Peak rate of H^+ secretion from oxyntic gland pouch in response to irrigation of antral pouch with solutions of amino acids

Solution in antral pouch	No. of tests	Peak H^+ response (μequiv/min)	
		Mean	Standard error
none	27	3.6	0.3
0.15 *M* NaCl	21	3.9	0.2
0.4 *M* L-serine	6	19.6	1.6
0.4 *M* D-serine	6	17.0	1.4
1.0 *M* L-alanine	6	18.5	1.7
1.0 *M* D-alanine	6	22.2	1.9
0.4 *M* glycine	6	19.1	1.6

Both pouches drained to the exterior through cannulas of the type described by GREGORY[3]. After an 18 h fast juice was collected continuously from the oxyntic gland pouch and divided into 15 min samples which were titrated with 0.2 *M* NaOH to pH 7.0 by glass electrode. Volume of test solution introduced into the antral pouch was in all instances 8 ml, found in preliminary studies to be the largest volume that did not release gastrin by distention. Contractions of the pouch moved the solution back and forth between the pouch and a reservoir connected to the cannula by a rubber tube[4]. The pH of the solutions introduced into the antral pouches was in all instances 7.0 and the pH of the solutions recovered was always greater than 6.0. The concentrations of amino acids used are those found in preliminary studies to give the highest response, that is, doubling the concentration gave no higher response. Test solutions were left in the pouch for 90 min. Peak response is taken as the highest rate of H^+ secretion during any 1 of the 6 15-min collection periods. Peaks occurred at 45 to 90 min. An equal number of tests were done in each of 3 dogs. The order of testing the various substances was randomized. As an index of the secretory capacity of these pouches, the mean maximal response to 8 μg/kg/h of pentagastrin was 134 μequiv/min.

acids as gastrin releasers. In the present study, for both serine and alanine the response to the D-isomer was not significantly different from that of the L-isomer (Table). Most biological systems distinguish between D- and L-isomers of amino acids. On of the few exceptions is the so-called sarcosine carrier[5] involved in intestinal transport of neutral amino acids; it shows equal affinity for D- and L-isomers. It is of great interest that of the amino acids tested in both systems those amino acids that show high affinity for the sarcosine carrier[6] are also effective releasers of gastrin[2]; this includes the 3 amino acids used in the present study[7].

Zusammenfassung. D- und L-Isomere von Alanin und Serin sind beide wirksam, von der Antrumschleimhaut aus den Gastrinmechanismus zu aktivieren.

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Evoked Activity in the Nervous System of *Callinectes sapidus* Following Phasic Excitation of the Statocysts

The role of the crustacean statocyst in determining body orientation with respect to gravity has been clearly established (KREIDL[1], SCHÖNE[2,3], and DIJKGRAAF[4,5]). The work of COHEN[6–8] suggests that the tonic output of certain primary afferent fibers coming from statolith hair receptors inside the statocyst is responsible for the attitudes assumed by the appendages as an animal is rotated about one of its axes.

Of what importance then are the thread hair receptors found in decapod statocysts? Do they also play a role in orientation? It is known that they do not come in contact with the statolith and are, therefore, not directly affected by gravity.

The present study was undertaken in an attempt to clarify some aspects of the functional role of thread hair receptors in decapods. Toward this end first-order and high-order units sensitive to phasic excitation of the statocysts were investigated in the swimming crab, *Callinectes sapidus*. Brief postural changes which accompany phasic excitation of the statocysts are described.

Materials and methods. Statocysts were exposed by cutting away portions of the surrounding exoskeleton. A probe attached to a micromanipulator was used to rotate either statocyst through a fixed 3° arc in the vertical plane. Basal segments containing the statocysts are hinged in *Callinectes* permitting vertical rotation. Impulses were recorded from nerves leaving the statocysts and cerebral ganglion with the aid of a preamplifier and displayed on one channel of an oscilloscope. The duration of the rotary stimulus was monitored on a second channel. Phasic evoked activity was photographed as a standing spot using a Kymograph camera.

Results. Evoked activity in first-order units from the statocysts. In *Callinectes* the central branches of the antennulary nerve innervate the statocysts. Spontaneous activity in these branches is restricted to afferent impulses from receptors inside the statocysts. Phasic rotation of a statocyst typically evoked responses like those shown in Figure 1A and B. Many afferent units were found which responded with a brief burst of repetitive activity to phasic excitation of a single statocyst. Figure 1B indicates that first-order units responding to rotation of a statocyst in one direction do not respond to rotation in the opposite direction. Destruction of bipolar sensory neurons projecting to thread hairs inside the statocyst abolished phasic evoked activity.

Evoked activity in high-order units originating in the central nervous system. High-order units which respond to

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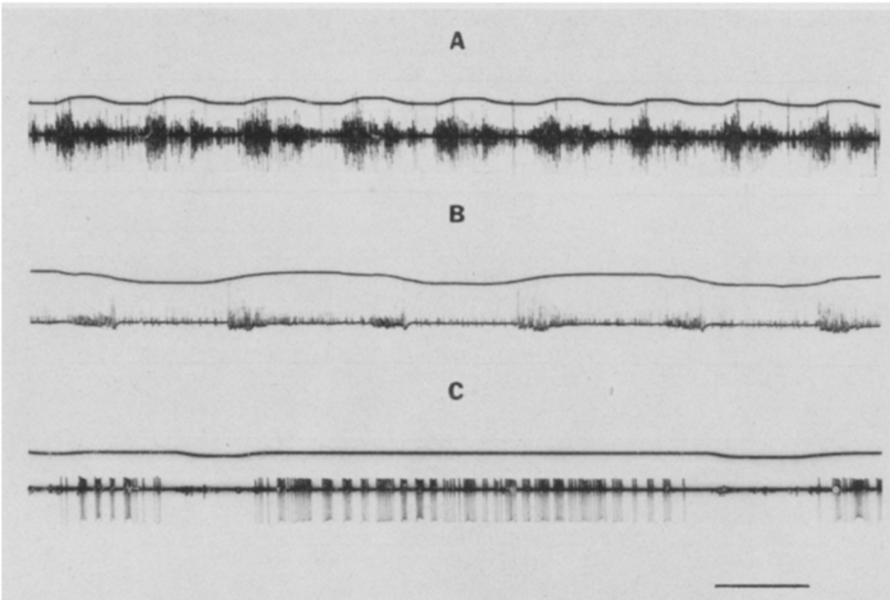

Fig. 1. A) Evoked activity in one of the central branches of the antennulary nerve. B) Evoked activity in a small bundle of first-order units from the statocyst. Several units shown are sensitive to rotation of the statocyst in one direction only. C) Time mark: 0.5 sec. Note: In A), B) and C) an upward deflection of the upper trace connotes dorsal rotation of the statocyst.

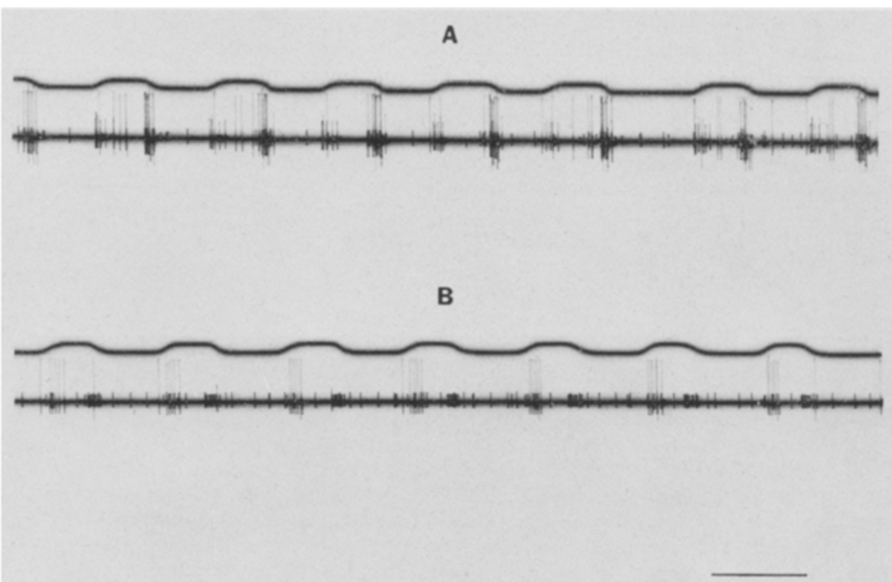

Fig. 2. A) Evoked activity in one of the circumesophageal connectives in response to rotation of the homolateral statocyst. B) Evoked activity in one of the connectives in response to rotation of the heterolateral statocyst. Time mark: 0.5 sec. Note: In both, A) and B), an upward deflection of the upper trace connotes dorsal rotation of the statocyst.

phasic excitation of the statocysts were found in all nerves leaving the cerebral ganglion with the exception of the tegmentary nerve. Efferent ganglionic nerves in which phasic units were consistently found include the circumesophageal connectives, optic, oculomotor, antennal and antennulary nerves.

Several repetitive high-order units were found in the circumesophageal connectives. One unit responded with a brief burst of activity to ventral rotation of the homolateral statocyst (Figure 2A). Other units in the connectives responded to rotation of the heterolateral statocyst (Figure 2B). Repetitive units were also identified in the lateral branch of the antennulary nerve (Figure 3) which innervates the muscles of the hinged portion of the basal antennulary segment. Evoked activity in efferent ganglionic nerves was abolished following destruction of the sensory neurons innervating the thread hairs.

Phasic leg movements accompanying rotation of a single statocyst. Frequently, dorsal rotation of a single statocyst resulted in brief but discrete phasic movements of the walking legs. These movements were characterized by a slight flexion of the first 4 pairs of walking legs toward the midline together with a more pronounced movement of the broadly flattened 5th pair of legs caudally. In general, leg movements on the side opposite the statocyst being rotated were more pronounced, with the greatest amount of movement occurring in the 5th leg. After a burst of activity, legs passively returned to their initial position. Recordings from peripherally sectioned leg nerves revealed units sensitive to dorsal rotation of the heterolateral statocyst (Figure 4).

Discussion. The findings presented suggest that thread hair receptors in the statocysts of decapods may play a role in the positioning of appendages during rapid rotational movements of the animal. This statement would seem especially true with regard to the more active decapods such as *Callinectes*. The results presented here indicate that movements sufficiently great to cause

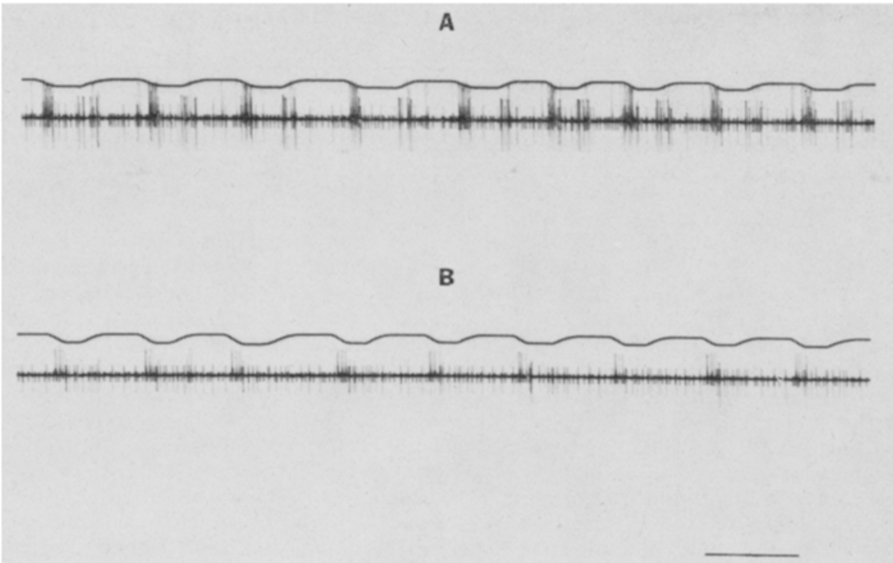

Fig. 3. A) Evoked activity in the lateral component of the antennulary in response to rotation of the homolateral statocyst. B) Evoked activity in the lateral component of the antennulary nerve in response to rotation of the heterolateral statocyst. Time mark: 0.5 sec. Note: In both, A) and B), downward deflection of the upper trace connotes dorsal rotation of the statocyst.

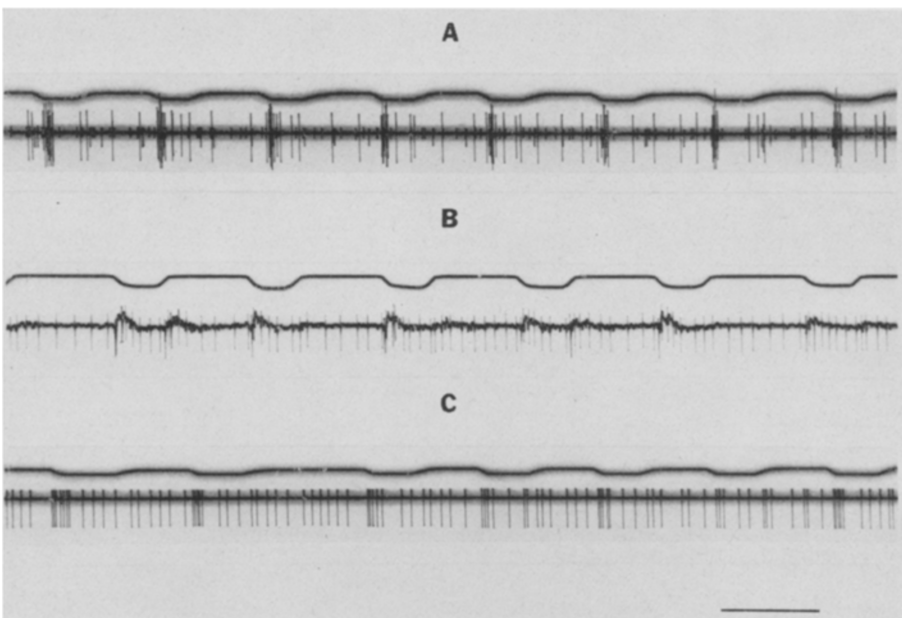

Fig. 4. A) Evoked activity in the proximal portion of a 5th leg nerve in response to rotation of the heterolateral statocyst. B) Evoked activity in the distal portion of a 5th leg nerve in response to rotation of the heterolateral statocyst. C) Change in the frequency of firing of one unit in the proximal portion of a 4th leg nerve during rotation of the heterolateral statocyst. Time mark: 0.5 sec. Note: In A), B) and C) downward deflection of the upper trace connotes dorsal rotation of the statocyst.

displacement of the thread hairs in the statocysts elicit bursts of activity in large numbers of high-order units in the central nervous system.

The fact that displacement of a single statocyst yields brief but coordinated movements of the walking legs suggests that thread hair receptors continually influence the positions of these appendages. Although movements were only observed in the walking legs, numerous units in nerves leading to other appendages were activated by phasic rotation of one statocyst. It is therefore possible that the thread hairs play an important role in determining the attitudes assumed by these appendages as well.

In support of this, WIERSMA[9], in describing phasic optomotor fibers in *Carcinus maenas* which respond to unidirectional rotation of the animal, suggests that the primary input to these fibers may be from the thread hair receptors in the statocysts. He states that these unidirectional optomotor fibers are not found in the crayfish or rock lobster, their absence explained by the fact that these forms do not rotate their bodies as rapidly as do crabs. It seems likely then that in active decapods, continual phasic adjustment of appendage position during rapid movement is made possible by the output of thread hair receptors in the statocysts.

Zusammenfassung. Experimenteller Nachweis bei der Schwimmkrabbe *Callinectes sapidus*, dass kurzes Rotieren über die Statocysten im Gehirn und im Nerven Potentiale evoziert, die für die Beinstellung von Bedeutung sind.

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