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SHORT COMMUNICATION

INTERNEURONES SENSITIVE TO WATER VIBRATIONS IN THE SECOND ABDOMINAL GANGLION OF THE CRAYFISH

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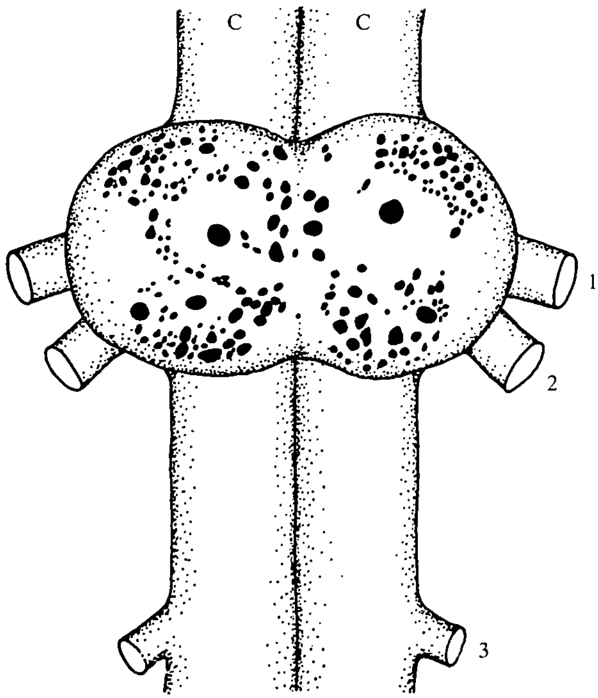
The body and appendages of crayfish are covered with mechanoreceptive sensory hairs which are highly sensitive to slight water movements (e.g. Wiese, 1976; Tautz & Sandeman, 1980). The central processing of this sensory input has been studied primarily in the abdominal ganglia and especially in the last (sixth) ganglion which innervates the tailfan of the crayfish (Wine, 1984). Plummer, Tautz & Wine (1986) describe the frequency selectivity of three types of mechanosensory interneurones in the sixth ganglion. The work presented here was undertaken to find out if these classes are represented in other abdominal ganglia as well.

The first five abdominal ganglia resemble each other much more than the sixth abdominal ganglion. Unlike the sixth ganglion they have only three pairs of nerves (roots) and also contain interneurones that project both anteriorly and posteriorly. The present investigation deals with interneurones originating in the second ganglion with axons projecting rostrally, a situation that resembles the case for all projecting interneurones in the last ganglion.

The experiments were performed on 20 animals of both sexes of the freshwater crayfish species *Orconectes limosus* ranging in length from 7 to 8 cm. In isolated abdomens the ventral surface of the connectives between the first and the second ganglia was exposed. The connectives were desheathed and the interneurone axons were penetrated, with glass microelectrodes, just anterior to the second ganglion in the hemiconnective ipsilateral to the stimulus. The preparation was totally submerged, ventral side up, in van Harrevelt saline and rested on long needles such that the dorsal cuticle with its sensory hairs was pointed downwards but was otherwise unrestrained. Water vibrations were produced by a sphere (diameter 1 cm) connected *via* a lever system to a vibrator. The sphere was directed towards the preparation at 45° from posterior and its movement was measured optically. Using the well-known formula for the near-field attenuation produced by a vibrating sphere (Markl, 1973), the water vibration intensity at the site of the preparation was

Key words: mechanosensory interneurones, water vibration, crayfish abdomen.

Anterior



Posterior

Fig. 1. Second abdominal ganglion with side nerves (1, 2, 3) and distribution of neurone somata revealed by toluidine blue staining. C, connective.

calculated for the edge of the abdomen next to the vibrator, resulting in a possible underestimation of the sensitivity of the interneurone by approx. 100%. The preparation was mounted in the centre of a cylindrical tank (diameter 35 cm). The vibrating sphere had a maximal distance of 1 cm from the preparation so that reflections from the walls of the tank were negligible. For technical reasons the range of tested water-vibration frequencies was limited to 10–80 Hz. In order to reveal the morphology of the interneurones which were penetrated, they were filled with 3% $CoCl_2$ solution and subsequently developed, fixed and intensified.

As in the other abdominal ganglia, the somata of the second ganglion are concentrated in clusters on the ventral part of the ganglion (Fig. 1). The somata of 30–40 pairs of interneurones that project only anteriorly were found in this ganglion by $CoCl_2$-backfills of the connective. These somata are typically positioned contralateral to the axons in the connective. The dendrites of the filled cells branch over a rather limited area and cross the midline to the soma side only to a very small degree (Fig. 2).

We found 11 interneurones of the kind we were searching for. Most of them showed a slow rate of irregular spontaneous activity (2–10 Hz). If stimulated by water vibrations, the interneurones responded to the stimulus with increased activity. The threshold curves determined for all cells reported here (Fig. 3) can easily be grouped into two types. The first kind (Fig. 3A) have high thresholds for water vibration at low stimulus frequencies with a steep drop of the threshold curve followed by a rather constant level towards higher frequencies. Neurones of the second kind (Fig. 3B) are equally sensitive over the whole frequency range tested. The spectral threshold curves of these cells resembled those found by Plummer *et al.* (1986) in the sixth abdominal ganglion in shape and absolute sensitivity. Plummer *et al.* (1986) described them as high-pass and broad-band neurones, based upon the filtering properties seen in their threshold curves. A third type of water-vibration-sensitive interneurone known from the sixth ganglion, the low-pass interneurone (Plummer *et al.* 1986), was not found in the second abdominal ganglion.

If the interneurones are grouped according to the properties of frequency response and soma position (Table 1), four different types can be distinguished. However, within one group it is not possible to differentiate any further on the basis of the data

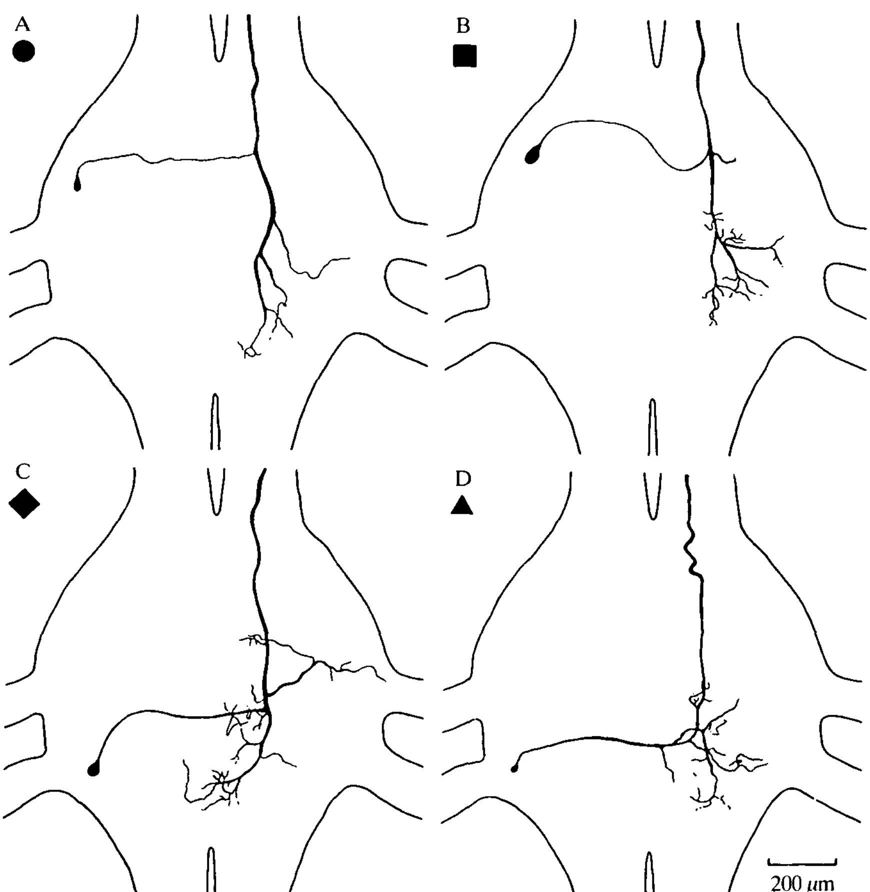


Fig. 2. Morphology of two broad-band interneurones (A,B) and two high-pass interneurones (C,D) in the second abdominal ganglion. Symbols beneath the letters correspond to those in Table 1.

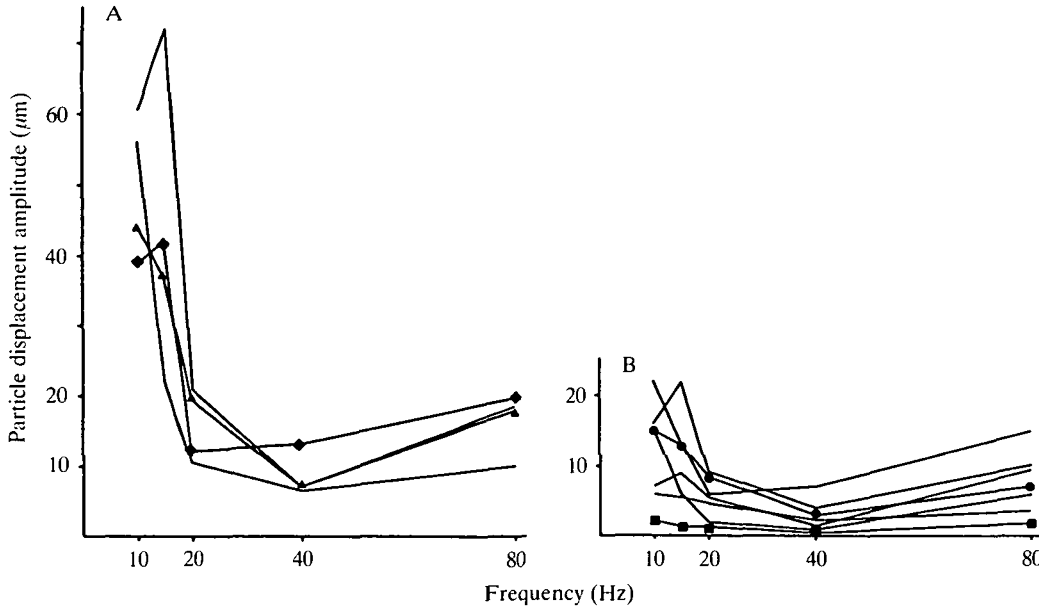


Fig. 3. Threshold curves for four high-pass interneurones (A) and seven broad-band interneurones (B). Particle displacement amplitude (μm) plotted against stimulus frequency (Hz). The symbols correspond to those in Fig. 2 and Table 1.

Table 1. *Four types of mechanosensory interneurones distinguished on the basis of frequency response and soma position in the second abdominal ganglion*

Type	*N*	Frequency response	Soma position	Symbol
1	7	BB	A	● ■
2	1	BB	P	
3	1	HP	A	
4	2	HP	P	◆ ▲

BB, broad band; HP, high pass; A, anterior; P, posterior; *N*, number of neurones. The symbols correspond to those in Figs 2, 3.

presented. Fig. 2 shows two pairs of individual cells selected from two of the groups shown in Table 1.

Of the three types of frequency-selective mechanosensory interneurones described by Plummer *et al.* (1986) for the sixth abdominal ganglion, we have found two in the second ganglion. However, it is likely that these cells may respond completely differently from those in the sixth ganglion to other water movement parameters (e.g. directionality, intensity, time course of stimulus).

It is not known whether crayfish can use the potential ability to distinguish between different frequency ranges. The water bug, *Notonecta*, discriminates prey from non-prey on the basis of the frequency contents of the water vibrations produced by members of these two groups (Lang, 1980). Crayfish may use the ability discussed here in the same context.

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