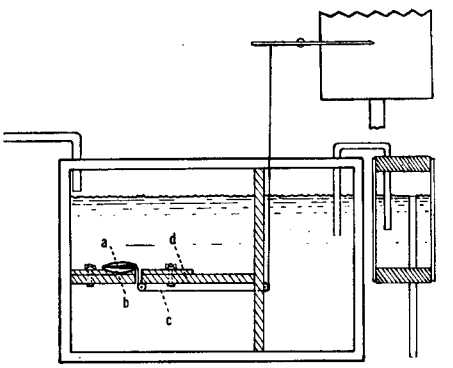

Fig. 1. Experimental apparatus for recording movements of bivalve shell during starfish attack (cf. text).

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of the optimum size in electivity index for the starfish, as known from the previous study. *Asterias amurensis* used here was about 53 mm in arm length. More than ten times the experiments were repeated and, because the duration of opening the bivalve by the starfish differed to some extent in each observation, it was necessary to mark down a time average.

Result and Consideration

The duration for the opening of the valve of each bivalve mollusc by the starfish was measured according to the movement of the valve as recorded by the kymograph. As shown in Table 1, the duration differs markedly according to the kinds of prey. For *Patinopecten yessoensis*, it was the shortest, it took 2 1/2 hrs. to open its shell, it took 3 1/2 hrs. for *Tapes japonica*, 5 hrs. for *Scapharca broughtonii*, 7 hrs. for *Crassostrea gigas*, and the case of *Mytilus edulis* it was the longest, about 8 hrs. However, the time requisite to open the shell of a bivalve seems to vary with the satiation degree of the starfish (cf. Tamura & Fuji, 1956). In this experiment a satiate starfish was used as predator. In the previous study (Kim, 1969) on the feeding of *Asterias amurensis* we can read a description of the degree of food preference of the starfish for several bivalve molluscs. In the present experiment, each duration for the opening of those bivalve molluscs by the starfish was closely related with that same degree of food preference. The order of its preference index on those food shell-fishes consists in the order of duration for the opening of the shells except in the case of *Patinopecten yessoensis*. These facts suggest that the food preference of *Asterias amurensis* on living bivalve molluscs has no relation with the substance or nature of the prey, but is affected by physiological and physical factors to open the shell. Tamura (1929) reported that the adductor muscle of a bivalve in shallow water has greater power than that living in deep water. The results of the present study indicate that bivalves living in shallow water need longer time to open their valves than those in deep sea except *Tapes japonica*, although it does not always agree with Tamura's report. From this fact, the duration for the opening of the valve by the starfish may be partly influenced

Table 1. The duration for the opening of the valve of each bivalve molluscs by the starfish

Species of shell-fishes	Time requisite to open shell (min)										Mean time (min)
	1	2	3	4	5	6	7	8	9	10	
Patinopecten yessoensis	180	195	225	120	165	135	140	100	150	110	154±11.7
Scapharca broughtonii	255	270	465	315	255	375	240	225	285	240	292±29.2
Crassostrea gigas	465	510	420	435	345	450	375	405	315	—	413±41.3
Tapes japonica	225	300	255	165	300	195	165	195	150	180	213±17.4
Mytilus edulis	660	625	615	555	525	510	420	500	465	405	528±27.3

the power of the adductor muscle of the molluscs.

Plate 1–A_1-C show the kymograph recording the process of the opening of the shells of five bivalve molluscs by the starfish. The movements of the valve of each species, according to the kymograph, may be divided into three types: Type A shows the movements of the valve, opening and closing, to be comparatively strong, as in the case of *Patinopecten yessoensis* and *Scapharca broughtonii* (Plate 1–A_1 & A_2); Type B shows slow and relatively weak successive movements of the *Tapes japonica* and *Crassostrea gigas* a short while after the starfish attacked (Plate 1–B_1 & B_2); Type C shows the closed valve of *Mytilus edulis*, its long resistance throughout the attacking time of the starfish and, in the end, its abruptly opening its valve (Plate 1–C). However, these three types proposed here appear to have no relations with the selective feeding on these preys by the starfish, but are due to the relationship produced between the predator and the prey on the occasion of the opening. Of all these processes of valve opening in the five bivalve molluscs, the most noteworthy feature is seen in the kymograph records of *Patinopecten yessoensis*. The kymograph records, in Plate 1–A_1, somewhat differ from those made by other bivalve molluscs; in *Patinopecten yessoensis* the movements are stronger and more frequent in succession and rougher and finer records are seen in the opening and closing of the valve. A strong movement of the valve in *Patinopecten yessoensis* occurs when the starfish attacks and then the starfish inserts its cardiac stomach between both valves. Then the starfish receives a strong physical impulse to its cardiac stomach by the movement of the valve, and sooner or later it leaves off *Patinopecten yessoensis*. These acts between starfish and *Patinopecten yessoensis* are repeated several times all the while, rough and fine features of the movements of the valve are recorded distinctly on the kymograph (cf. Plate 1–A_1 & A'_1).

In conclusion *Patinopecten yessoensis* is not an easy prey for the starfish. The fact that *Patinopecten yessoensis* has the lowest value in electivity index and preference among several bivalve molluscs when attacked by the starfish (Kim, 1969) seems to be caused by the ecological characteristics of this animal as described above.

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Summary

1. The duration requisite for the opening of several bivalve molluscs as food by *Asterias amurensis* and the process to open them were observed according to kymograph records.

2. The duration for the opening of each bivalve mollusc was ca. 2 1/2 hrs. for *Patinopecten yessoensis*, 3 1/2 hrs. for *Tapes japonica*, 5 hrs. for *Scapharca broughtonii*, 7 hrs. for *Crassostres gigas*, and 8 hrs. for *Mytilus edulis*.

3. The features recorded on the kymograph may be divided into the following three types; Type A: comparatively strong movements of the valve, opening and closing, as shown in *Patinopecten yessoensis* and *Scapharca broughtonii*. Type B: relatively slow and weak successive movements which were observed a short while after the starfish attacked as in *Tapes japonica* and *Crassostrea gigas*. Type C: valve closed for 8 hours throughout the starfish attacking as seen in *Mytilus edulis*.

4. Judging from the records of the kymograph, *Patinopecten yessoensis* is not an easy prey for the starfish.

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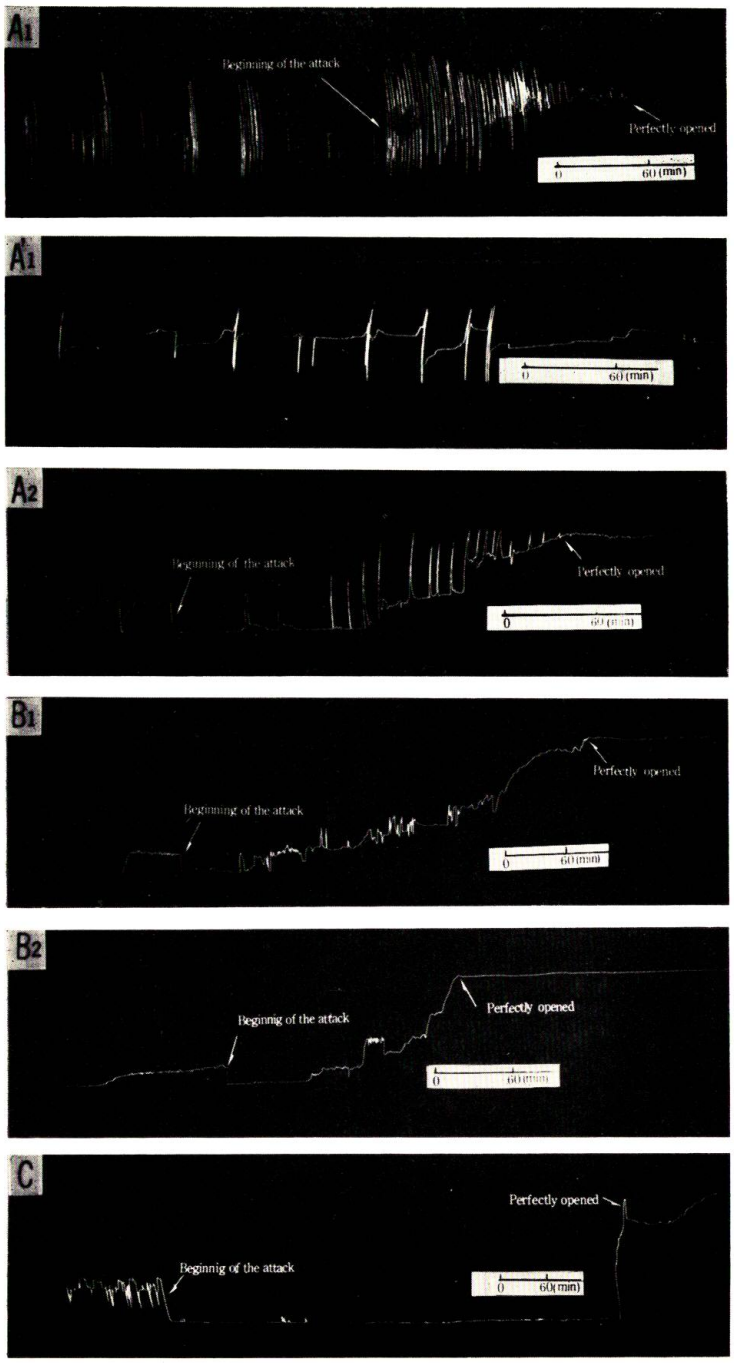
Explanation of plate I

Kymograph records of movements of bivalve shells during the period of starfish attacks.

A_1 : *Patinopecten yessoensis*
A'_1: *Patinopecten yessoensis* (under normal condition without starfish)
A_2 : *Scapharca broughtonii*
B_1 : *Crassostrea gigas*
B_2 : *Tapes japonica*
C : *Mytilus edulis*



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