SYNAPTIC TRANSMISSION IN THE 7TH ABDOMINAL GANGLION OF THE SCORPION. HETEROMETRUS FULVIPES (C. KOCH)

K. YELLAMMA, K. SUBHASHINI. P. MURALI MOHAN AND K. SASIRA BABU

Department of Zoology,
Sri Venkateswara University, Tirupati – 517 502

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Summary: Electrical recordings made from the peripheral nerves of the 7th abdominal ganglion in the scorpion, H. fulvipes showed pronounced activity on ipsilateral stimulation of the connective and minimum activity on the contralateral side. Measurement of conduction velocities and synaptic delays indicated that ipsilateral pathways are probably monosynaptic and excitatory, while contralateral pathways might be polysynaptic and inhibitory. The nature of transmission has been suggested to be chemical.

Key words: Heterometrus fulvipes 7th abdominal ganglion monosynaptic pathways chemical transmission
ipsilateral, contralateral polysynaptic pathways

INTRODUCTION

Investigations on the nature of synaptic pathways in the central nervous system have been quite extensive in several crustaceans and insects (4, 3, 7, 6, 5). Information on the organization of the nervous system in arachnids is relatively sparse, with the exception of the studies of Babu (1) on the microanatomy of certain arachnids, and of Venkatachari (10) on the synaptic pathways in the nerve cord of the scorpion. The present study is an attempt to elucidate the general features of the possible synaptic junctions involved in transmission across the 7th abdominal ganglion of the scorpion H. fulvipes.

MATERIAL AND METHODS

Adult scorpions were used for the investigations. The animals were dissected out to expose the 7th abdominal ganglion with all its peripheral nerves intact. Recordings were made from all the peripheral nerves while stimulating the connective both ipsilaterally and contralaterally (Fig. 1) by means of paired platinum electrodes. Some length of
Anatomical organization of the motor neurons of the 5th (5N), telsonic (TeN) and 4th (4N) nerves of the 7th abdominal ganglion (7Gn.). Note the ipsilateral nature of the dendrites (Dn) of 5N and TeN motor neuron and their bilateral nature in the 4N motor neuron. 5N and TeN proceed to innervate the stinger muscles (StM) and telson (Te) respectively, while 4N innervates the 4th segmental muscles (4SeM). 3 Se, 4 Se & 5 Se – 3rd, 4th and 5th metasomatic segments; 1p Stim & Co Stim – Sites of ipsi & contralateral stimulation from the connective (Con); Re1, Re2 & Re3 – Sites of recording from 5N, TeN and 4N respectively; Th – Through fibre; Ter – Axonic terminations from the connective; CB – Cell body; Ax – Axon; Dn – Dendrites.
the connective and peripheral nerves was involved (varying from 0.8 mm to 12 mm for different nerves) while measuring the conduction velocities. The velocity of the conduction was hence calculated using the formula \( V = \frac{D}{T} \) where \( V \) is the velocity, \( D \) is the conduction distance between the stimulating and recording electrodes and \( T \) is the conduction time. For the measurement of synaptic delays the stimulating and recording electrodes were placed at the anterior and posterior ends of the ganglion involving no distance between the connective and the nerve in question except the ganglion itself. In this case the conduction time itself was taken as the synaptic delay. A Grass S44 stimulator was used to deliver square-wave pulses and the action potentials were fed through a Grass P5 amplifier and displayed on a Tektronix 502A oscilloscope and photographed with a Grass C4R kymograph camera.

**RESULTS AND DISCUSSION**

Ipsilateral stimulation of the connective elicited a burst of activity with several peaks of large action potentials in all the peripheral nerves studied (Fig. 2A, C, E), elicited at different thresholds ranging from 2.2V to 2.6V, with conduction velocities ranging from 1 to 7 m/s. The synaptic delays varied between 0.5 and 1.2 m/s. The spikes were characterized by steep and distinct ascending and descending phases, resembling unit action potentials. However, with critical alterations in the stimulus strength quantal jumps in the spike were observed, revealing the compound nature of these action potentials. The general features of this activity bear several resemblances to that recorded from the central nervous system of several arthropods (7, 5).

The conduction velocities of the fastest spikes in all the peripheral nerves were found to be 5-7 m/s and were comparable to the conduction velocities of the giant fibres or with the through-conducting large fibres of other invertebrates (2). The activity also included small potentials with lower conduction velocities (1-2 m/s), elicited at higher thresholds (4V), probably by slow and non-giant fibres (7). In contrast to this, a different pattern of activity was recorded in the 5th (Fig. 2B) and telsonic (Fig. 2D) nerves to contralateral stimulation of the connective, where the response consisted of only a couple of very small and highly labile action potentials with conduction velocities of 1 to 1.5 m/s elicited at thresholds between 3.0V and 5.0V. The synaptic delays varied between 4 and 4.4 msec. Similar cases with pronounced activity on the ipsilateral side and lower activity on the contralateral side in several arthropods (8) lend support to the findings in the present study.
Fig. 2: Electrical activity recorded from the 5th (A,B) telsonic (C,D) and 4th (E,F) segmental nerves of the 7th abdominal ganglion, while stimulating the connective ipsilaterally (A,C,E) and contralaterally (B,D,F). Note the presence of a burst of activity in all the nerves for stimulation of the ipsilateral connective and the absence of such activity for contralateral stimulation in the 5th and telsonic nerves. Also note the presence of a burst of activity in 4th segmental nerve for contralateral stimulation.

Calibration: Sweep – 2 msec.
Short synaptic delay during ipsilateral stimulation and longer delay during contralateral stimulation indicate that the synapses in the ipsilateral half could be predominantly monosynaptic while those in the contralateral half could be predominantly polysynaptic. Such suggestions have been made in other invertebrates (4, 3, 6). In contrast to this, a burst of activity was recorded in the 4th segmental nerve (Fig. 1F) upon contralateral stimulation of the connective as obtained for other peripheral nerves with ipsilateral stimulation. The activity was elicited at a threshold of 2.4 to 3.0 V with a conduction velocity of 1.5 to 6.5 m/s. The shorter synaptic delay of 1.2 to 1.4 msec indicates that the nature of these synapses is probably excitatory. Since a synaptic delay of more than 0.5 msec would indicate the existence of chemical synapses, it may be presumed that the transmission in the present case is predominantly chemical (2). Evidence in support of this contention was also obtained by the demonstration of the presence of acetylcholine (ACh), a neurotransmitter, in significant quantities in the nervous system of H. fulvipes (9).

Anatomical investigations (11) carried out on the seventh abdominal ganglion have also indicated anatomical (synaptic) connections between various neurons of the peripheral nerves only ipsilaterally, and the absence of such connections on the contralateral side. This reveals that contralateral pathways are mostly indirect, involving circuitous synaptic links. The 4th segmental nerve is an exception to this pattern, where the dendritic arborizations extend into the contralateral half also. This explains the high level of activity in this nerve both for ipsilateral and contralateral stimulations. Further, this feature seems to bear significance in the movement of the metasomatic segment. As can be noticed from Fig. 1, the joint between the 3rd and 4th metasomatic segments facilitates both vertical and lateral movements of these two segments. On the other hand, the joint between the 4th and 5th metasomatic segments is more rigid and allows only vertical movement of these segments. Since the 4th segmental muscles are innervated by the 4th nerve, it is suggested that multidirectional movement of this segment requires direct synaptic links for the motor neurons of this nerve both ipsilaterally and contralaterally. On the other hand, the motor neurons of the 5th nerve which innervates the muscles of the 5th metasomatic segment may need only ipsilateral contacts for the mere up and down movement of the segment. This suggestion, however, needs further experimental clarification.

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REFERENCES


