ANNAL. BIOL. TIHANY	43	3–19	HUNGARIA 1976

RHYTHMIC ACTIVITY OF NEURONES IDENTIFIED IN THE CENTRAL NERVOUS SYSTEM OF *HELIX POMATIA* AND ITS CHANGES CAUSED BY DAZOMET AND DIPTEREX

TRUONG VAN BAY and ISTVÁN KISS
Biological Research Institute of the Hungarian Academy of Sciences, Tihany, Hungary

Received: 9th February, 1976

In the past years a number of examinations was carried out in our Institute on the central nervous system of *Helix pomatia* revealing the localization and function of some giant neurones. In isolated ganglion SAKHAROV and SALÁNKI et al. (1972; 1973) examined the properties of the RPal bimodal oscillatory cell, while S.-RÓZSA and SALÁNKI (1973) identified some neurones taking part in the regulation of the heart using a semi-intact preparation.

In the present work we wished to obtain further electrophysiological data in order to better understand the neurones of the visceral ganglion. For this purpose we studied the characteristic properties of the potential generation of 14 randomly selected neurones. Another aim of the experiments was to study the sensitivity of the soma of these neurones to two substances used in plant protection (Dazomet and Dipterex).

It is well known in the literature that the chemical sensitivity of the soma even of neurones located side by side can be different, thus it is to be expected that the various neurones give heterogenic reactions also to the above drogs in the case of a specific effect.

Material and methods

The examinations were conducted on cells localized in the visceral ganglion of the isolated central nervous system of *Helix pomatia*, at room temperature, in all the seasons.

The preparation was placed in a chamber containing 3 ml physiological saline. Membrane and action potential were recorded by glass microelectrodes of 5–10 MOhm resistance filled with 2.5 M KCl. The recording electrode was connected to a high input impedance amplifier (VÉRÓ, 1974). During the experiments the membrane potential was measured using a digital voltmeter. The action potentials were photographed from the screen of an Alvar oscilloscope. The membrane potential of the cells was shifted through the recording electrode by inserting a bridge circuit.

For studying the rhythm of the spontaneous activity interspike interval histograms were analyzed, which were graphically represented on the basis of long-lasting registrations containing hundreds of action potentials. The

histograms were estimated in such a way that the interspike intervals between the consecutive spikes were measured, and the duration of these intervals plotted against the relative probability of their occurrence.

In the present experiments the following solutions were used: Dazomet (3,5-dimethyl-tetrahydro-1,3,5-tiadiazin-2-tion) 10^{-2}, 10^{-3}, 10^{-4} and 10^{-5} M; Dipterex (0,0-dimethyl-1-hydroxy-2,2,2-trichlor-aethylphosphate) 10^{-2}, 10^{-3} and 10^{-5} M dissolved in physiological solution. The composition of the physiological solution was: NaCl – 6.5 g, KCl – 0.14 g, $NaHCO_3$ – 0.02 g, NaH_2PO_4 – 0.01 g, $CaCl_2$ – 0.12 g dissolved in 1 litre of distilled water.

For a quantitative estimation of the drug effects the frequency of spontaneous activity observed following the drug application was expressed in per cent of the control frequency.

Results

I. Types of the neurone activities

The neurones can be considered to be well identifiable, if the number of ganglia under study is great enough and in addition to the localization of the neurones their activity type and connections are also taken into consideration (KERKUT et al., 1975; KISS and SALÁNKI, 1971). In the present examinations no identification corresponding to the above criteria was performed. The neurones were randomly selected, only their localization was considered, which was mapped in the case of different preparations. On the scheme *(Fig. 1)* only such neurones are represented, which were identifiable in more than one preparation considering the above conditions.

The membrane potential of the neurones shows a marked variability ranging between 40 and 72 mV. As regards the resting potential practically no difference was found between the pacemaker and synaptically influenced neurones, the average values were 60 ± 1.9 mV and 57 ± 2.4 mV, respectively. Neither does the amplitude of the action potential of the pacemaker

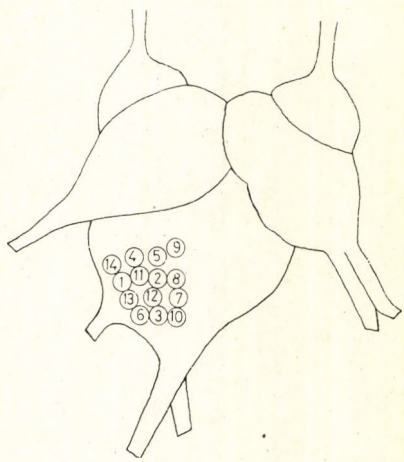


Fig. 1. Localization of the examined neurones in the visceral ganglion

and synaptically driven neurones differ, values of 65 ± 1.5 mV and 65 ± 2 mV were measured, respectively. The amplitude of the somatic discharge is variable even in the case of the same identifiable neurone of different preparations. Considering that the action potentials of small amplitude are resulted by an injury of the soma, they cannot be regarded as physiological ones. Thus potentials with overshoot having an amplitude more than 50 mV were only analyzed. This value represents the lower limit of the amplitude, while the upper limit is 90 mV.

The form and duration of the spikes were not analyzed in detail. In most of the cases the impulse duration ranged between 4 and 8 msec.

The frequency of discharges exhibits a marked variation from preparation to preparation. On the other hand, striking differences were observed in the firing rate of the same cell when it was watched for a long period *(Fig. 8)*.

On the basis of the main parameters of the spontaneous activity the examined neurones can be classified into the following groups:

1. Pacemaker neurones

Neurones Nos 1, 2 and 3 are included in this group. They are characterized by a continuous regular rhythm generation *(Fig. 2)*. In some cases the so-called latent pacemaker property can be observed, when the neurones are silent and their membrane potential exceeds the average value. In natural conditions or under some artificial influences the membrane potential can decrease and a regular pacemaker activity appears. The average values of their firing rate: cell 1 – 1.2 cps; cell 2 – 0.9 cps; cell 3 – 0.8 cps.

They have practically no synaptic input, which is confirmed by the following facts; synaptic potentials can be only sporadically recorded and a hyperpolarization of their membrane does not result in an appearance of EPSP-s. Upon depolarization neurone 2 has a slight capacity of accommodation,

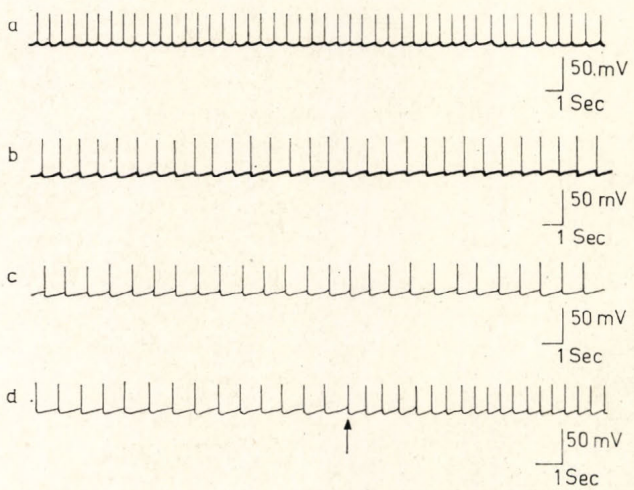


Fig. 2. Pacemaker activity recorded from neurones 1, 2 and 3 *a; b; c;* regular pacemaker rhythm, neurones 1, 2 and 3 *d;* effect of depolarization on neurone 2. Arrow marks the onset of depolarization

the higher frequency is maintained for a long time *(Fig. 2d)*. All the above properties seem to be evidence of a pacemaker spike generation.

The nature of the interspike interval histograms corresponds to the same type of activity. Consequently, these neurones can be characterized by a histogram of appropriate form: monomodal histogram and an approximately normal distribution is obtained *(Fig. 3)*.

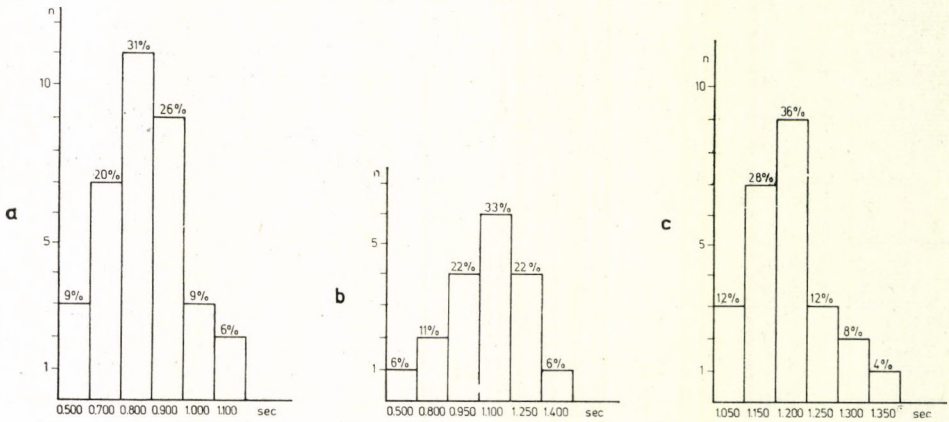


Fig. 3. Interspike interval histograms characterizing the pacemaker neurones; *a:* neurone 1; *b:* neurone 2; *c:* neurone 3

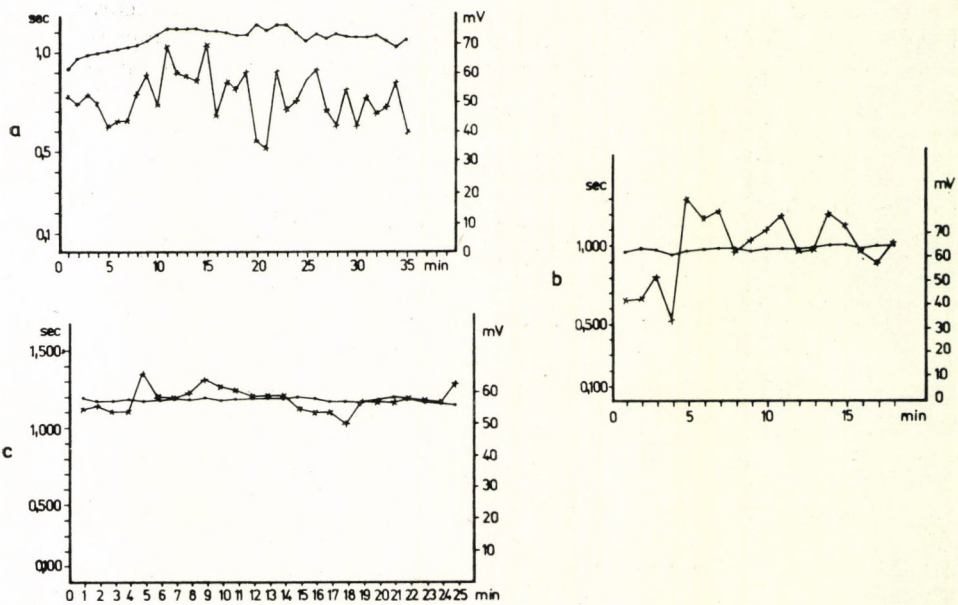


Fig. 4. Temporal alterations in the amplitude and interspike intervals of the action potentials of pacemaker neurones. Upper line: change of amplitude; lower line: change of interspike intervals; *a:* neurone 1; *b:* neurone 2; *c:* neurone 3

Changes of the interspike intervals in time show a fluctuation of relatively small degree *(Fig. 4)*. In the case of neurone 5 the more pronounced alteration observed in the 5th min following penetration might be attributed to a delayed normalization of the activity following the damage.

2. Synaptically influenced pacemaker neurones

The common properties of these giant neurones are:

a) The firing threshold of their soma is higher than the average level.

b) Irregular rhythm resulted by a summation of the pacemaker and synaptically evoked activity. Consequently, these neurones cannot be characterized by an interspike interval histogram of appropriate form. In the case of neurone 6 an asymmetric monomodal distribution is obtained *(Fig. 5)*. Another group of neurones is also characterized by a monomodal histogram, but it is of different type as compared to the above. This is rather similar to the normal distribution except the asymmetric form. Neurones 7, 8, 9 and 10 give good instances of this *(Fig. 6)*. The nature of interspike interval distribution is bimodal in the case of neurone 13 and multimodal in the case of neurone 12 *(Fig. 7)*.

c) Changes of the interspike intervals in time show a considerable fluctuation *(Fig. 8)*.

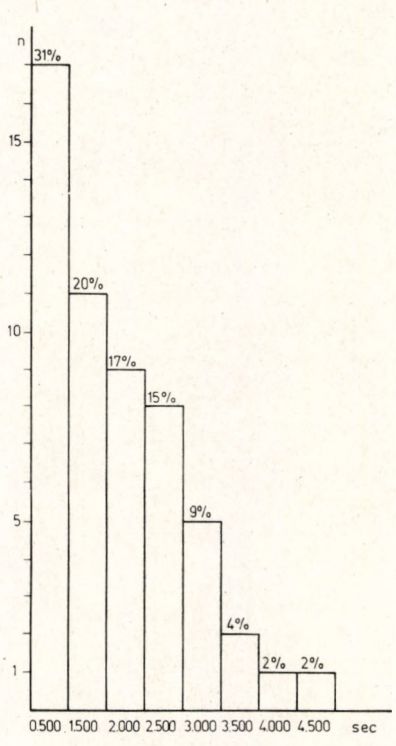


Fig. 5. Interspike interval histogram characterizing neurone 6

d) When recording the neuronal activity on different preparations or on the same preparation for a long time at least four main types of the activity patterns can be distinguished:

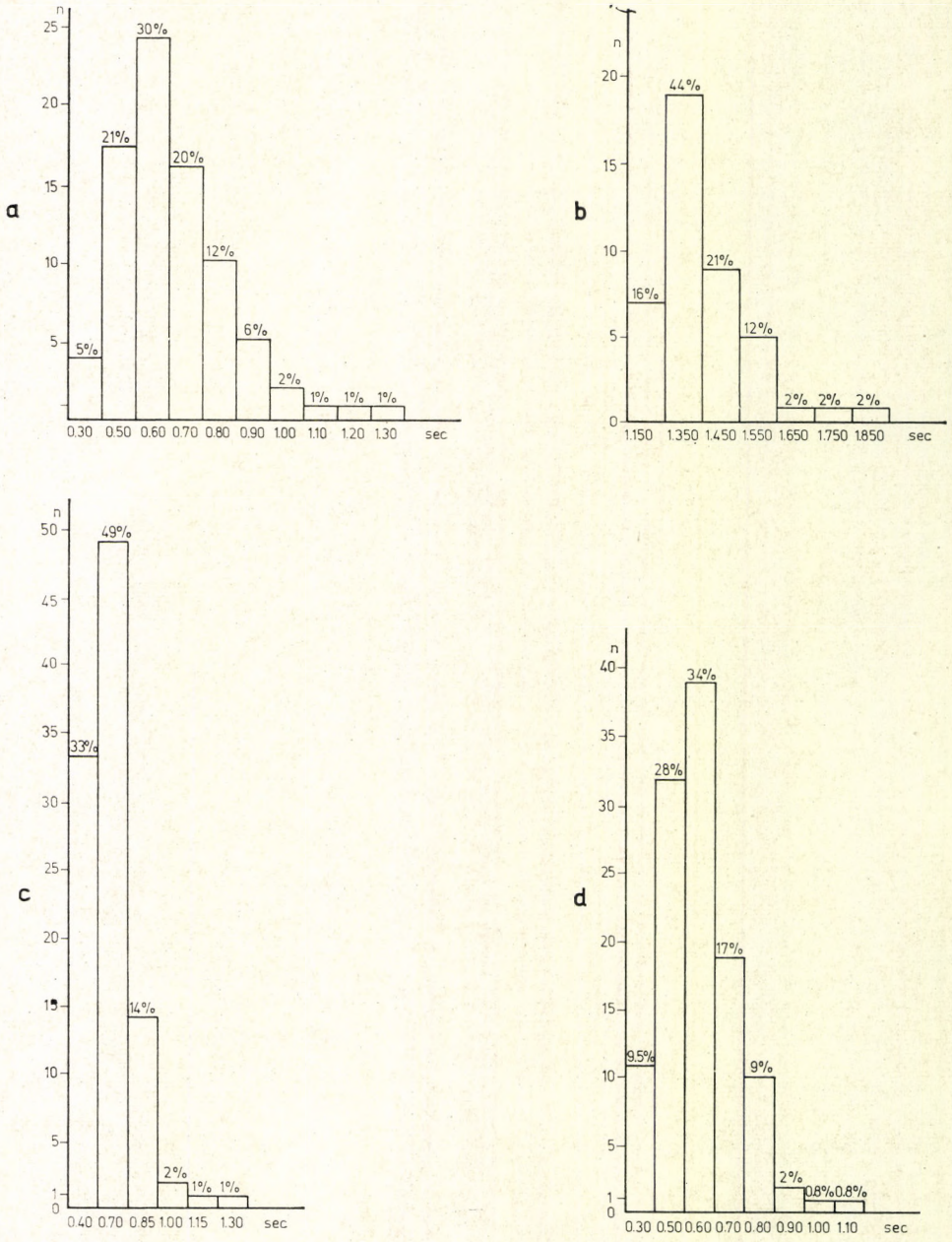


Fig. 6. Monomodal interspike interval histograms of the synaptically influenced pacemaker neurones; *a:* neurone 7; *b:* neurone 8; *c:* neurone 9; *d:* neurone 10

silent state *(Fig. 9d)*,
regular activity with low firing rate *(Fig. 9a)*,
irregular activity with low firing rate *(Fig. 9c)*,
irregular activity with higher firing rate *(Fig. 9b)*.

These activity types alternate from time to time even in the case of the same cell. Such an alteration in the activity pattern can be well demonstrated in *Fig. 8* showing the temporal changes of the interspike intervals. The activ-

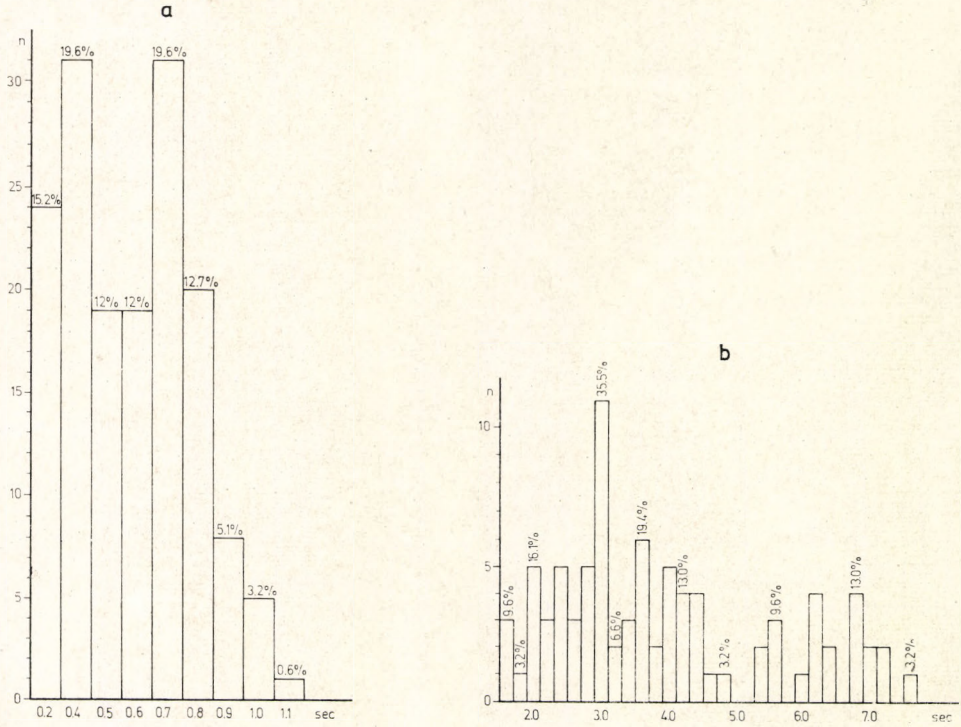


Fig. 7. Bimodal and multimodal interspike interval histogram; *a:* neurone 13; *b:* neurone 12

ity pattern can be altered by a displacement of the membrane potential, for instance when using hyperpolarization of an appropriate magnitude the pacemaker potential generation ceases and the neurone functions entirely under synaptic control or becomes silent *(Fig. 9c* and *d)*. When displacing the membrane potential in depolarizing direction the pacemaker character becomes more pronounced instead of the irregular sequence of action potentials.

In some cases it appears as if the discharges were of pacemaker origin. However, following a hyperpolarization of the membrane it is demonstrable that the activity is driven synaptically, since under such conditions the EPSP-s become fairly visible *(Fig. 9c)*.

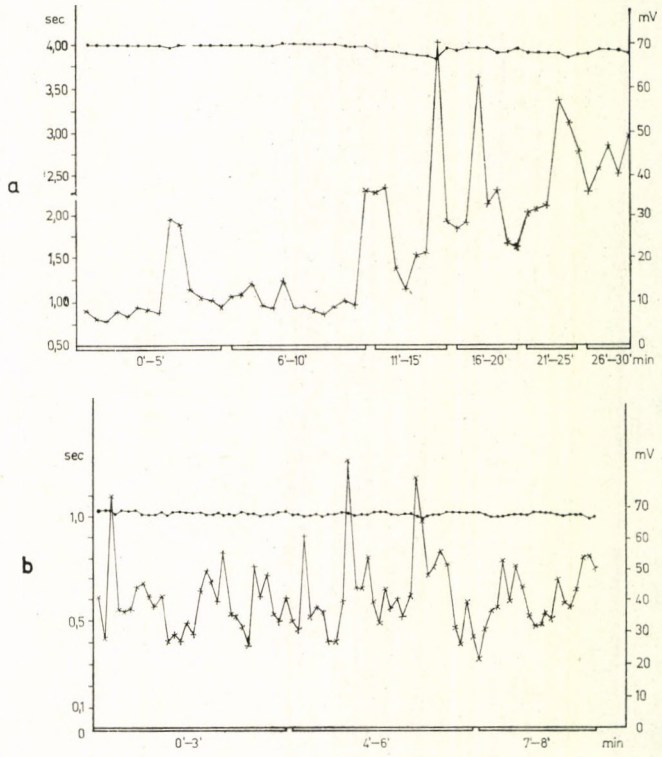


Fig. 8. Temporal alterations in the amplitude of the action potentials and in the interspike intervals of the synaptically influenced neurones. Upper line: change of amplitude;

The average values of the firing rates are represented in *Table I.*

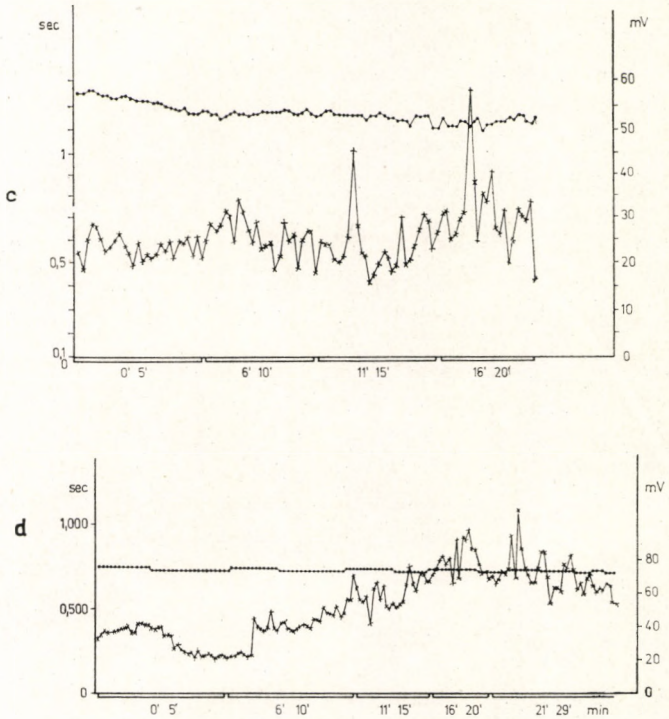
TABLE I

The average values of the firing rate of the synaptically influenced pacemaker and driven neurones

No. of cell	Synaptically influenced pacemaker					Synaptically driven		
	6	7	8	9	10	13	4	14
Firing rate (cps)	0.58	1.51	0.72	1.58	1.69	1.80	0.95	1.30

Among the neurones belonging to this group the following more detailed classification can be made.

Neurones 6, 7, 9 and 10 have a quite similar activity. Sometimes a pacemaker character is dominating *(Fig. 10a)*, at other times the pacemaker basic rhythm is modulated by synaptic inputs. The effect of EPSP-s sometimes is



ower line: change of interspike intervals; *a:* neurone 6; *b:* neurone 7; *c:* neurone 9; *d:* neurone 13

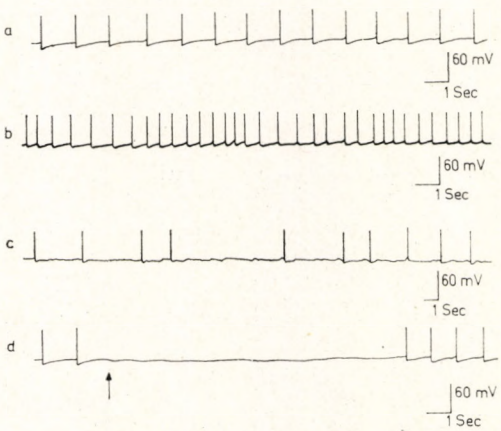


Fig. 9. Types of the activity patterns of the synaptically influenced pacemaker neurones. *a:* Regular activity with low firing rate (neurone 6). *b:* Irregular activity of higher firing rate. *c:* Irregular activity with low firing rate. *d:* Silent state evoked by artificial hyperpolarization on neurone 6. Arrow marks the onset of hyperpolarization

only realized in the development of a less regular sequence of the potentials *(Fig. 10c)*, but at another time the activity pattern is determined by the synaptic input. These cells received two kinds of input. The effect of the excitatory input is resulted in an intermittent increase in the firing rate *(Fig. 10b* and *d)*, while the inhibitory input causes a decrease in the frequency *(Fig. 10d)*.

In the case of neurones 8 and 11 in general the pacemaker character is dominating. This basic rhythm is occasionally modulated by EPSP-s *(Fig. 11a)*. The synaptic influence is so slight that the interspike interval histograms hardly differ from the normal distribution characterizing the pacemaker neurones *(Fig. 6b)*.

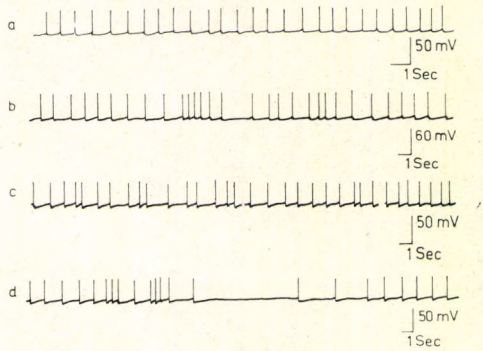


Fig. 10. Activity patterns characterizing neurones 6, 7, 9 and 10. *a:* Pacemaker activity; *b* and *d:* Transient increase in the firing rate during the continuous activity evoked by EPSP; *c:* irregular rhythm; *d:* inhibition like ILD

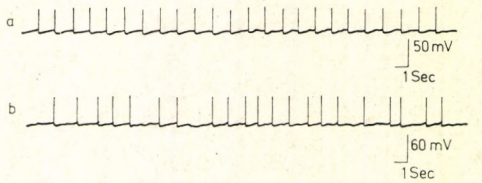


Fig. 11. a: Neurone 11. Pacemaker potentials with excitatory postsynaptic potentials. *b:* Neurone 12. The continuous activity is interrupted by IPSP-s from time to time

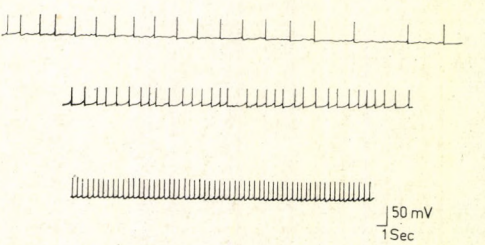


Fig. 12. The characteristic activity patterns of neurone 13

Neurones 12 and 13 are controlled by very complicated synaptic inputs. Their activity is equally influenced by compound EPSP and IPSP inputs *(Fig. 11b* and *Fig. 12)*. The irregularity of this activity pattern is reflected also in the bimodal or multimodal character of the interspike interval histograms *(Fig. 7)*.

3. Synaptically driven neurones

Neurones 4 and 14 belonging to this group have practically no pacemaker activity, their activity patterns are entirely determined by synaptic inputs *(Fig. 13)*.

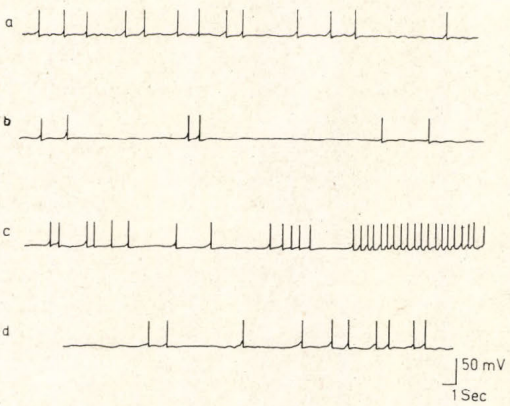


Fig. 13. The characteristic activity patterns of the synaptically driven neurones; *a* and *b:* cell 14; *d:* cell 4

II. Effect of the examined drugs on the spontaneous activity

1. Effect of Dazomet

Most of the examined neurones were sensitive to Dazomet. When increasing the concentration the effect became more pronounced. On the basis of the nature of the reactions given to Dazomet the neurones can be classified into three groups.

a) Dazomet causes an excitation (depolarization) resulting in the increase of the firing rate. The effect of Dazomet is characterized by a slow time course and restoration. For the latter washing out is required. Excitatory effect was observed in 12 cases of 29 experiments. Under the influence of Dazomet the increase in the firing rate reached as much as 300 % expressed in the per cent of control *(Table II)*. The most pronounced excitatory effect appeared on neurone 7b at 10^{-4} M concentration and on neurones 13a and 1c at 10^{-2} M concentration. In the case of the other neurones less pronounced effects were detected.

b) Dazomet causes an inhibition (hyperpolarization) resulting in the decrease of the firing rate. The most pronounced hyperpolarization developed on neurones 1a, 3a, 4a and 10a. The firing rate decreased to 75 per cent on

TABLE II

Effect of Dazomet on the spontaneous activity of neurones

Cell	Substances	Membrane potential		Action potential		Firing rate		Firing rate following the application of the the drug in per cent of the control (%)
		spontaneous activity mV	drug effect mV	spontaneous activity mV	drug effect mV	spontaneous activity cps	drug effect cps	
3a	Dazomet	52	50	55	50	0.8	0.6	75
33b	10^{-5} M	42	40	50	51	0.2	0.2	100
4b	10^{-5} M	60	58	65	64	0.2	0.2	100
5a	10^{-5} M	69	68	71	70	0.5	0.5	100
9a	10^{-5} M	60	61	62	60	0.8	0.9	113
	Dazomet							
1a	10^{-4} M	53	55	70	72	0.4	0.3	75
1b	10^{-4} M	42	43	60	61	0.2	0.2	100
2a	10^{-4} M	60	62	68	69	0.2	0.2	100
2b	10^{-4} M	40	38	50	52	0.2	0.2	100
4a	10^{-4} M	57	54	60	58	0.7	0.2	29
5b	10^{-4} M	60	61	65	63	0.2	0.2	100
6b	10^{-4} M	59	62	70	72	0.6	0.13	22
7b	10^{-4} M	72	75	80	79	0.04	0.12	300
8c	10^{-4} M	48	46	50	58	0.6	0.8	133
12c	10^{-4} M	51	49	60	65	0.6	0.8	133
13c	10^{-4} M	52	50	60	62	0.3	0.2	66
	Dazomet							
6a	10^{-3} M	62	64	65	63	0.4	0.5	125
7a	10^{-3} M	64	59	66	57	0.4	0.6	150
8a	10^{-3} M	40	38	45	50	0.4	0.7	117
10a	10^{-3} M	70	65	73	68	0.5	0.3	60
11a	10^{-3} M	62	60	66	64	0.7	0.6	86
12a	10^{-3} M	60	61	64	62	1.0	1.0	100
	Dazomet							
11c	10^{-2} M	70	68	70	69	0.1	0.2	200
6c	10^{-2} M	52	50	60	55	0.8	1.2	150
7c	10^{-2} M	57	52	80	75	0.5	0.2	40
13a	10^{-2} M	69	64	70	65	0.1	0.3	300
13b	10^{-2} M	70	64	70	65	0.2	0.4	200
14a	10^{-2} M	70	65	70	67	0.4	0.5	125
14c	10^{-2} M	51	53	60	62	0.2	0.2	100

cells 1a and 3a, to 29 per cent on the cell 4a, to 60 per cent on the cell 10a as compared to the spontaneous activity. Inhibitory effect was observed on 8 of 29 cells under study *(Table II)*.

c) Neurones classified into this category exhibited neither depolarization, nor hyperpolarization following the application of Dazomet. In this case the firing rate was unaltered. Nine of the 29 examined neurones proved to be insensitive to Dazomet *(Table II)*.

2. Effect of Dipterex (trichlorphon)

On the basis of the nature of the reactions given to Dipterex the neurones can also be classified into three groups.

TABLE III

Effect of Dipterex on the spontaneous activity of neurones

Cell	Substances	Membrane potential		Action potential		Firing rate		Firing rate following the application of the drug in per cent of the control %
		spontaneous activity mV	drug effect mV	spontaneous activity mV	drug effect mV	spontaneous activity cps	drug effect cps	
	Dipterex							
2c	10^{-5} M	57	58	59	58	0.4	0.4	100
3c	10^{-5} M	72	70	75	74	0.2	0.2	100
4c	10^{-5} M	57	53	60	55	0.8	0.6	75
5c	10^{-5} M	64	62	67	60	0.4	0.6	150
10b	10^{-5} M	70	68	78	78	0.2	0.3	150
10c	10^{-5} M	59	60	77	77	0.2	0.24	120
	Dipterex							
8b	10^{-3} M	65	72	70	–	0.02	–	0
9b	10^{-3} M	58	56	60	61	0.2	0.2	100
11b	10^{-3} M	66	68	69	65	0.2	0.4	200
12b	10^{-3} M	60	62	63	62	0.2	0.2	100
	Dipterex							
9c	10^{-2} M	63	60	68	–	0.2	–	0
11c	10^{-2} M	50	49	60	58	0.1	0.1	100
14b	10^{-3} M	60	64	70	68	0.04	0.2	500

a) Dipterex caused an excitation (depolarization) on five of 13 neurones under study. Similarly to that of Dazomet the effect of Dipterex is characterized by a slow time course and long lasting restoration, which requires washing out. Under the influence of Dipterex the increase in the firing rate was 150 per cent on cell 10b, 200 per cent on cell 11b, 500 per cent on cell 14b expressed in the per cent of the control activity.

b) Dipterex caused an inhibition (hyperpolarization). The most pronounced hyperpolarization developed on cells 4c, 8b and 9c. On neurone 4c the activity decreased to 75 per cent of the control, in the case of the other two cells the potential generation completely ceased *(Table III)*.

c) Dipterex caused no change in neuronal activity. Dipterex caused neither depolarization, nor hyperpolarization, and the firing rate was unaltered on neurones 2c, 3c, 9b, 11c and 12b *(Table III)*.

In the tables neurones marked by a, b, c represent neurones of same location examined in different preparations. It can be seen that the cells considered to be identical sometimes gave various reactions in different preparations. It might be due to the variable sensitivity of a given neurone or perhaps to the insufficiency of visual identification in the different preparations. Supposing the latter case, the examinations in fact were not performed on identical, but were performed on neighbouring cells.

Discussion

On the basis of the present results pacemaker and synaptically influenced neurones can be distinguished in the visceral ganglion of *Helix pomatia* similarly to that described on other Gastropod preparations (SAKHAROV, 1975).

Most of the neurones are active at the moment of inserting the electrode, the activity becomes normal following the injury and is maintained for hours. This refers to a powerful neuronal activity in the isolated ganglion, which postulates either the existence of a great number of neurones with spontaneous activity or extraordinarily rich branching efferent pathways of a few cells of this nature.

The present results support the earlier observations that in the ganglia of Molluscs the activity type of neurones having identic topographical localization is nearly the same in different preparations. Nevertheless, an identification based only on the localization does not seem to be sufficient for the repetitive, reliable recognition of a great number of medium-size neurones.

For analyzing the rhythm of the spontaneous activity the graphical representation of interspike interval histograms appears to yield good indexes. These histograms call the attention to the differences not readily visible in the recordings. The analysis of the interspike intervals of a regular sequence of potentials gives a monomodal histogram, which approximates the normal distribution and differs from that more and more with increasing irregularity of the sequence of action potentials.

The monomodal histograms suggest that only one pacemaker or synaptic site on the neuronal membrane may be responsible for the generation of the rhythmic discharge. On the contrary, the bimodal histograms reflect that the activity is generated either in two separated sites of the membrane, or is a resultant of a pacemaker oscillation and some synaptic influence. Of course in order to better understand the differences in the interspike interval histograms also some other details should be taken into consideration, which are connected with the heterogenic membrane characteristics of the neuronal membranes.

The examination of the chemical sensitivity is essential in particular on the neighbouring neurones having similar electrophysiological parameters.

The firing rate is not suitable for the identification, because it is rather variable from preparation to preparation.

Under the present experimental conditions marked differences were observed in the firing rate of the same cell, when it was watched for a long time. In respect of the complex regulation it seems to be important that in the case of most neurones of the visceral ganglion a transition can be developed between the different types of activity, for example a clear pacemaker activity can change into a driven one.

There is a quite limited possibility to compare the ganglion maps made in different species *(Aplysia, Lymnaea, Helix)* mainly because of the notable heterogeneity of their anatomy. In *Aplysia* and *Helix* some cells have been found that may be most likely regarded as functional homologues (Sakharov, 1975), for example, the Br-cell (Arvanitaki and Chalazonitis, 1961; Strumwasser, 1965; Salánki et al., 1972). In the course of the examination of the left visceral ganglion of *Helix* we failed to find neurones being identical with any special cell described in other species. In *Helix* neurones of burst activity can be rarely found. The spontaneous activity of *Aplysia* neurones are modulated by IPSP inputs to a higher degree (Kandel et al., 1967), which suggests the existence of more inhibitory or so-called double action interneurones.

In general, the neurones discharge with a firing rate more than 1 cps, which can be regarded as a background activity modulated by synaptic inputs.

The most important properties of the action potential series of pacemaker origin and the basic principles of the synaptic control are in agreement with those described on other Mollusc species. Concerning their activity types the neurones examined in the present work are presumably like those described by CHALAZONITIS (1968) and FRAZIER et al. (1967) on *Aplysia* regarded as synaptically driven pacemaker cells. These cells of plastic activity being under complicated synaptic control might play an important role in the ganglionic integration.

The results of the present examinations with respect to the chemical sensitivity of neurones are connected with the findings of some authors (GLAIZNER, 1968; WILGENBURG, 1970; KISS and SALÁNKI, 1971), who observed the most various combinations of the effects of mediator substances studied on the central neurones, since we also found a great variability of the sensitivity of different neurones to the chemicals used in the plant protection.

The effect of Dipterex used as insecticide is realized through the inhibition of cholinesterase, furthermore, it is known (NANDA and DUTTA, 1975) that it depletes the neurosecretory cells, too. The latter effect is considered to be specific one. Dazomet used as herbicide and nematicide exerts effect by releasing methylisothiocyanate gas (WHITEHEAD, 1973).

Following the application of Dazomet and Dipterex three main types of reactions were found: depolarization followed by an increase in the firing rate, hyperpolarization followed by an inhibition of the activity and insensitivity. The types of effect concerning certain aspects can be compared with the effects of ACh, 5-HT and other known transmitters, since the application of the latters can result in the same three types of reactions (TAUC and GERSCHENFELD, 1962; ZEIMAL and VULFIUS, 1968; ASHER, 1972; GERSCHENFELD, 1973). Neither the excitatory nor the inhibitory effect was coupled with a considerable change in the resting potential. Neither any damage of the neurones, nor an appearance of synaptic potentials were characteristic. Consequently, the reactions evoked by both Dazomet and Dipterex can be accounted for an influence of the permeability of the soma. The fact that even the equal concentration of the same substance resulted in different responses on the various cells refer to a specific effect of the examined drugs. On the basis of the present results it can be established that the preparation used seems to be a suitable object for the investigation of the substances used in chemical plant protection.

Summary

In the visceral ganglion of the central nervous system of *Helix pomatia* the spontaneous activity of 14 neurones was examined as well as the chemical sensitivity of these neurones to Dazomet and Dipterex used in the plant protection was tested. The chemicals were applied in perfusion.

On the basis of the spontaneous activity pacemaker, synaptically influenced and driven cells can be distinguished. The differences among the interspike interval histograms of these neurones were analyzed. In addition the magnitude of the membrane potential, the amplitude of the action potentials, the firing rate and the temporal changes of all the above parameters were studied during long lasting recording.

The results do not differ considerably from the data obtained on other

Gastropod species. The activity pattern of the neurones under complicated synaptic control shows a plasticity of high degree, which refers to an important role of these neurones played in the ganglionic integration.

Similarly to the transmitter substances Dazomet and Dipterex caused an excitation on some of the cells and an inhibition on the others, while in a part of the neurones they were ineffective. The effect of the substances under study can be regarded as a specific one modifying the permeability of the somatic membrane.

REFERENCES

ARVANITAKI A., N. CHALAZONITIS (1961): Slow waves and associated spiking in nerve cells of *Aplysia*. — *Bull. Inst. Oceanogr. Monaco*, No. 1224.

ASHCER P. (1972): Inhibitory and excitatory effects of dopamine on *Aplysia* neurones. — *J. Physiol.* **225**, 173—209.

CHALAZONITIS N. (1968): Synaptic properties of oscillatory neurone. — In: *Neurobiology of Invertebrates* (Ed.: J. SALÁNKI) *Akadémiai Kiadó, Budapest and Plenum Press, New York*, pp. 201—226.

FRAZIER W. T., E. R. KANDEL, I. KUPFERMANN, R. WAZIRI, R. E. COGGESHAL (1967): Morphological and functional properties of identified neurons in the abdominal ganglion of *Aplysia californica*. — *J. Neurophysiol.* **30**, 1288—1351.

GERSCHENFELD H. M. (1973): Chemical transmission in Invertebrate central nervous system and neuromuscular junctions. — *Physiol. Rev.* **53**, 1—119.

GLAIZNER B. (1968): Pharmacological mapping of cells in the suboesophageal ganglia of *Helix aspersa*. — In: *Neurobiology of Invertebrates* (Ed.: J. SALÁNKI) *Akadémiai Kiadó, Budapest and Plenum Press, New York*, pp. 267—284.

KANDEL E. R., W. T. FRAZIER, R. WAZIRI, R. E. COGGESHAL (1967): Direct and common connections among identified neurons in *Aplysia*. — *J. Neurophysiol.* **30**, 1352—1376.

KERKUT G. A., J. D. C. LAMBERT, R. J. GAYTON, J. E. JOKER, R. J. WALKER (1975): Mapping of nerve cells in the suboesophageal ganglia of *Helix aspersa*. — *Comp. Biochem. Physiol.* **50**A, 1—25.

KISS I., J. SALÁNKI (1971): The heterogenic chemical sensitivity of the central neurones of *Lymnaea stagnalis* L. — *Annal. Biol. Tihany* **38**, 39—52.

NANDA O. K., B. DUTTA (1975): Effect of Dipterex application on the brain secretory neurones of *Periplaneta americana*. — *Acta Biol. Cracoviensia, Ser. Zool.* **18**, 103—107.

SAKHAROV D. A. (1975): Nerve cell homologies in Gastropods. — In: *Neurobiology of Invertebrates, Gastropoda Brain* (Ed.: J. SALÁNKI) *Akadémiai Kiadó, Budapest (in press)*.

SAKHAROV D. A., J. SALÁNKI (1969): Physiological and pharmacological identification of neurons in the central nervous system of *Helix pomatia*. — *Acta physiol. Acad. Sci. hung.* **35**, 19—30.

SALÁNKI J., I. VADÁSZ, K. ELEKES (1972): Physiological and morphological characteristics of Br-type neuron in the central nervous system of the snail *Helix pomatia* L. — *Acta physiol. Acad. Sci. hung.* **42**, 243—254.

SALÁNKI J., VADÁSZ, M. VÉRÓ (1973): Temperature dependence of the activity pattern in the Br-type cell of the snail *Helix pomatia* L. — *Acta physiol. Acad. Sci. hung.* **43**, 115—124.

STRUMWASSER F. (1965): The demonstration and manipulation of a circadian rhythm in a single neuron. — In: *Circadian Clocks, North Holland Publishing Co., Amsterdam*, pp. 442—462.

S.-RÓZSA K., J. SALÁNKI (1973): Single neurone responses to tactile stimulation of the heart in the snail *Helix pomatia* L. — *J. Comp. Physiol.* **84**, 267—279.

TAUC L., H. M. GERSCHENFELD (1962): A cholinergic mechanism of inhibitory synaptic transmission in a molluscan nervous system. — *J. Neurophysiol.* **25**, 236—262.

VÉRÓ M. (1974): Voltage clamp measurement set-up for investigation of membrane parameters. — *Annal. Biol. Tihany* **41**, 111—117.

WHITEHEAD A. G. (1973): Control of cyst-nematodes (Heterodera sp.) by organophosphates, oxymecarbamates and soil fumigants. — *Ann. appl. Biol.* **75**, 439—479

WILGENBURG H. van (1970): An electrophysiological analysis of neurons in the visceral and parietal ganglia of *Helix pomatia*. — *Nooy's Drukkerij-Purmerend, Ph. D. Thesis.*

ZEIMAL E. V., E. A. VULFIUS (1968): The action of cholinomimetics and cholinolytics on the Gastropod neurons. — In: *Neurobiology of Invertebrates* (Ed.: J. SALÁNKI) *Akadémiai Kiadó, Budapest and Plenum Press, New York*, pp. 255—265.

HELIX POMATIA KÖZPONTI IDEGRENDSZERÉBEN IDENTIFIKÁLT NEURONOK RITMIKUS MŰKÖDÉSE ÉS ANNAK VÁLTOZÁSA DAZOMET ÉS DIPTEREX HATÁSA ALATT

Truong Van Bay és *Kiss István*

Összefoglalás

Helix pomatia központi idegrendszerének viscerális ganglionjában 14 neuron spontán aktivitását vizsgálták, valamint ezen neuronok kémiai érzékenységét a növényvédelemben használt Dazometre és Dipterexre, amely anyagok alkalmazása perfúzióban történt.

A spontán aktivitás alapján pacemaker, szinaptikus befolyásolt pacemaker és vezérelt sejtek különíthetők el, melyek interspike intervallum eloszlási hisztrogramjai közti különbségeket analizálták. Vizsgálták továbbá a membránpotenciál nagyságát, az akciós potenciál amplitúdóját, a kisülési frekvenciát és mindezen paraméterek időbeli változásait hosszabb időn keresztül történő regisztrálás folyamán.

Az eredmények nem különböznek lényegesen a más Gastropoda fajokon kapott adatoktól. A bonyolult szinaptikus vezérlés alatt álló neuronok aktivitási mintázata nagyfokú plaszticitást mutat, amelynek alapján e neuronoknak a ganglionáris integrációban fontos szerep tulajdonítható.

A Dazomet és Dipterex a transzmitter anyagokhoz hasonlóan egyes sejteken serkentést, másokon gátlást hozott létre, míg a neuronok egy részén hatástalan volt. A vizsgált anyagok hatása a szóma membrán permeabilitását befolyásoló specifikus hatásnak tekinthető.