Chemoreceptive Property in Feeding of the Prawn Penaeus japonicus

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Chemoreceptive Property in Feeding of the Prawn *Penaeus japonicus*

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Abstract

Chemoreception of the prawn *P. japonicus* was investigated using the eyestalk-ablated individuals in two experiments. For the examination of chemical stimulants involved in the searching behaviour, each solution of the amino acids, proteins and saccharides was dropwise added to water in a tank holding an individual. To identify the substance that stimulates the prawn during the process of ingestion, each of the amino acids, proteins and saccharides was mixed individually with curdlan to make pellets of uni-composition. As a result, the chemical property of the receptors associated with the searching showed a more selectivity to amino acids, especially arginine and glycine, than to saccharides. Reversely, for ingestive response, some protein such as casein and gelatine as well as saccharides, glucose and starch, were more stimulative than amino acids.

Feeding response at the first process of the feeding behaviour includes chemical recognitions such as the olfactory and taste receptions[1]. These functions are performed by the appendages of the cephalo-thorax, especially by the sensory setae present in the mouth-parts[2].

Properties of the chemoreceptors related to feeding have been studied ethologically in Natantia species, *Palaemonetes pugio*[3] and *Penaeus japonicus*[4], and in Reptantia species, *Homarus gammarus*[5], *Callinectes sapidus*[6], *Petrolisthes cinctipes*[7] and *Plagusia dentipes*[8]. Many of these studies deal with the chemical sensitivity of the materials to amino acids, saccharides and raw extract which exist commonly in food.

To understand the chemoreceptive property of the prawn *P. japonicus*, its chemical responses in feeding have been studied. Eyestalk-ablated individuals were used because their feeding behaviour appeared at the day-time after the operation. This phenomenon has been already reported in the spiny lobster *Panulirus argus* during the evaluation of the threshold for the 1st antenna after eyestalk-ablation[9-12]. Therefore, it is necessary to take into account the effect of the eyestalk-ablation on the threshold in the discussion of results.

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Material and Methods

The prawn *Penaeus japonicus* weighing about 10 g were used in the present experiments.

After eyestalk-ablation by compression with hot tweezers, the individuals were separately placed in a cubic container, 5 *l* in volume, and subjected to the following experiments.

The 1st experiment was done to clarify a chemical property of the prawn's receptor involved in the searching behaviour. Occurrence of the searching reaction for solutions, which were dropwise added, of five different concentrations of amino acids, proteins and saccharides, was investigated. Final concentrations of each substance in the container were 2×10^{-4}, 2×10^{-5}, 2×10^{-6}, 2×10^{-8} and 2×10^{-10} mol/*l*. The minimum concentration of each substance that gave a positive response was determined as the threshold value. For each concentration, six trials were undertaken. For each trial, a new individual was usually used. However, for same concentrations of the substances, the solutions were sometimes added successively after short intervals using the same prawn, until it exhibited a positive response. As for proteins and polysaccharides, 0.5% solutions were only prepared as original solutions because of their unidentified molecular weight. The solvent was sea water, and the solution was non-adjusted for pH.

The 2nd experiment was carried out for the ingestion reaction following the searching behaviour. Each of the amino acids, proteins and saccharides was prepared with β-1, 3-glucan[13], curdlan (Wako P. C. I., code No. 032-09902), for the pellet of uni-composition. Then, after about 0.2 mmol of each substance was mixed with 0.1 g curdlan and 2 m*l* of sea water, the mixture was coagulated in hot water. The substance of unidentified molecular weight was mixed to obtain the pellet containing 2.5% of the matter. Blank test was treated with the pellet containing curdlan only. The number of trials was different for each substance, ranging from six to fifteen times. For each trial of the substances, the same prawn was used until it reacted positively. The repeated trials were undertaken using different individuals.

During the experiments, water temperature was 19.5—22.3℃.

Results and Discussion

The 1st Experiment

The substances examined were presented with their results in Fig. 1. Two amino acids, arginine and glycine, gave an extremely strong stimulus to the prawn. It seems that their ethological threshold may be 2×10^{-10} mol/*l* or lower than this value, and correspond nearly to that value for taurine or glutamic acid resulted previously from the response ratio of individuals among a population in crabs[14]. It is on electrophysiological record that glutamic acid, glutamine and taurine have been strong stimulants for the 1st antenna or dactylopodite of pereiopod in crabs and lobsters[15-18]. Glycine has been reported to be less stimulative than other amino acids or to be non-stimulant in lobster[19]. For the prawn *P. japonicus*, the

feeding rate increased after addition of glycine to the diet[20]. It is considered that the chemical sensitivity to amino acids is different among decapod species, and each species has the proper receptor for specific amino acids. Furthermore, eyestalk-ablation does not seem to affect distinctly the chemical sensitivity of the prawn *P. japonicus*, unlike in species previously reported[9-12].

For proteins, the positive response is achieved only by bovine albumin (Fig. 1). It has been reported that peptides and albumin are very weak stimuli for the porcelain crab[7].

For sugars, cellobiose and galactose showed to be a high stimulant (Fig. 1). Their ethological thresholds were determined to be 2×10^{-8} or 2×10^{-9} mol/*l*. These values indicate, at least, 10 times lower sensitivity, comparing with amino acids such as arginine and glycine. In the hermit crab, trehalose and glucose have a comparatively high stimulating effect and their ethological threshold has been recognized as higher than amino

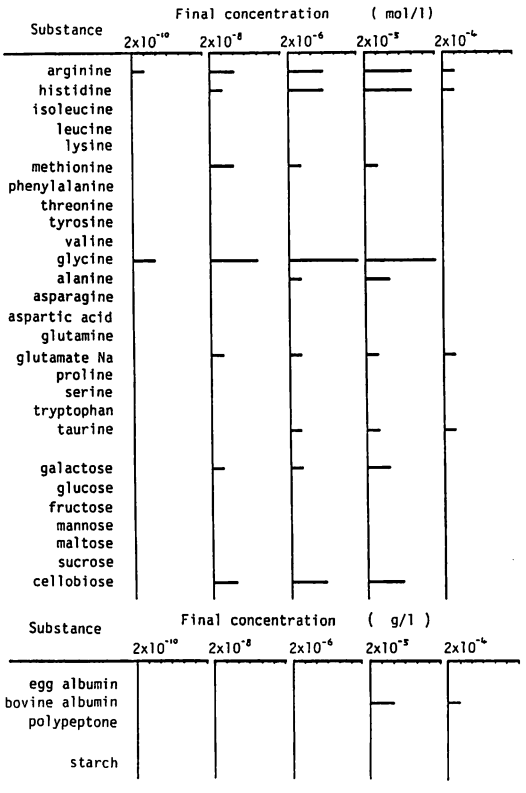

Fig. 1. Searching response of the eyestalk-ablated prawn to each solution dropwise added. The horizontal lines corresponding to each substance indicate the number of positive reactions to six trials at respective concentrations.

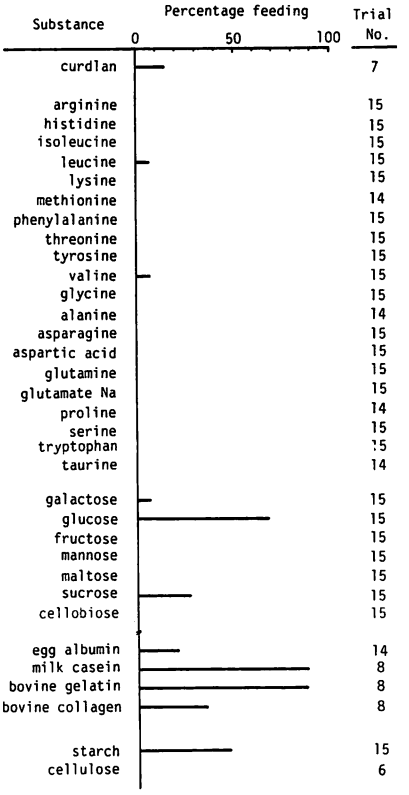

Fig. 2. Ingesting response of the eyestalk-ablated prawn to each pellet of uni-composition of the substance. The percentage feeding means the percentage of the positive reaction to total trials.

acids by 100-1000 times[7]. But galactose was a weak stimulant. Cellobiose was not referred to in that report. In the prawn *P. japonicus*, differing from the hermit crab, sugars showed to be generally a weaker stimuli than amino acids.

As a result, the chemical property of the receptor seems to be specialized for the detection of amino acids such as arginine and glycine during the searching procedure of the prawn *P. japonicus*.

The 2nd Experiment

Amino acids were either extremely weak or non-stimulant for ingestion (Fig. 2). For proteins, a very high value of the percentage feeding was recognized at 87.5%, especially in both milk casein and bovine gelatin. The percentage feeding means the number of positive responses to 100 trials.

For saccharides, glucose and starch showed high percentage feedings at 66.7% and 46.7%, respectively. The value for sucrose was lower than the two.

Considering these results, the prawn seems to prefer proteins and saccharides to amino acids during the process of ingestion. Among saccharides, glucose indicates to be a strong stimulus for the intake reaction of food. As for this tendency of chemoreception, it has been affirmatively reported previously in the crab *Uca pugilator*[21] that saccharides become more effective stimulants than amino acids at its ingestion.

Based on the above mentioned results, it is proposed that in the feeding behaviour of the prawn *P. japonicus* a chemical stimulus from specific amino acids such as arginine and glycine elevates the searching behaviour. Then, in successive process of ingestion, the detection of proteins and saccharides preferred by the prawn brings about an active intake of food. However, it needs another experiments with non-eyestalk-ablated prawns to prove this proposition.

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