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COORDINATION BETWEEN PNEUMOSTOME MOVEMENTS AND CYCLIC LOCOMOTION IN *PLANORBARIUS CORNEUS* (MOLLUSCA, PULMONATA)*

SHORT COMMUNICATION

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In a reduced preparation of *Planorbarius corneus* consisting of the CNS and mantle complex, both the dopamine precursor L-DOPA and the serotonin precursor 5-HTP have been found to be able to induce and maintain rhythmic pneumostome (PN) movements coupled, in a neurotransmitter-specific manner, to fictive cyclic locomotion. Following transection of the pedal commissures, the pharmacologically induced movements of the PN were coordinated with the locomotory rhythm generated by the left pedal ganglion.

Keywords: Central pattern generator – motor rhythm – neurotransmitter – monoamine precursor – gastropod snail

In pulmonate molluscs, air breathing is accomplished by the alternate opening and closing movements of the pneumostome (PN). We have earlier found that, in the pond snail, *Lymnaea stagnalis*, these respiratory movements are sometimes well coordinated with movements of the foot and shell. Specifically, coordination was observed during intense (muscular, cyclical) locomotion that is expressed by the pond snail at elevated loads, e.g. when the mollusc gets out of water [5, 6]. In reduced *Lymnaea* preparations (the isolated CNS or CNS plus PN), a sharp increase of dopamine or serotonin levels was found to be required to induce intense fictive locomotion and associated PN rhythmicity [2, 3]. Furthermore, two neurotransmitter-specific modifications of phase coupling of respiration to locomotion were distinguished [4]. Rhythmic PN movements were invariably coordinated with the left central pat-

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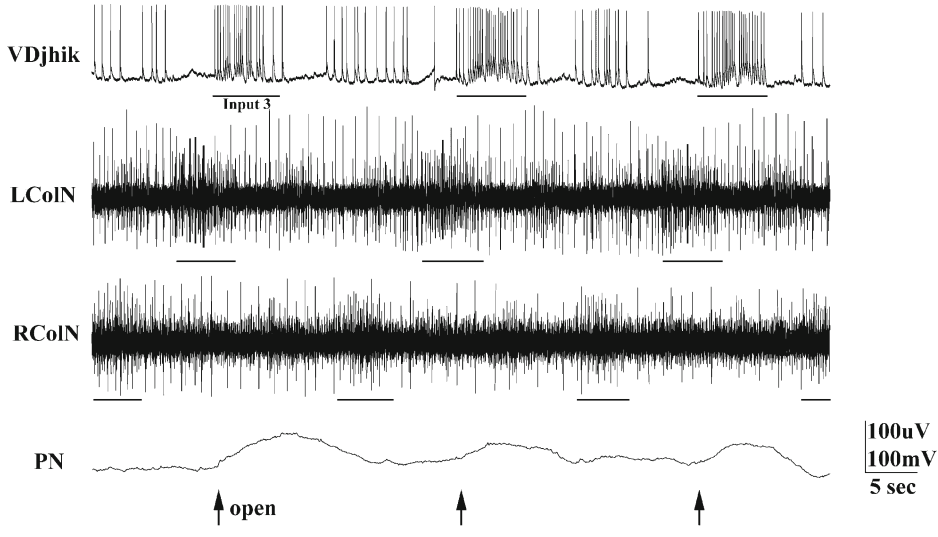

Fig. 1. L-DOPA-induced coordination between the motor rhythm of the pneumostome (PN) and fictive locomotion. **VDjhik,** a neuron of the visceral VDjhik cluster. **Input 3,** an excitatory respiratory input. **RColN,** right columellar nerve. **LColN,** left columellar nerve. **PN,** pneumostome movements. Arrow, start of opening

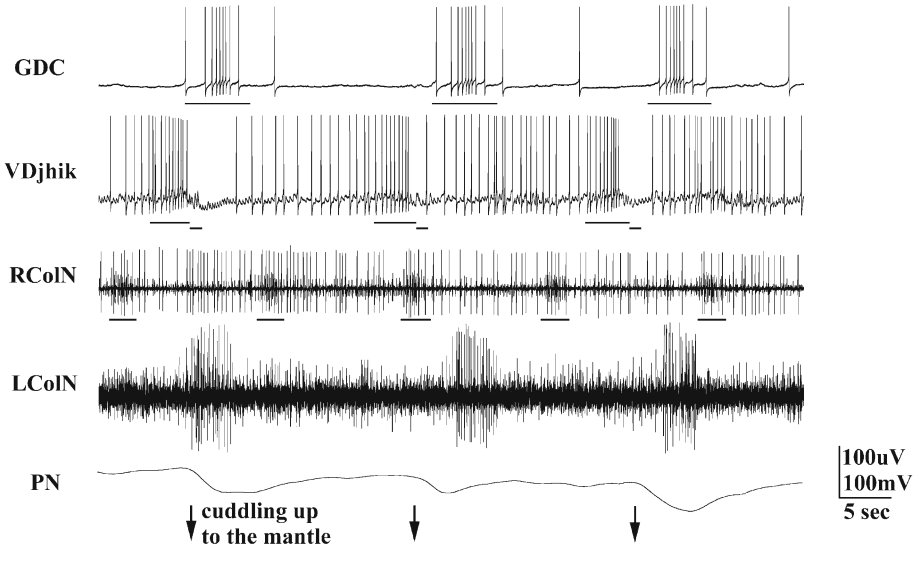

Fig. 2. 5-HTP-induced coordination between the motor rhythm of the pneumostome (PN) and fictive locomotion. **GDC,** the giant dopaminergic neuron (cell LPeD1). **VDjhik,** a neuron of the visceral VDjhik cluster. **RColN,** right columellar nerve. **LColN,** left columellar nerve. **PN,** pneumostome movements. Arrow, start of cuddling up to the mantle

tern generator (CPG) for locomotion, thus suggesting that the mechanism for locomotor-respiratory coordination is organized in an asymmetrical manner. It seemed therefore interesting to examine *Planorbarius corneus*, a freshwater pulmonate whose CNS/body plan appears as a mirror image of that in *Lymnaea*.

Experiments were performed at the Kropotovo biological station (Moscow Region). Mature specimens of *P. corneus* were collected in local ponds, anaesthetised with injection of 0.1 mM $MgCl_2$ and a reduced preparation (CNS plus mantle, including PN) was prepared. Rhythmic movements of PN and fictive locomotion were induced by bath application of either serotonin precursor 5-HTP or dopamine precursor L-DOPA (both 0.5 mM). The electrophysiological technique involved standard intracellular recording from visually identified neurons and extracellular recording from the left and right columellar nerves. The onset of the columellar burst corresponding to the forward movement of the shell was assumed to be the starting point of the locomotor cycle (LC). Phases of the normalized LC (NLC) are designated as per cent of its full time, with NLC 0 at the columellar burst onset. PN movements were recorded using photocell. Snail Ringer was as in [1]. Chemicals were from Sigma.

The data obtained in pharmacological and transection experiments are shown in Table 1. It is evident from the Table (see also Figs 1 and 2) that both L-DOPA and 5-HTP induce sustained fictive locomotion and rhythmic movements of the PN. The onset of the L-DOPA-induced PN movement is phase-coupled to an early portion of the LC (ca. NLC 25), whereas that of the 5-HTP-induced one to its late portion (ca. NLC 90). In this respect, the *Planorbarius* preparation behaves similarly to the *Lymnaea* one, thus suggesting conservativism of the underlying neuronal mechanisms.

Table 1
Pharmacologically induced pneumostome and locomotor rhythms in *Planorbarius corneus*

Pedal ganglia	L-DOPA		5-HTP	
Connected	Period of locomotor cycle. sec 23.3 ± 2.1		Period of locomotor cycle. sec 16.7 ± 3.9	
	PN opening NLC 24.8± 3.9	PN closure NLC 63.3± 5.7	PN cuddling up NLC 91.3± 4.4	PN returning NLC 43.6± 5.6
Disconnected	Period of locomotor cycle. sec 25.2± 2.3 (LColN) 16.4± 1.6 (RColN)		Period of locomotor cycle. sec 16.2± 4 .1 (LColN) 15.2± 4.2 (RColN)	
	PN opening* NLC 25.1± 4.2	PN closure* NLC 65.0± 6.3	PN cuddling up* NLC 90.0± 3.8	PN returning* NLC 42.3± 6.5

* Pneumostome (PN) movements phase-coupled to normalised locomotor cycle (NLC) in the left columellar nerve (LColN). RColN, right columellar nerve.

One of the differences between the two preparations is that, in *Lymnaea,* the 5-HTP-induced rhythmic movements included opening and closing of the PN, whereas in *Planorbarius* they did not. The difference suggests that, for some reason, air breathing is prevented during 5-HTP-induced intense locomotion in *Planorbarius.*

The other difference concerns asymmetry. As shown in Table 1, after transection of pedal commissures, rhythmic movements of the PN were coordinated with rhythmicity of the left pedal ganglion (i.e. the left locomotor CPG). The result is surprising as, in *Lymnaea* too, they were coordinated with the left pedal ganglion which in fact corresponds to the right one of *Planorbarius.*

The pedal ganglia of both *Planorbarius* and *Lymnaea* are not symmetrical structures. The most obvious difference between the left and right ones is that one of them contains a giant dopamine cell (GDC, left in *Planorbarius*, right in *Lymnaea*), whereas the other contains a giant serotonin cell (GSC, right in *Planorbarius*, left in *Lymnaea*). It appears from the obtained evidence that this neurochemical asymmetry has no connection to the observed functional asymmetry, coordination of the PN with the left CPG for locomotion.

To conclude, our results show that there are both similarities and differences between *Planorbarius* and *Lymnaea* with respect to coordination between intense locomotion and PN movements.

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