A MAGYAR TUDOMÁNYOS AKADÉMIA
TIHANYI BIOLÓGIAI KUTATÓ INTÉZETÉNEK ÉVKÖNYVE
1976
(VOL. XLIII)

ANNALES INSTITUTI BIOLOGICI (TIHANY) HUNGARICAE ACADEMIAE SCIENTIARUM

TIHANY, 1976

ANNAL. BIOL. TIHANY

A MAGYAR TUDOMÁNYOS AKADÉMIA
TIHANYI BIOLÓGIAI KUTATÓ INTÉZETÉNEK ÉVKÖNYVE
1976
(VOL. XLIII)

ANNALES INSTITUTI BIOLOGICI (TIHANY) HUNGARICAE ACADEMIAE SCIENTIARUM

TIHANY, 1976

Szerkesztő:

S.- Rózsa Katalin

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

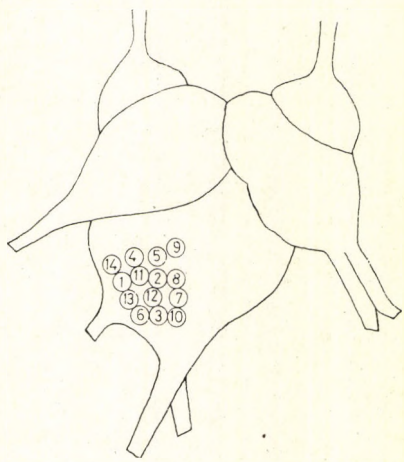


Fig. 1. Localization of the examined neurones in the visceral ganglion

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,

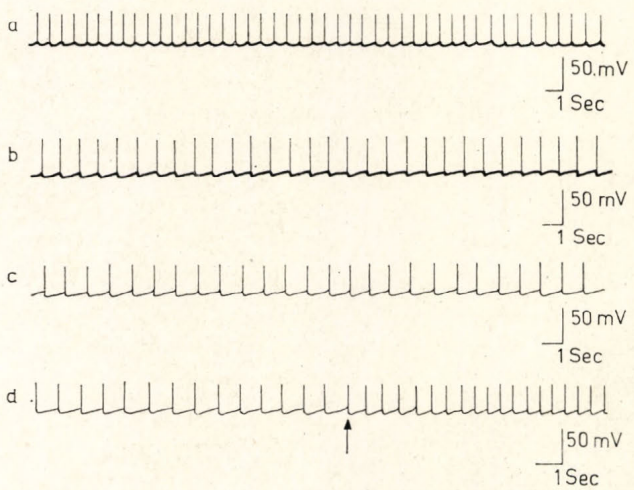


Fig. 2. Pacemaker activity recorded from neurones 1, 2 and 3 *a; b; c;* regular pacemaker rhythm, neurones 1, 2 and 3 *d;* effect of depolarization on neurone 2. Arrow marks the onset of depolarization

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)*.

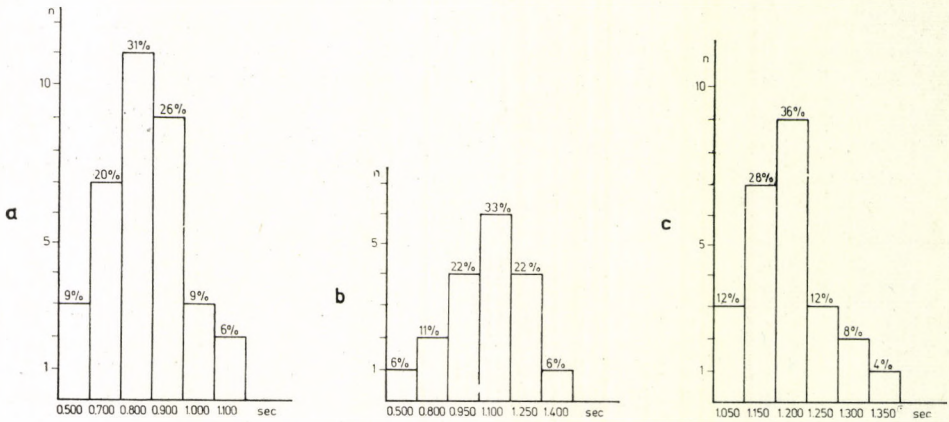


Fig. 3. Interspike interval histograms characterizing the pacemaker neurones; *a:* neurone 1; *b:* neurone 2; *c:* neurone 3

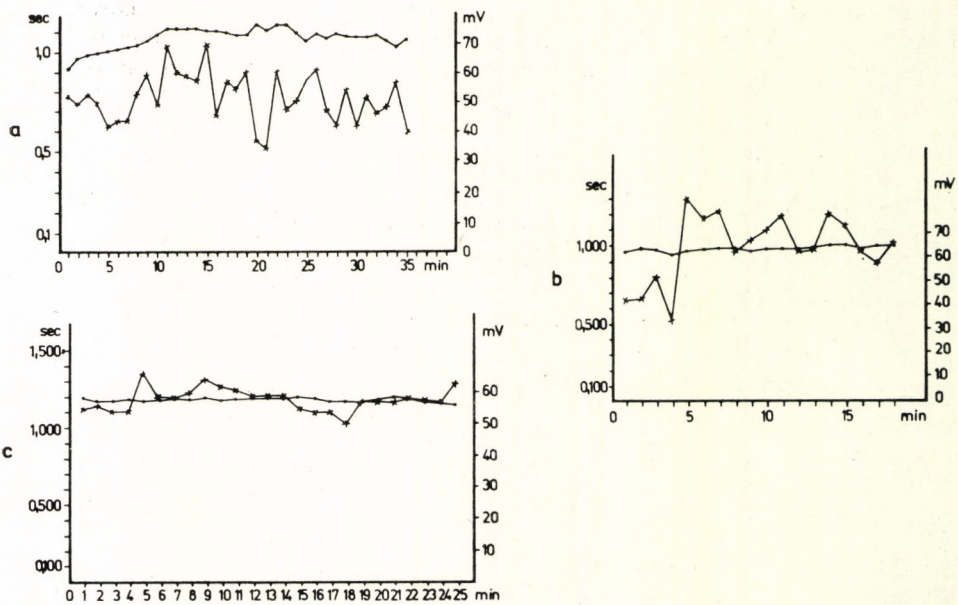


Fig. 4. Temporal alterations in the amplitude and interspike intervals of the action potentials of pacemaker neurones. Upper line: change of amplitude; lower line: change of interspike intervals; *a:* neurone 1; *b:* neurone 2; *c:* neurone 3

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)*.

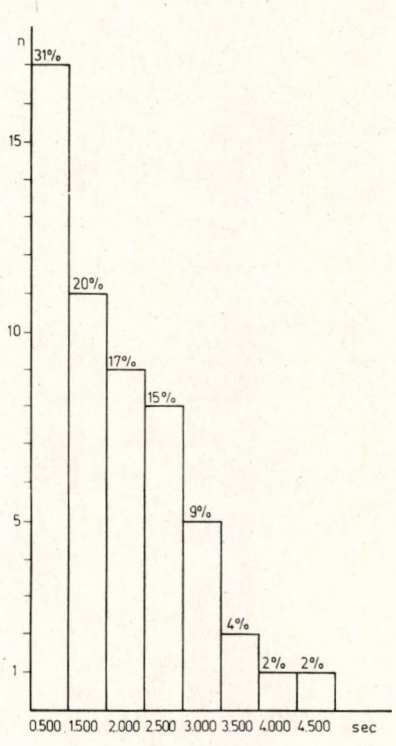


Fig. 5. Interspike interval histogram characterizing neurone 6

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:

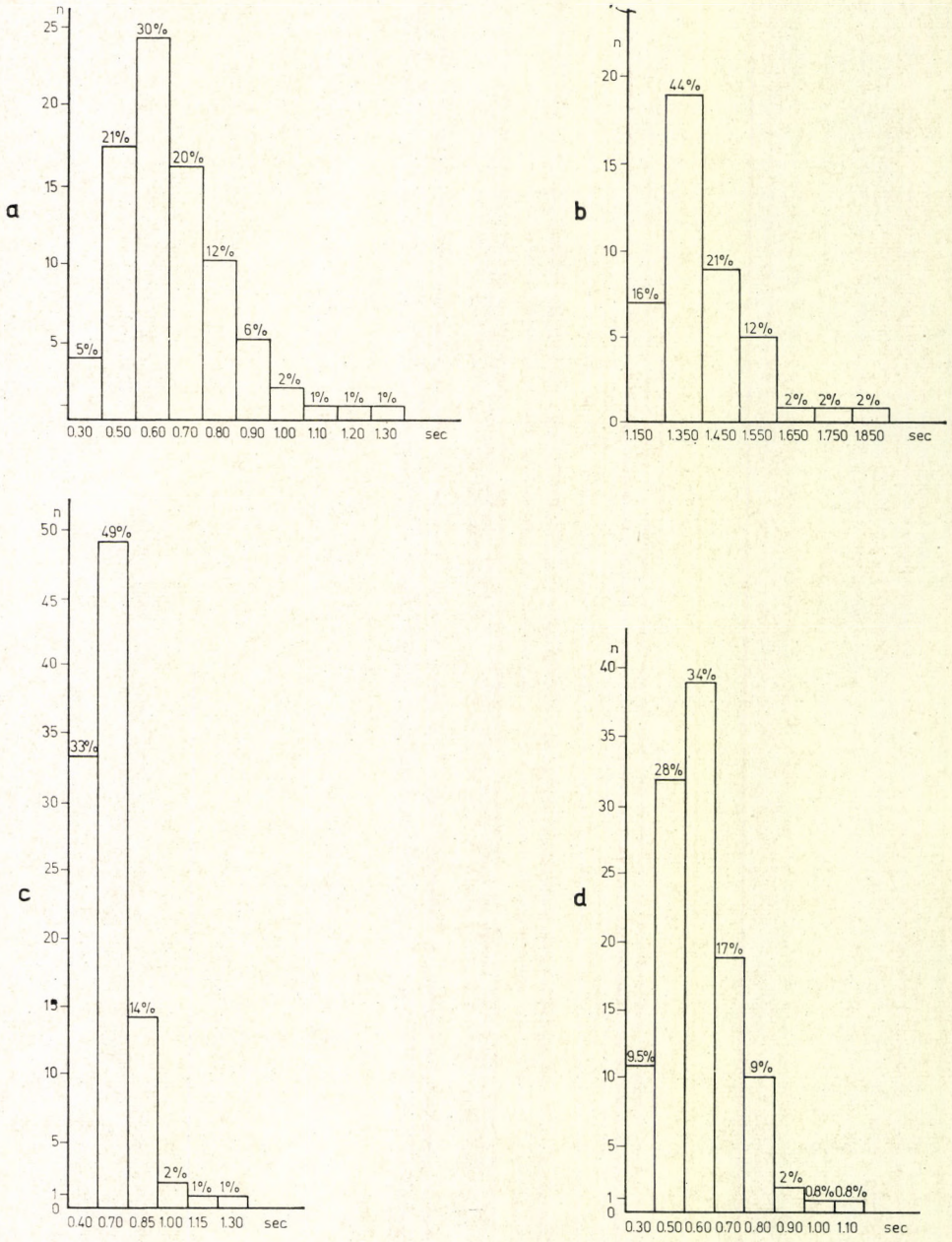


Fig. 6. Monomodal interspike interval histograms of the synaptically influenced pacemaker neurones; *a:* neurone 7; *b:* neurone 8; *c:* neurone 9; *d:* neurone 10

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-

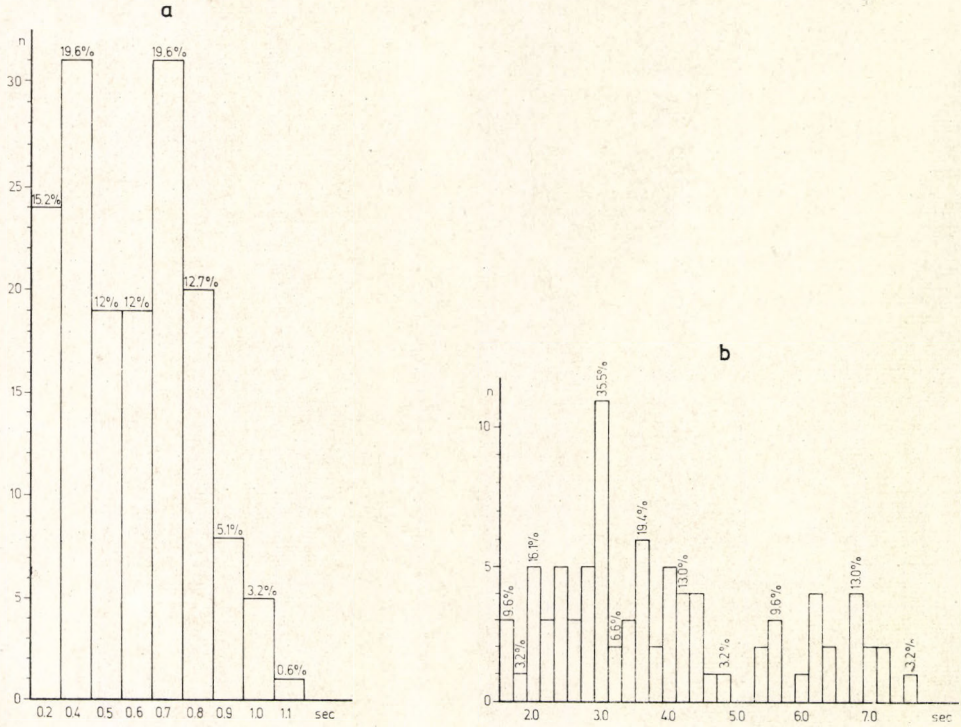


Fig. 7. Bimodal and multimodal interspike interval histogram; *a:* neurone 13; *b:* neurone 12

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)*.

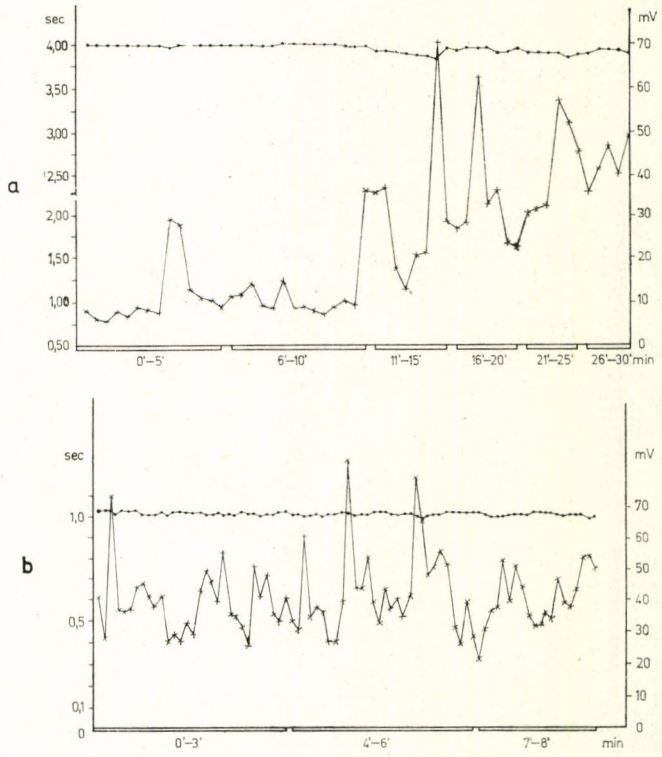


Fig. 8. Temporal alterations in the amplitude of the action potentials and in the interspike intervals of the synaptically influenced neurones. Upper line: change of amplitude;

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

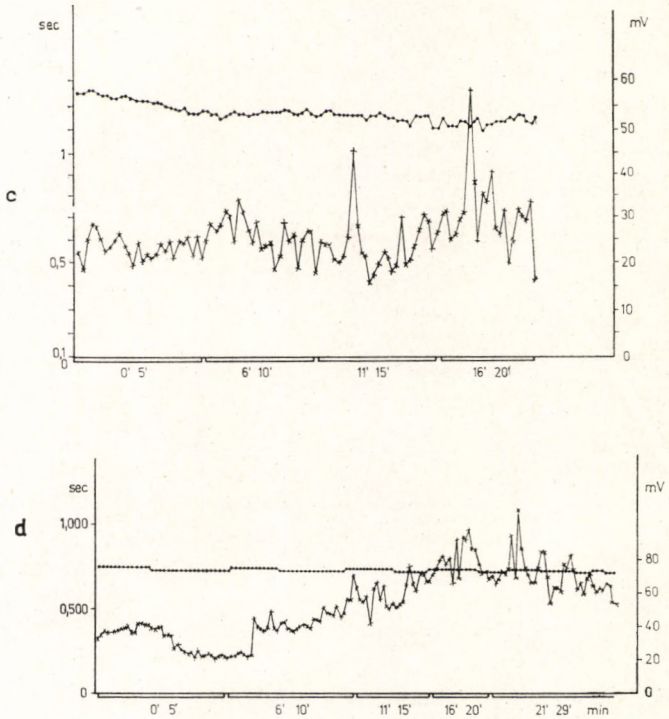
TABLE I

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

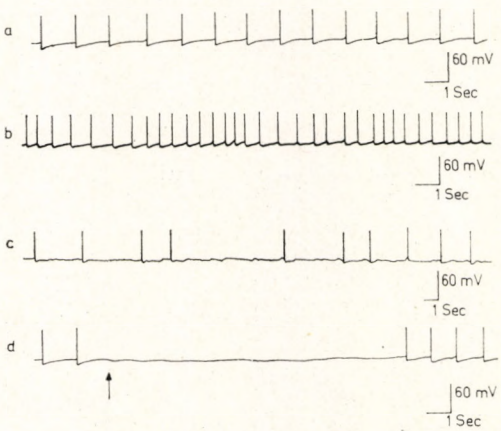


Fig. 9. Types of the activity patterns of the synaptically influenced pacemaker neurones. *a:* Regular activity with low firing rate (neurone 6). *b:* Irregular activity of higher firing rate. *c:* Irregular activity with low firing rate. *d:* Silent state evoked by artificial hyperpolarization on neurone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

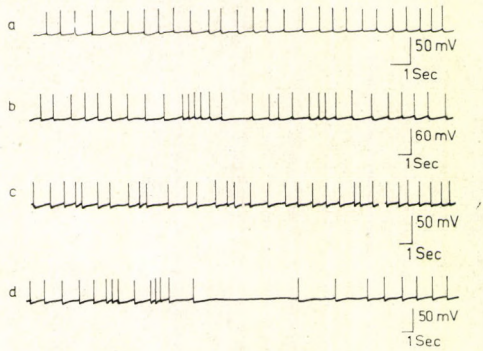


Fig. 10. Activity patterns characterizing neurones 6, 7, 9 and 10. *a:* Pacemaker activity; *b* and *d:* Transient increase in the firing rate during the continuous activity evoked by EPSP; *c:* irregular rhythm; *d:* inhibition like ILD

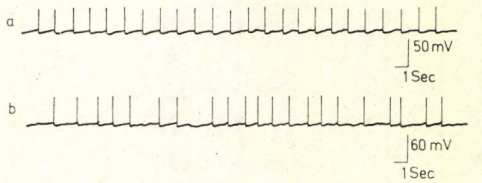


Fig. 11. a: Neurone 11. Pacemaker potentials with excitatory postsynaptic potentials. *b:* Neurone 12. The continuous activity is interrupted by IPSP-s from time to time

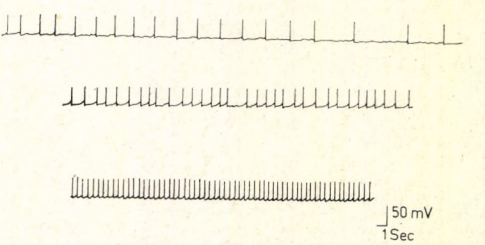


Fig. 12. The characteristic activity patterns of neurone 13

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)*.

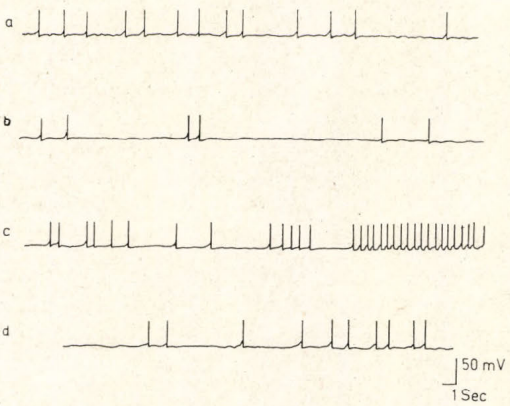


Fig. 13. The characteristic activity patterns of the synaptically driven neurones; *a* and *b:* cell 14; *d:* cell 4

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.

ANNAL. BIOL. TIHANY | 43 | 21–27 | HUNGARIA 1976

EFFECT OF COPPER AND LEAD COMPOUNDS ON THE ACTIVITY OF THE FRESH-WATER MUSSEL

JÁNOS SALÁNKI and ISTVÁN VARANKA

Biological Research Institute of the Hungarian Academy of Sciences, Tihany, Hungary

Received: 15th March, 1976

Waste materials of industrial or agricultural origin polluting natural waters very often contain various metallic compounds, damaging living organisms by affecting various physiological processes. In most cases the harmful effect becomes obvious only when mass death of some organisms occurs, while chronic disturbances remain masked for a long time. Biological tests are restricted mainly to the determination of the lethal concentrations.

It is well known from earlier investigations that marine and fresh-water mussels are very sensitive to changes in temperature (LOOSANOFF, 1958), to some organic compounds (KORRINGA, 1952), to SH-blocking agents like Hg and Cd (SALÁNKI, 1961) and to the lack of oxygen (SALÁNKI, 1965; 1966). The harmful effect manifests itself in the decrease of life functions, especially of the filtering activity and finally in the death of the animal. Any change in filtering activity can be monitored by registering the valve movement or measuring the cleaning of the water. There are various methods for such purpose (COLE and HEPPER, 1953; SALÁNKI and BALLA, 1964; HOGGARTH and TRUEMAN, 1967; VÉRÓ and SALÁNKI, 1969). The change in the activity to the damaging effect of various external influences appears much earlier than the death of the animals, thus by investigating this process the effect of sublethal doses can be discovered.

In the present experiments the effect of copper sulphate, lead chloride and lead nitrate was investigated on the rhythmic and periodic activity of the fresh-water mussel. Copper and lead compounds contaminate surface waters as plant protecting agents or as industrial waste materials and can cause damage in living organisms. The aim of the present work was to investigate the effect of different concentrations of the above substances, whether they can evoke a noticeable change in the mussel's life phenomena. We wanted also to clear up whether these typical filtering organisms may be suitable for signalling the effect of sublethal concentrations of copper and lead compounds.

Material and methods

The experiments were carried out on 10–14 cm long *Anodonta cygnea* specimens, during summer and autumn. The animals were collected from fish

ponds, but before treatment they were kept in Balaton water either in natural conditions or in aquaria with running water.

For the investigation the mussels were placed in separate vessels containing 3 litre of Balaton water. The temperature of the water was not controlled, thus varied between 15 and 24 °C according to laboratory conditions in summer and autumn. The water was changed in the vessels every day in the morning hours. Activity of the animals was registered continuously by a mussel actograph (SALÁNKI and BALLA, 1964) for several weeks. From the record the duration of the open and closed position of the valves can be measured with great accuracy; the former corresponds to the active, filtering period while the latter to the rest period (SALÁNKI and LUKACSOVICS, 1967). The alteration of the active and rest periods lasting both for several hours and being the result of the functioning of the adductor muscles is called as periodic activity. The duration of the active and rest periods can show significant variability even in control conditions, therefore at counting the mean values we took in consideration at least one week duration. Further on, we kept one animal without treatment in each series of experiments to monitor any change in the activity caused by uncontrolled circumstances. If more than 10 per cent difference occurred in the activity of this control animal, the results of the given series were not evaluated.

The chemicals used in the experiments were dissolved in Balaton water and diluted further in the vessels in which the animals were placed. Before adding the substances the activity of mussels was recorded for one–two weeks. The daily change of water was performed after the addition of the chemicals as before, but also the tested substance was solved in it. The concentration value was each day the same, regardless of the possible accumulation process.

Evaluation of the data was carried out on the basis of actograms. In each animal the mean duration of the active periods was determined for the control period and for the period following the treatment. The mean values were compared taking the control value as 100 per cent. This way the fall of activity below 100 per cent means the shortening of the active periods and *vice versa*. The effect of various concentrations was evaluated from 5 – 8 experiments carried out on different mussels.

The changes of the frequency of the rhythmic, fast contractions observable during active periods were not analyzed, since this frequency depends also in the length of the active period (SALÁNKI et al., 1970), nor were the mean of the rest times and its changes investigated.

The death of the animals is accompanied by the loss of the contractility of the adductor muscles resulting in the complete opening of the valves. This was the criterion we used in our experiments for determining mortality.

Results

The effect of $CuSO_4$ was investigated in $10^{-3} - 10^{-9}$ g/l concentrations, 10^{-3} g/l proved to be lethal. In this concentration the death of animals occurred usually within 10 hours. Following the addition of $CuSO_4$ the immediate closure of the shells was observed. In some cases this was followed by their opening and the animal performed rhythmic activity for a few hours *(Fig. Ia)*, while in other cases the relaxation of the adductor muscles after long closure

was the sign of the death of the animal *(Fig. 1b)*. In the former case the amplitude of the rhythmic contractions became less and less before the death of the animal, while in the latter case after opening no rhythmic valve movement was observed.

With decreasing concentrations of the $CuSO_4$ the mortality of the mussels decreased, nevertheless the death of animals occurred sometimes after long

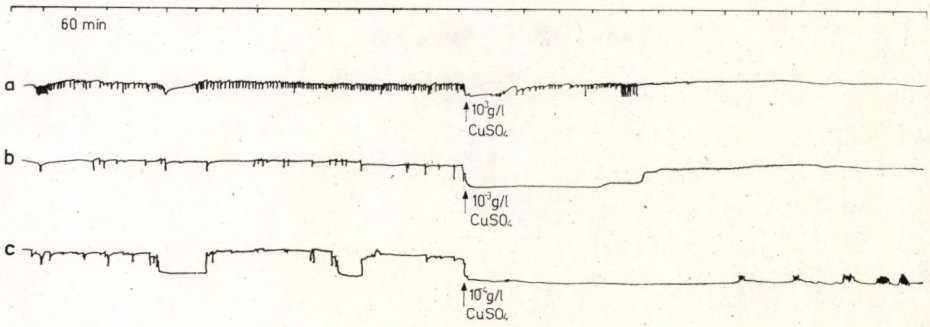


Fig. 1. Effect of $CuSO_4$ on periodic activity. *a* and *b* — 10^{-3} g/l; *c* — 10^{-4} g/l

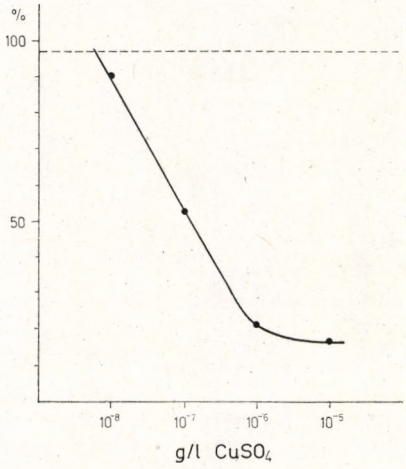


Fig. 2. Decrease of the duration of active periods plotted against $CuSO_4$ concentration

lasting (7 – 17 days) treatment in 10^{-4} g/l concentrations, too. In $10^{-4} - 10^{-5}$ g/l concentrations the duration of the active periods became shorter, the duration of activity reached only 5 – 20 per cent of the control. The duration of active periods varies between 10 and 60 minutes, and in this range it depends on the concentration only to a slight degree.

From 10^{-6} to 10^{-8} g/l the effect depends linearly on the concentration of the $CuSO_4$ *(Fig. 2)*. The threshold was 10^{-8} g/l, at which concentration the shortening of the active periods was about 10 per cent. The effect of $CuSO_4$ was permanent, adaptation was not observed within two weeks long exposure

(Fig. 3). On the record also the lengthening of the rest periods and the increase of the fast rhythmic contractions during active periods are well observable.

Washing (returning to fresh-water) restores control activity. Total restoration requires about 24—48 hours, when the original values of active periods are again observable.

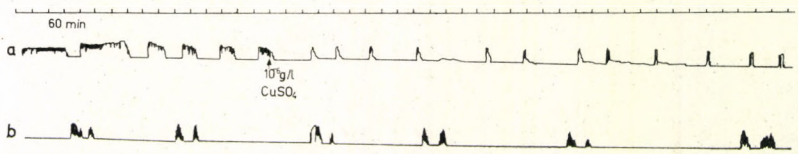


Fig. 3. Effect of 10^{-6} g/l $CuSO_4$ on the periodic activity of *Anodonta* when adding the solution (*a*) and on the 12th day (*b*)

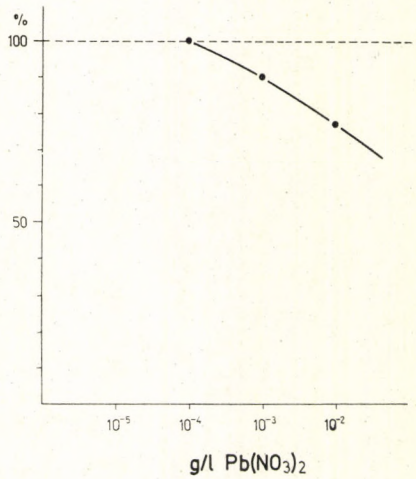


Fig. 4. Decrease of the duration of active periods plotted against $Pb(NO_3)_2$ concentration

Among lead compounds the effect of $PbCl_2$ and $Pb(NO_3)_2$ were investigated in the range of $10^{-2}-10^{-6}$ g/l concentration. Lead chloride has no effect on the activity of the mussels. Lead nitrate caused a similar but much weaker effect than copper sulphate. In 10^{-3} g/l concentration of lead nitrate the decrease in the duration of active periods was about 10 per cent, and even in 10^{-2} g/l only about 20 per cent decrease was observed *(Fig. 4)*. At the same time, in contrast to the effect of copper sulphate, the restoration was not complete after lead nitrate within 24 hours.

Discussion

The mussel-killing effect of different heavy metal compounds and of industrial waste materials is well established (KORRINGA, 1952) and the threshold of toxicity was described among others for copper salts, too. MARKS (1938) found that the highest concentration of Cu which can be tolerated by

Mytilus is 0.1 – 0.2 mg/l. This same range of concentration was described by SCOTT and MAJOR (1972) as the threshold of toxicity in *Mytilus* using Cu-chloride dihydrate. On the larvae of *Mytilus* 3.5×10^{-4} M Cu-citrate caused 50 per cent mortality (WISELY and BLICK, 1967) which corresponds to 2.2×10^{-2} g/l concentration. According to our data $10^{-4} - 10^{-3}$ g/l $CuSO_4$ kill *Anodonta*.

Our experiments were conducted primarily with the aim to establish whether Cu and Pb influence the main physiological functions of mussels in sublethal concentrations or not and that the effect to which degree can be followed by recording the motor activity of the animals. In the case of $CuSO_4$ 10^{-8} g/l proved to be the threshold of sensitivity, decreasing the activity by about 10 per cent; 50 per cent decrease was reached in 10^{-7} g/l $CuSO_4$ solution. $PbCl_2$ and $Pb(NO_3)_2$ did not cause decrease in activity at the concentration of 10^{-4} g/l. This value is much higher than the level occurring even in polluted natural waters.

The long lasting closure of the shells to $CuSO_4$ was observed in *Mytilus* by CLARKE (1947) and SCOTT and MAJOR (1972) keeping the animals in 10^{-2} and 3×10^{-4} g/l concentration of Cu solution, respectively. In these concentrations, however, in 3 – 4 days the death of the animals was observed.

Our results show that the effect of low, sublethal Cu concentrations influencing the physiological functions can be investigated by recording the periods of activity and rest, and that this latter procedure can be used as a test method. The decrease of activity means the decrease of the feeding, oxygen uptake, growth and also that of water cleaning. According to our data the presence of 10^{-8} g/l $CuSO_4$ is already harmful in this respect.

Similarly to other water organisms mussels accumulate a lot of inorganic compounds in the body, among them also Cu (SCOTT and MAJOR, 1972). A low amount of copper is present in the various tissues of mussels even in physiological conditions, its concentration reaches 0.1 – 0.5 mg/100 g wet tissue in the muscle, mantle and gill of *Mytilus* (MARKS, 1938). These values can increase as a result of accumulation, and through acute or chronic effect similarly to other metal ions, Cu becomes toxic for intracellular enzyme processes. The inhibition of tissue respiration was described in mollusc among other substances for mercury and cadmium (LUKACSOVICS and SALÁNKI, 1964; SALÁNKI and LUKACSOVICS, 1965), while a similar effect in total animal for copper was reported by SCOTT and MAJOR (1972). SH-blocking agents cause the shortening of the active periods in mussels (SALÁNKI, 1961; 1976), therefore it can be supposed that Cu ions evoke the inhibitory action on the duration of the active periods also through influencing the respiratory processes.

The toxic effect of copper on the living organisms can be modified by various properties of the water (pH, temperature, presence of other substances) (BRUNGS et al., 1976). To clear up the role of these conditions and also to throw light on the mechanism of the effect of Cu on the mussel's activity require further investigations.

Summary

The rhythmic movement of the valves and the duration of their open and closed position was recorded by an actograph. It was found that $CuSO_4$ in 10^{-8} g/l concentration decreases the duration of the active periods by 10

per cent, while 10^{-7} g/l results in the 50 per cent reduction of the active periods. Death of animals occurred at $10^{-3}-10^{-4}$ g/l.

$PbCl_2$ and $Pb(NO_3)_2$ did not cause any noticeable change in the activity at 10^{-2} and 10^{-4} g/l concentration respectively.

The applied method is suitable for testing the harmful, but sublethal effect of substances influencing already in lower doses basic physiological processes. The observed phenomenon reflecting the filtering activity too, is probably the consequence of the damage of the respiratory system.

REFERENCES

Brungs W. A., J. R. Geckler, M. Gast (1976): Acute and chronic toxicity of copper to the fathead minnow in a surface water of variable quality. — *Water Res.* **10,** 37—43.

Clarke G. L. (1974): Poisoning and recovery in barnacles and mussels. — *Biol. Bull.* **93,** 73—91.

Cole H. A., B. T. Hepper (1953): The use of neutral red solution for the comparative study of filtration rates of lamellibranchs. — *J. Conseil* **19,** 197—203.

Hoggarth K. R., E. R. Trueman (1967): Techniques for recording the activity of aquatic invertebrates. — *Nature* **213,** 1050—1051.

Korringa P. (1952): Recent advances in oyster biology. — *Quart. Rev. Biol.* **27,** 266—308.

Loosanoff V. L. (1958): Some aspects of behaviour of oysters at different temperatures. — *Biol. Bull.* **114,** 57—70.

Lukacsovics F., J. Salánki (1964): Effect of substances influencing tissue respiration and of the temperature on the O_2 consumption of the gill tissue in *Unio tumidus*. — *Annal. Biol. Tihany* **31,** 55—63.

Marks G. W. (1938): The copper content and copper tolerance of some species of Molluscs of the southern California coast. — *Biol. Bull.* **75,** 224—237.

Salánki J. (1961): Data on peripheral control of slow rhythm in periodic activity in *Anodonta*. — *Fiziol. Zhurn.* **47,** 1194—1198 (in Russian).

Salánki J. (1965): Oxygen level as a specific regulator in the rhythmic activity of fresh-water mussel (*Anodonta cygnea* L.). — *Acta Biol. Acad. Sci. Hung.* **15,** 299—310.

Salánki J. (1966): Comparative studies on the regulation of the periodic activity in marine lamellibranchs. — *Comp. Biochem. Physiol.* **18,** 829—843.

Salánki J. (1976): Kagyló-teszt vízszennyezések biológiai hatásának vizsgálatára. — *Hidrológiai Közlöny* 281—282.

Salánki J., L. Balla (1964): Ink-lever equipment for continuous recording of activity in mussels. — *Annal. Biol. Tihany* **31,** 117—121.

Salánki J., B. Glaisner, E. Lábos (1970): On the temporal organization of periodic and rhythmic activity in fresh-water mussel (*Anodonta cygnea* L.). — *J. Interdiscipl. Cycle Res.* **1,** 123—134.

Salánki J., F. Lukacsovics (1965): Effect of agents influencing the periodic activity of mussels on the in vitro respiration of siphon tissue of *Anodonta cygnea* L. — *Annal. Biol. Tihany* **32,** 83—92.

Salánki J., F. Lukacsovics (1967): Filtration and O_2 consumption related to the periodic activity of freshwater mussel (*Anodonta cygnea* L.). — *Annal. Biol. Tihany* **34,** 85—98.

Scott D. M., C. W. Major (1972): The effect of copper (II) on survival, respiration, and heart rate in the common blue mussel, *Mytilus edulis*. — *Biol. Bull.* **143,** 679—688.

Véró M., J. Salánki (1969): Inductive attenuator for continuous registration of rhythmic and periodic activity of mussels in their natural environment. — *Med. and Biol. Engng.* **7,** 235—237.

Wisely B., R. A. P. Blick (1967): Mortality of marine invertebrate larvae in mercury, copper and zinc solutions. — *Aust. J. mar. Freshwat. Res.* **18,** 63—72.

RÉZSZULFÁT ÉS ÓLOMVEGYÜLETEK HATÁSA A TAVIKAGYLÓ (*ANODONTA CYGNEA* L.) AKTIVITÁSÁRA

Salánki János és *Varanka István*

Összefoglalás

Szerzők aktográffal regisztrálták a kagylók ritmikus héjmozgását, valamint azok nyitott és zárt állapotának időtartamát.

Rézszulfát 10^{-8} g/l koncentrációban 10%-kal csökkenti a tavikagyló aktivitását, 10^{-7} g/l pedig a több órás aktivitási szakaszok 50%-os redukciójához vezet. Az állatok pusztulása 10^{-3}—10^{-4} g/l $CuSO_4$ alkalmazásakor következik be.

Ólomklorid és ólomnitrát még 10^{-2}, ill. 10^{-4} g/l koncentrációban sem okozott észrevehető változást az aktivitásban.

Az alkalmazott eljárás alkalmas különböző károsító anyagok subletális, de életfolyamatokat befolyásoló dózisainak tesztelésére. A megfigyelt hatás, mely a filtrációs aktivitás alakulásának tükröződése is, valószínűleg a légző rendszer károsodásának következménye.

ANNAL. BIOL. TIHANY | 43 | 29–35 | HUNGARIA 1976

GLASS CAPILLAR DRAWING MACHINE FOR ELECTROPHYSIOLOGICAL PURPOSES

MIHÁLY VÉRÓ

Biological Research Institute of the Hungarian Academy of Sciences, Tihany, Hungary

Received: 3rd February, 1976

The glass microelectrode is one of the most important research tools for investigating the cell activity. Practical electrophysiological investigations require a high number of electrodes, so a suitable drawing machine is normally used to provide the glass capillars thus required. In this way, both quantita-

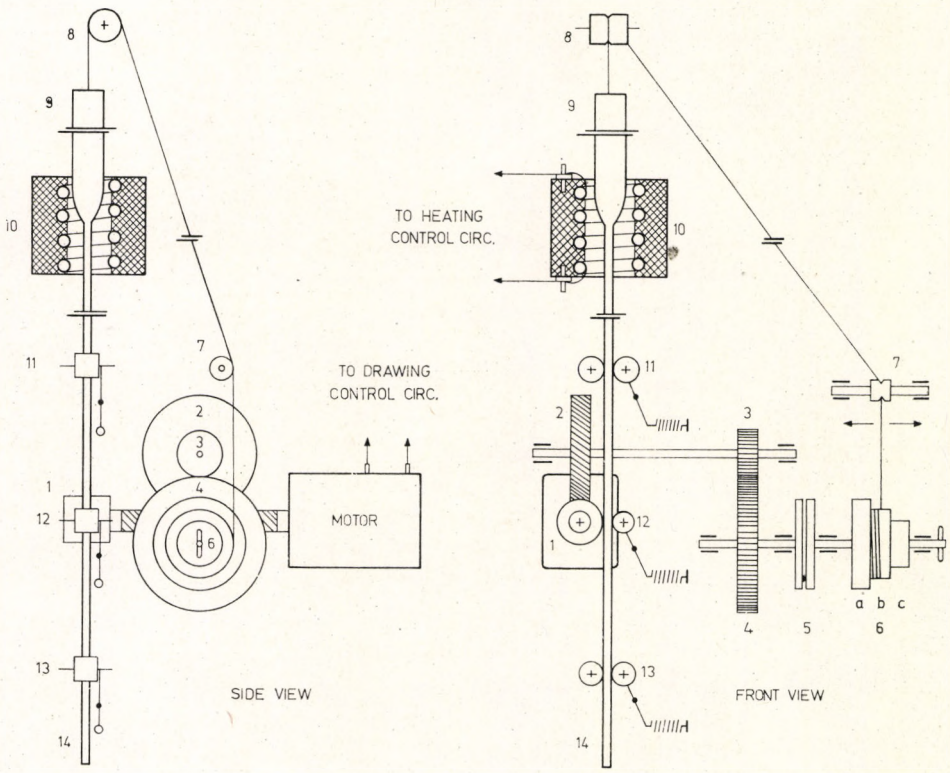


Fig. 1. Simplified functional arrangement of the capillar drawing machine

tive and qualitative requirements of the experiments are satisfied economically.

Locally fabricated drawing machines for providing microelectrodes are now applied in several laboratories instead of factory produced microelectrodes. A capillar drawing machine for this purpose has been developed in our Institute, involving vertical arrangement and providing suitable heating and drawing parameters. The simplified functional arrangement of this machine is shown in *Fig. 1.*

In the following, the arrangement will be explained in the sequence of operation steps. The starting position of the end of glass-tube (9) is within the

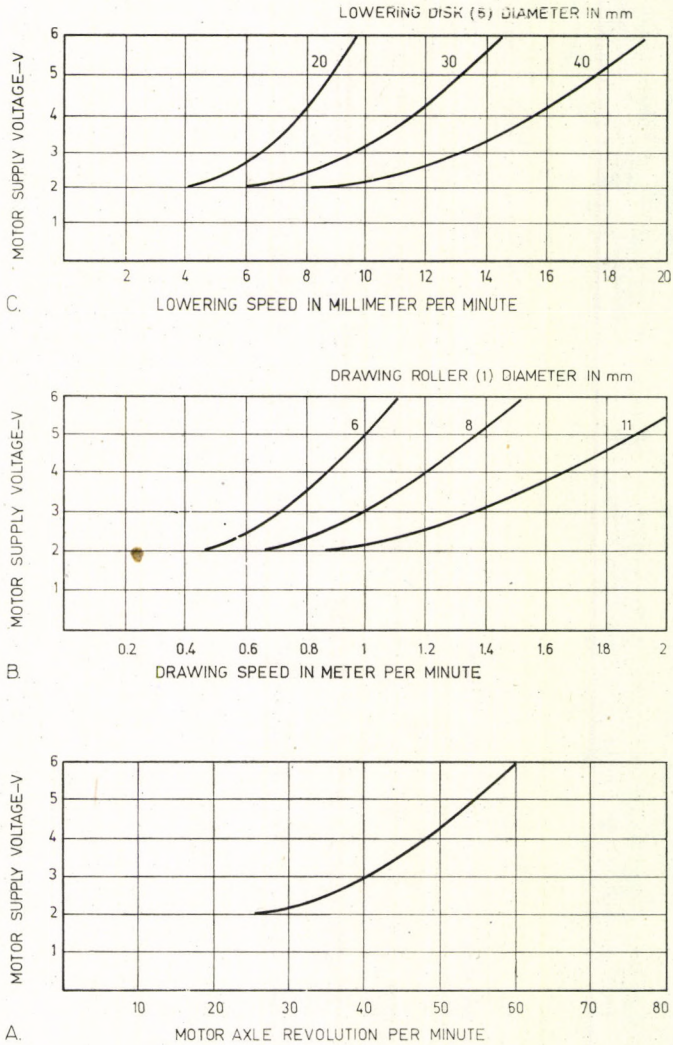


Fig. 2. Drawing parameter functions. *a)* Motor revolution, *b)* drawing speed, *c)* lowering speed

oven (10); 15 to 20 minutes after switching on the heating, the softening temperature of the glass is reached, and the glass may be slowly pulled out of the oven. The diameter of the pulled-out glass tube is reduced to 1. . 2 mm, and may thus be easily led through between the upper leading roller (11) and the drawing roller (1) and pressing roller (12). Switching on the supply voltage of the drawing motor, the continuous production of the capillar may now be started. The finished glass capillar (14) is available after passing between the lower leading rollers (13).

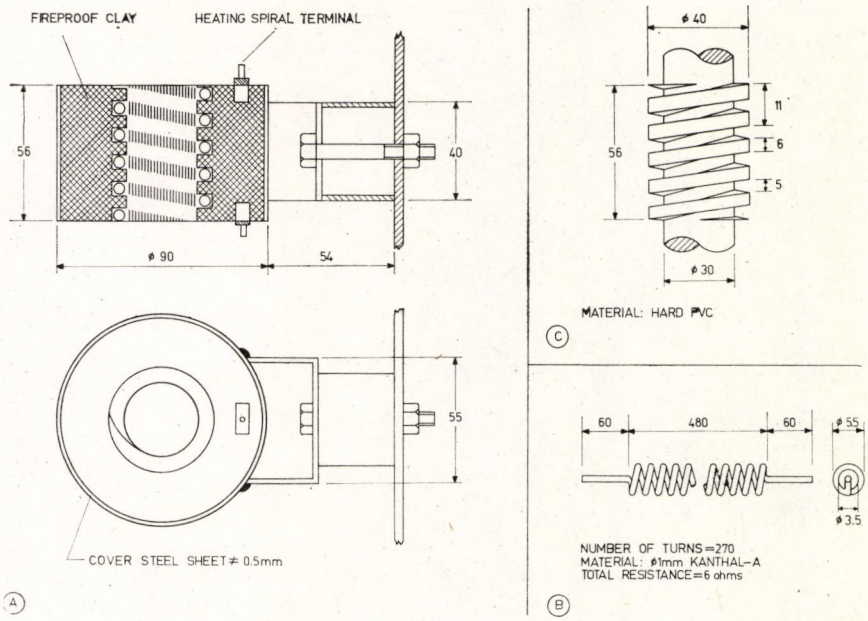


Fig. 3. Oven layout. *a)* Dimensional outlines of oven, *b)* heating spiral dimensions, *c)* forming tool for oven

During the capillar pulling-out process, the high diameter glass tube (9) has to be pushed in continuously into the oven (10), but with a reduced speed compared with the pulling-out speed. This task is provided by the 3-step lowering disk (6), lowering continuously the glass tube (9) into the oven (10) by means of a steel wire. The drawing roller (1) and the lowering disk (6) are engaged through a speed reducing cogwheel transmission (2, 3, 4) and a disconnecting clutch (5). Before the pulling is started, the position of the glass tube relative to the glass oven is adjusted by means of the clutch. The continuous pulling of the capillar is provided by a DC motor with a shaft on which drawing rollers (1) of different diameters may be fastened.

Fig. 2 a shows the revolution of the motor axle as a function of the supply voltage. The speed ranges available with drawing rollers (1) of different diameters are shown in *Fig. 2b*. *Fig. 2c* shows the speed ranges available with lowering disks of different diameters (6a, 6b, 6c).

The glass tube is melted in the oven illustrated in *Fig. 3a*. The oven contains fireproof clay within an iron shell. The clay is provided with a groove for holding the heating spiral. The spiral shown in *Fig. 3b* has been produced of Kanthal-A type material which has a maximum operating temperature of 1300 deg C, a melting point of 1510 deg C, and a specific resistance of 1.77 Ohms/m. The groove for holding the heating spiral has been pressed by means of the forming tool shown in *Fig. 3c*, embedded into the oven by means of fireproof clay mixed with glass-water. After drying, it has been turned out along the winding. Following this, the heating spiral was placed into the groove, and was heated to appr. 1000 deg C. The fireproof clay was thus drained totally and provided a high stability heating element.

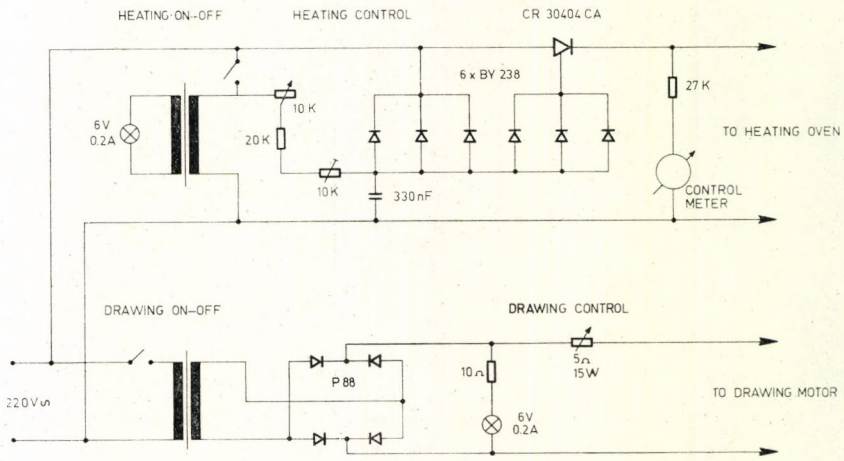


Fig. 4. Heater and drawing motor control circuit

The circuit diagram of the oven and the drawing motor control circuit is shown in *Fig. 4*. The heating power is controlled by a thyristor of type CR 30404 CA (AEI Semiconductors Ltd). At the beginning of the mains voltage negative half cycle, the thyristor is not conducting, and the 330 nF capacitor is charged to the negative peak voltage through the diodes. Following this, the capacitor voltage rises in the positive direction according to the RC time constant. During the mains voltage positive half cycle, the capacitor voltage reaches the level $U_{GT} + U_D = +3$ V needed for the thyristor ignition and for the conducting of the diodes connected to the thyristor control electrode, thus switching on the heating, and simultaneously disabling the control circuit. Heating power is controlled by the 10 kOhm potentiometer. Switched-on heating is indicated by a control lamp, and heating voltage is shown by a meter.

A 5 Ohm potentiometer serves for adjustment of the supply voltage of the drawing motor and thus for revolution control. Another control lamp serves for indicating the switched-on status of the drawing circuit.

The drawing machine is suitable for drawing capillars from glass tubes having diameters up to 25 mm. In our Institute, 17 mm glass tubes are used

from which capillars in the range between 0.5 and 4 mm may be drawn with suitably adjusted drawing, lowering and heating parameters. For electrophysiological investigations, glass materials having exceptionally good electrical properties are needed, so boro-silicate glass material is generally preferred.

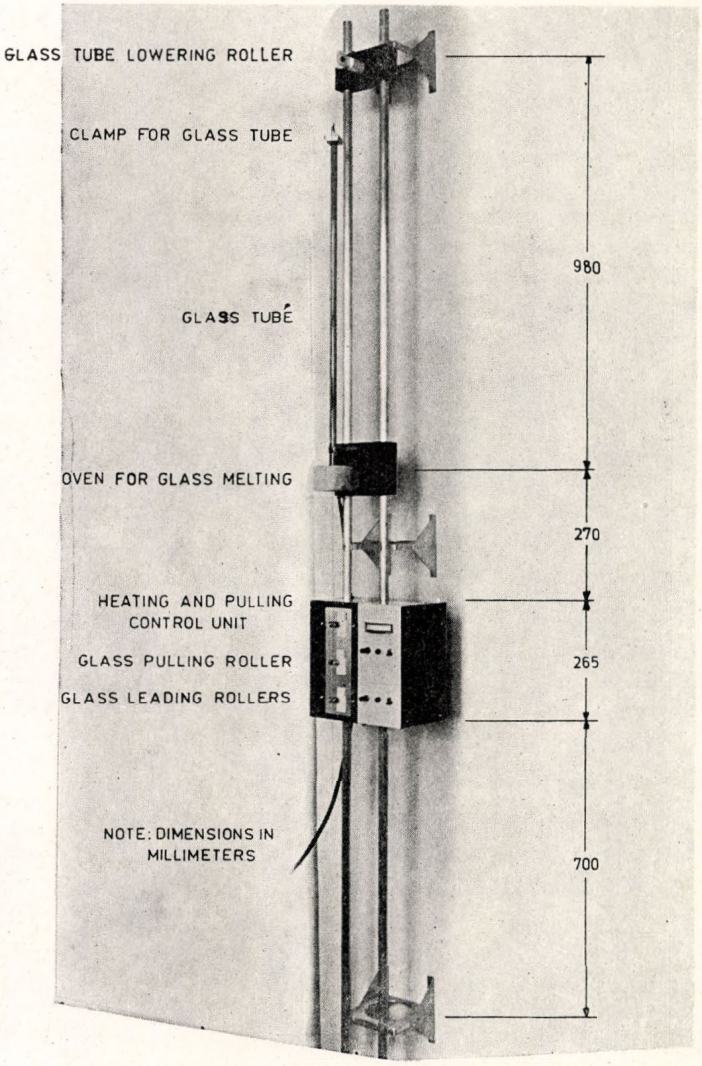


Fig. 5. Layout of the capillar drawing machine

Accordingly, Pyrex and Corning 7740 type glass material has been applied in our Institute (softening point at appr. 820 deg C) which proved to be suitable for microelectrodes having good electrical and mechanical properties.

The layout and more important dimensions of the capillar drawing machine developed in our Institute are shown in *Fig. 5*. The principle technical data are summarized in the following.

Specifications

Material to be drawn	glass tube which melts below 1300 deg C (Pyrex, Corning 7740), outer diameter max 25 mm, length max 900 mm
Drawing principle	drawing is accomplished by a lowering roller and a drawing roller which rotate at different speeds
Drawing ratio (typical data):	
increase of length (times)	50 80 100 150 250
decrease of diameter (times)	0.23 0.18 0.13 0.09 0.05
Adjustment of drawing ratio	by gears
Decrease of inner and outer diameters	at the same ratio
Non-uniformity of diameter	less than 5 % of the diameter
Drawing speed	48 cm/min min, 200 cm/min max
Lowering speed	4 mm/min min, 19 mm/min max
Electric oven temperature	1300 deg C max
Power requirement	220 volts AC, 10 A

Summary

A drawing machine of vertical arrangement, suitable for producing microelectrode capillars, is presented. Heating and drawing parameters of the machine are adjustable within wide ranges, and the machine is thus suitable for producing capillars from generally used glass materials meeting the measurement requirements. The required capillar diameter is easily adjustable, and the dimensions are reproducible with high accuracy during several drawing courses.

In the paper, mechanical and electrical performance of the machine, the control ranges of the drawing and heating parameters, the glass materials which may be applied, and the principle technical data are presented.

REFERENCES

Aktielbolaget Kanthal (1961): *Kanthal Handbook, AB John Antonsons Press, Göteborg*

Avelev V. D. S. A. Evdokimov (1967): Apparatus for automatic drawing of microelectrode capillaries. — *Fiziol. Zhurn.* **6,** 600—602 (in Russian)

Evdokimov S. A., O. A. Nikitin (1967): Continuous stretching of glass capillary tubes for preparing microelectrodes. — *Fiziol. Zhurn.* **2,** 216—218.

Harper C. (1970): *Handbook of Electronic Packaging. — McGraw-Hill Book Co., New York*

Lengyel B., Z. Boksay, B. Csákváry (1966): *Electrical Properties of Silicate Glasses. — Akadémiai Kiadó, Budapest* (in Hungarian)

Shimadzu Seisakusho ltd. (1973): Technical Data Bulletin Shimadzu glass drawing machine, type GDM-1.

ÜVEGKAPILLÁRIS HÚZÓ KÉSZÜLÉK ELEKTROFIZIOLÓGIAI MUNKÁKHOZ

Véró Mihály

Összefoglalás

A vertikális elrendezésű üveghúzó berendezéssel mikroelektródákhoz alkalmas kapillárisok készíthetők. A készülék fűtési és húzási paraméterei széles határok között változtathatók, így alkalmas arra, hogy az általánosan használt üveganyagokból a mérési követelményeknek megfelelő kapillárisokat húzzon. A kívánt kapilláris átmérő könnyen beállítható és a méretek többszöri húzásnál is nagy pontossággal reprodukálhatók.

A dolgozat részletesen ismerteti a készülék mechanikai és elektromos működésének részleteit, a húzási és fűtési paraméterek szabályozási tartományait, a használható üveganyagokat és a készülék fontosabb technikai adatait.

ANNAL. BIOL. TIHANY	43	37–42	HUNGARIA 1976

MOVEMENT INDICATOR FOR BIOLOGICAL OBJECTS WITH ELECTRO-OPTICAL SENSING DEVICE

MIHÁLY VÉRÓ

Biological Research Institute of the Hungarian Academy of Sciences, Tihany, Hungary

Received: 3rd February, 1976

In the course of complex electrophysiological investigations, e.g. investigation of muscle activity neuronal control, important information may be gained from recordings showing small movements of biological objects. For practical investigations of this kind, simultaneous multichannel microelectrode recordings and bipolar nerve recordings are applied, so conventional methods are difficult to apply for movement recordings. Conventional mechanical or electromechanical methods have further drawbacks such as their direct mechanical contact with the test object. In most cases, the preparation is damaged at the contact site, resulting in false recordings. Another drawback of conventional movement indicators is the loading of the test object which influences the movement, especially in the case of preparations of small sizes or having small movement energies.

All these problems are solved by electro-optical sensing devices developed during recent years. The movement indicator comprises opto-electronical elements, and operates on the reflection principle. The primary radiator is a light-emitting diode (LED), and the radiation reflected from the moving object is sensed by a phototransistor. This method has the great advantage of not being in direct contact with the test object, thus not loading the object, and is also suitable for recording high-speed movements. As the primary radiator LED operates in the infrared region, recordings may take place both in dark-

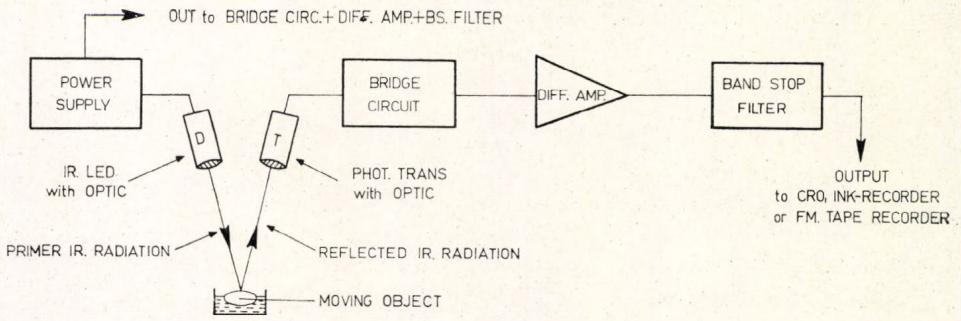


Fig. 1. Movement indicator functional block diagram

ness and during daylight or artificial light conditions. An important feature of the method is the negligible heating effect of the test object which is possible by the use of low intensity light sources, still providing high enough reflection from the preparation.

The functional block diagram of a movement indicator built in our Institute is shown in *Fig. 1.* The infrared radiation of light emitting diode D, which is reflected from the surface of the biological object, is sensed by phototransistor T. The detected signal level is dependent on the movement amplitude. The bridge circuit and the amplifier serve to compensate the constant interfering signals of different levels. Amplifier output is connected to a bandstop filter for eliminating 50 Hz mains interfering signals. The output signal

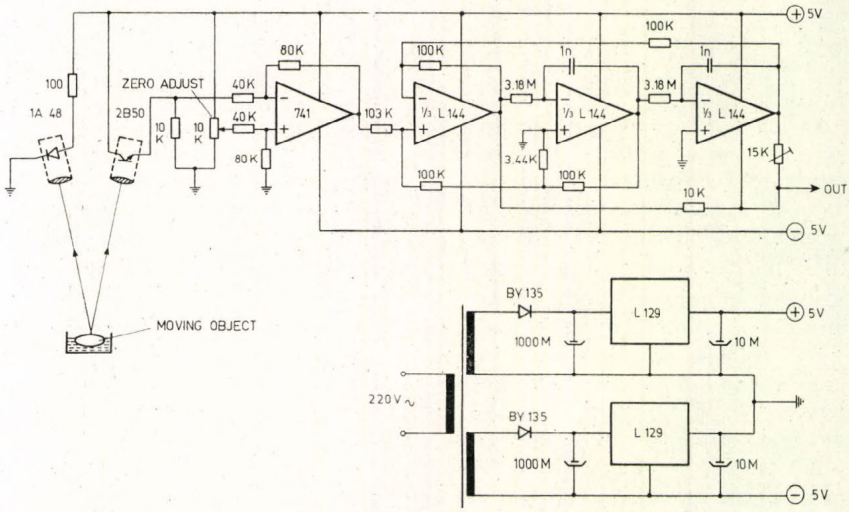


Fig. 2. Movement indicator circuit diagram

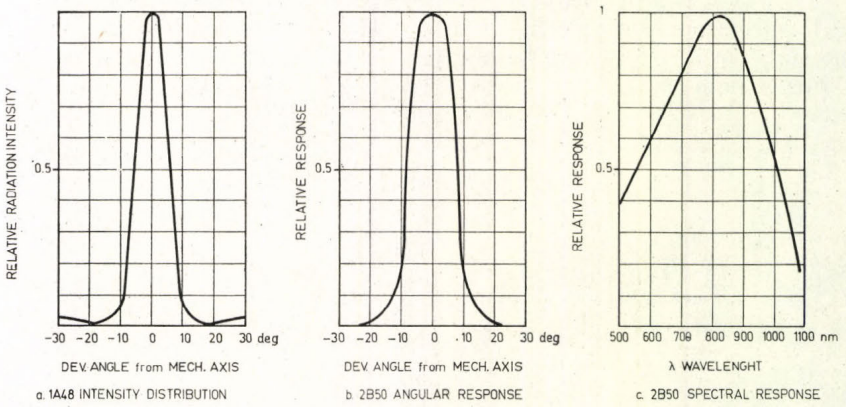


Fig. 3. Light emitting diode and photo transistor characteristics. *a)* Intensity distribution of 1A48 light emitting diode, *b)* angular response of 2B50 photo transistor, *c)* spectral response of 2B50 photo transistor

of the band-stop filter which is proportional to the movement amplitude is connected to an oscilloscope, a stripchart recorder or a tape recorder. A common power supply serves all circuits.

The detailed circuit diagram of the movement recorder is shown in *Fig. 2*. The primary radiator of the indicator is a GaAs light-emitting diode which emits light of wave length $\lambda = 940$ nm. The light-emitting diode is equipped

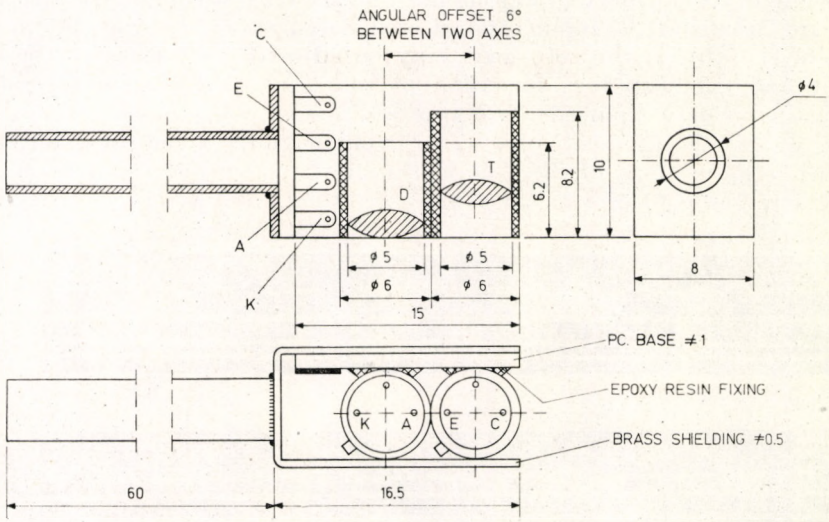


Fig. 4. Layout of the movement indicator sensing head, with principle dimensional outlines

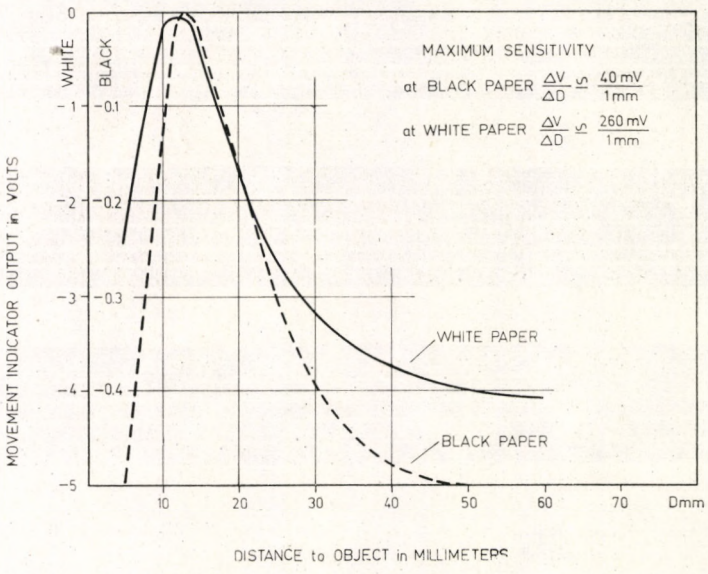


Fig. 5. Sensitivity response of the movement indicator

with an optical system limiting the radiation to a small area. *Fig. 3* shows the spatial distribution of the radiation in case of the applied type 1A48 IR-LED (ASEA-HAFO). The infrared radiation reflected from the object is sensed by a Si phototransistor. The directivity of the type 2B50 phototransistor (ASEA-HAFO) is provided by a built-in optical system resulting in an angular response as shown in *Fig. 3b*. The spectral response of the 2B50 phototransistor as a function of the wave length is shown in *Fig. 3c*. The phototransistor is operating in an emitter follower circuit, and the output signal is given through a bridge circuit on the input of a differential amplifier. During the quiescent state of the object, the zero level may be adjusted by means of the bridge circuit and the amplifier, for different reflecting surface and for different external interfering light effects of constant level. Zero level has to be adjusted before every measurement in order to avoid amplifier saturation during high amplitude movements of the object. The amplifier output is connected to an active band-stop filter which has the circuit of the universal active filter of

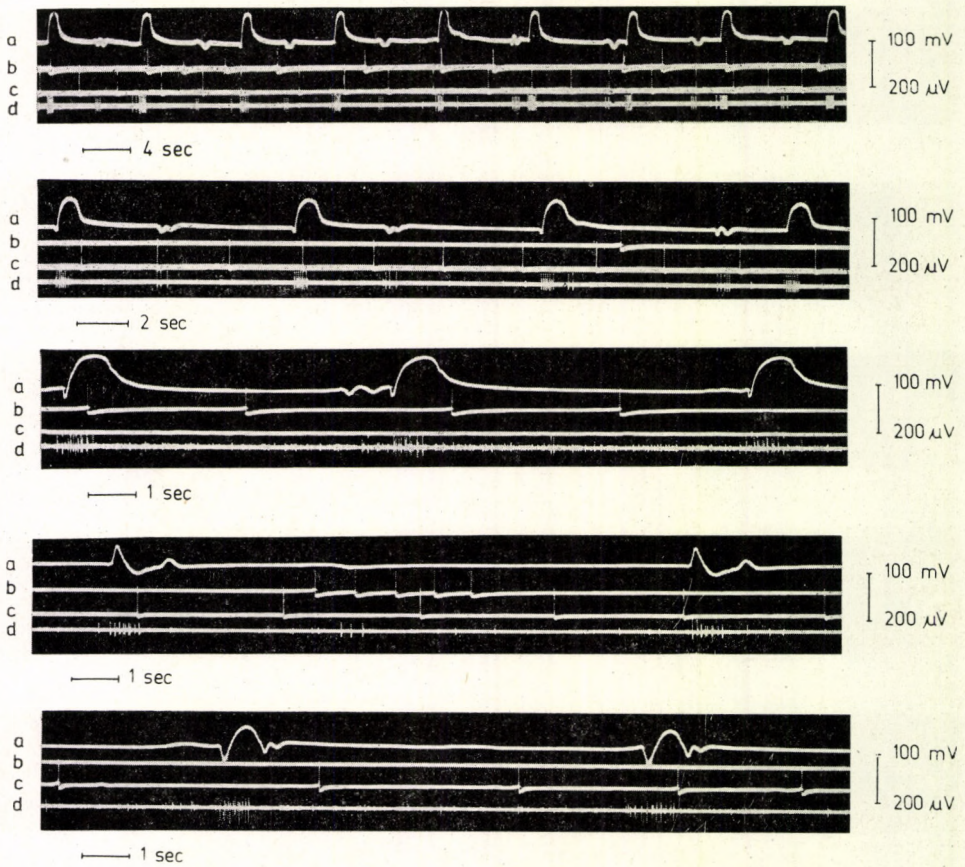


Fig. 6. Typical multichannel records from snail (*Helix pomatia* L). Trace *a)* — heart contraction, traces *b)* and *c)* — action potentials of two neurons, trace *d)* — nerve activity. The 100 mV calibration refers to traces *a*, *b*, *c*, the 200 μV calibration refers to trace *d*

type UAF 11/15 (Burr-Brown Res. Corp.). In the filter built in our Institute, a triple op-amp of type L 144 (Siliconix Inc.) is used, based on the data sheet of the UAF circuit (PSD-295A and AN-61 Application Note). Using the basic UAF 11/15 active filter, the suitable choice of four resistors yields a band-stop filter at a given frequency having small dimensions (but is equally applicable for band-pass, low-pass and high-pass purposes).

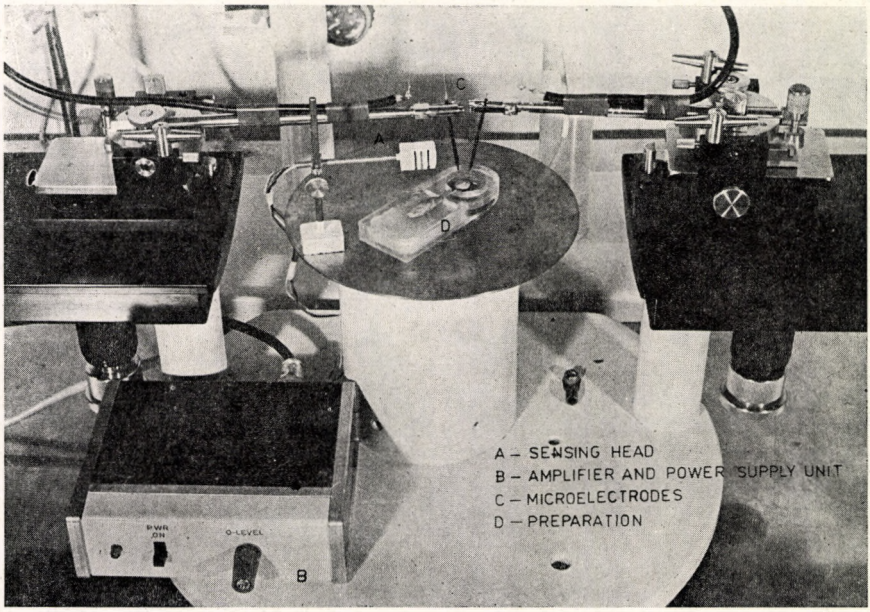


Fig. 7. Photograph of a measurement set-up showing the movement indicator and a test preparation with microelectrodes

A common ± 5 V power supply serves the light emitting diode, the phototransistor, the amplifier and the active filter. The supply voltages are regulated by 5 V voltage regulators of type L 129 (SGS-ATES) providing suitable low hum voltage needed by light-emitting diodes.

Layout of the movement indicator sensing head is shown in *Fig. 4.* The light-emitting diode and the phototransistor are fixed on separate stands in two assemblies and are adjustable by magnets near the test preparation. The sensing probe is connected by a cable to the amplifier and filter unit and to the power supply.

Fig. 5 shows the sensitivity reponse of the movement indicator as a function of distance to the object. The reference zero level has been adjusted in the focal point of the sensing part (F = 12.5 mm). The response has been traced by using black and white paper for reflecting surface, so the voltages generated by reflecting surfaces during practical measurements fall between the two curves. The *Figure* shows that a relatively high level signal is available even with surfaces having low reflection factors, thus insuring a suitable signal-to-noise ratio during movement indication.

Fig. 6 shows typical multichannel records of a snail (*Helix pomatia* L.): heart contraction, action potentials recorded by microelectrodes from two

central neurons, and bipolar recording of the heart nerve activity have been simultaneously investigated. On the recording of the heart movement, the movement effects are clearly visible, and at some parts, even the amplitude-time function of the auricle and ventricle contractions may be observed.

Fig. 7 shows a photograph of a measurement set-up including the movement indicator assemblies, the test preparation and the microelectrodes used for the recording. According to the experiences of our Institute, the movement indicator described is easily applicable to complicated multichannel electrophysiological measurements, and facilitates long-time recordings without damaging the preparation. Additionally to the applications mentioned, it may also be used for other kinds of investigations such as the recording of insect wing movements.

Summary

An electro-optical sensing device for recording movements of biological objects is presented, making possible considerable simplifications during recordings of small object movements. It is especially suitable for simultaneous multichannel recordings. In the paper, details are given from the electrical parameters and mechanical arrangement of the sensing part, and auxiliary circuits and their functions are described. The sensitivity response of the movement indicator and a practical recording prove that the output signal proportional to the movement shows high enough signal-to-noise ratio during measurements on actual biological test objects.

REFERENCES

Application Note for Universal Active Filters, AN-61 (1973): *Burr-Brown Res. Corp. Tucson, Arizona, USA.*

Lhotsky S., C. Phaneup, J. M. Langlois, S. Gagué, D. Poussart (1975): Optocardiography. In vivo measurements of the insect cardiac activity with a new optical method. — *J. Insect Physiol.* **21**, 237—248.

McPhie D. (1967): Gallium arsenide lamps — *Component Technology (from Plessey Company Ltd, UK) January* 1967, 28—30.

Opto-components Catalog (1974): ASEA-HAFO, Fack, S-16210, *Vallingby, Sweden.*

Universal Active Filter Catalog, PDS-29SA (1974): *Burr-Brown Res. Corp. Tucson, Arizona, USA.*

MOZGÁS-INDIKÁTOR BIOLÓGIAI OBJEKTUMOKHOZ ELEKTRO-OPTIKAI ÉRZÉKELŐVEL

Véró Mihály

Összefoglalás

A biológiai objektumok mozgásának regisztrálásához készült elektro-optikai érzékelő jelentősen egyszerűsíti a kisméretű objektumok mozgásának regisztrálását, mely különösen előnyös szimultán, több csatornás elvezetésnél. A dolgozat részletesen ismerteti az érzékelő rész elektromos paramétereit, mechanikai elrendezését, valamint a kiegészítő áramköröket és azok funkcióit. A mozgás-indikátor érzékenységi görbéje és gyakorlatból vett regisztrátum jól szemlélteti, hogy a mozgással analóg kimenő jel, megfelelő jel/zaj viszony mellett biztosítja a regisztrálást a biológiai gyakorlatban előforduló méréseknél.

ANNAL. BIOL. TIHANY	43	43–46	HUNGARIA 1976

ON THE OCCURRENCE OF TWO BLUE-GREEN ALGAE IN LAKE BALATON

ZSUZSANNA H.-BARTHA

Water Research Institute for Water Research (VITUKI), H-1095 Budapest, Kvassay J. Street 1, Hungary

Received: 27th February, 1976

New species of algae hitherto unknown in Lake Balaton appeared especially in recent years (H.-BARTHA, 1974; HAJDU, 1974; TAMÁS, 1972, 1974). The appearance and spreading of the new algae and reed-grass species (TÓTH, 1972) are most likely the results of a progressive eutrophication of Lake Balaton. In this paper the occurrence of a blue-green alga hitherto unknown from Lake Balatan, and the blooms of *Anabaena flos-aquae* appearing in spots in Lake Balaton are reported.

1. Appearance of *Gloeotrichia natans* (HEDW.) RABH. in the Fűzfő Bay

Stratiotes aloides L., a reed-grass having been a very rare species in Lake Balaton previously, has increased immensely especially in the northern basin of the lake during recent years (TÓTH, 1972). In 1974, experts of VITUKI made collections in order to study the biota of *Stratiotes* stands. On the 24th of July, 1974, some small-sized, pulpy colonies with a diameter of 2–4 mm were found on the leaf thorns of *Stratiotes aloides* L., collected in the environs of the beach of Fűzfő. These blue-green coloured, spherical colonies were formed by *Gloeotrichia natans* (HEDW.) RABH., a species of blue-green algae. Description of the material studies is as follows.

The colony is hard and more or less regularly spherical in shape, with a diameter of 2–4 mm. The internal filaments of the colony are radially arranged, the external ones are short and sporogenous. The length of mostly sporogenous, internal filaments attain about 1/2–2/3 of the radius of the colony. The filaments uniformly attenuate from the terminal heterocyst with increasing distances between the cells towards the end of the filament, and the single cells are linked together only by a thin mucus. The cells at the fore-part of the filament have a width of 10–11.2 μ and a length of 12.5 μ, while in the direction of the end of the filament their length ranges from 12.5 to 28.7 μ, and their width attains only 2–3 μ. The spherical, or flattened spherical heterocyst has a diameter of 17.5–21.2 μ, and seldom bears an equatorial plica on its surface. The solitary spore is placed behind the heterocyst. The yellowish-brown spore is cylindrical and narrows in the direction of its end. Its width ranges from 15

to 16.2 μ (7.5 – 10 μ at its narrower end), and its length varies between 46.2 and 57.7 μ. Around the spore a colourless, 40 to 41.2 μ wide mucous capsule can be seen *(Fig. 1)*. According to the literature data, this species is new to Lake Balaton. The appearance and rapid spreading of the reed-grass species in Lake Balaton produced new habitats making the appearance of this new species possible.

2. The blooms of *Anabaena flos-aquae* (Lyngb.) Bréb. appearing in spots at the pier of Keszthely

On the 3rd of September, 1974, László Tóth, an expert of VITUKI observed some blue-green spots of 10 cm in diameter situated above the littoral reed-grass stands between the pier of Keszthely and Büdös-canal from which he collected samples. At the time of collecting and prior to sampling the weather was warm and calm. Having studied the water samples it was established that the blooms appearing in small spots were exclusively produced by *Anabaena flos-aquae* (Lyngb.) Bréb., one of the blue-greens *(Fig. 2a)*. Up to the present, two variaties of this species were known from Lake Balaton: f. *jacutica* (Kissel.) Elenk., and var. *gracilis* Kleb. (Hortobágyi, 1943, 1962). Description of the collected material is as follows.

The solitary filaments without mucus have a regular spiral form, or they are irregularly curved *(Figs 2c, d, e)*. Most frequently they constitute only

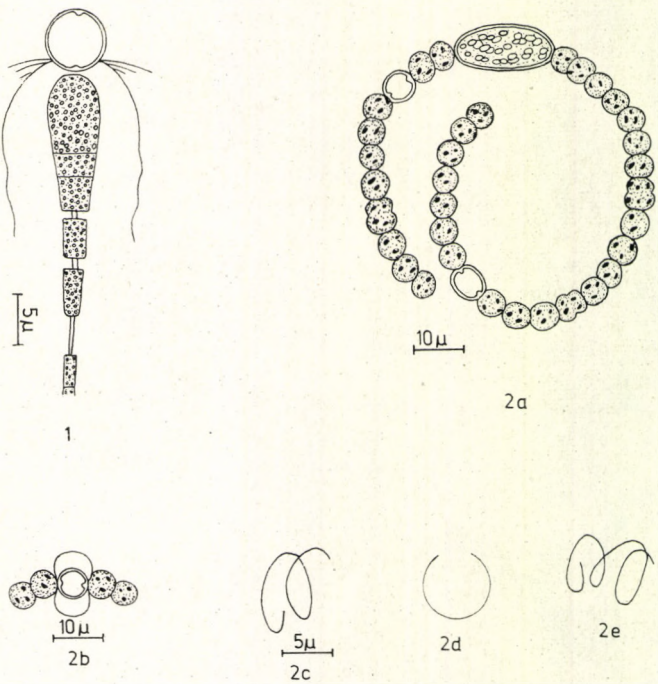


Fig. 1. Gloeotrichia natans (Hedw.) Rabh.
Fig. 2. Anabaena flos-aquae (Lyngb.) Bréb. *a* — trichome with heterocysts and spores, *b* — heterocyst with an inflated external membrane, *c, d, e* — filaments of various shape

in a circular form. Intervals between the turnings of regularly twisted filaments range from 9 to 12.5 (18.7) μ, but occasionally they are quite close to each other. The width of turnings varies between (20) – 55 and 61 μ. The vegetative cells filled with vacuoles have a spherical, or flattened spherical shape, their width is about (4) – 6.2 – 7.5 – (8.7) μ. The heterocysts are usually spherical (with a diameter of 7.5 μ), and rarely ellipsoidal having about 8.7 – 10 μ width and 10 – 11.2 μ length. The solitary heterocysts of intercalar position are situated far from the spores. In some specimens of the material fixed in formaldehyde solution an inflated external membrane could be seen *(Fig. 2b)*. According to KOMÁREK and ETTL (1958), they are only spontaneous products having no taxonomic value. The solitary spores of 10.5 – 15 μ width and 16 – 22.5 μ length are cylindrical, straight, or slightly curved, and their uncoloured wall is smooth. The young spores are already longer than their width.

The above description perfectly corresponds to that of *Anabaena flos-aquae* (LYNGB.) BRÉB. f. *aptekariana* ELENK. (ELENKIN, 1938, p. 729; HOLLERBACH et al., 1953, p. 266). The specimens studied by us differ from the above mentioned f. *jacutica*, described from Lake Balaton previously, in the number of spores and their relative position, as well as from the var. *gracilis* in their measurements.

These variants and forms distinguishable in nature had been combined by modern taxonomists into the species. This, however, seems to be incorrect, because the remote appearance in space and time of the three variants described from Lake Balaton conveys different information. It is highly probable that the appearance of f. *aptekariana* ELENK. may be in close connection with the advanced eutrophication of the Keszthely Bay.

Summary

The paper reports the appearance of a blue-green alga, new for the flora of Lake Balaton. The hard, pulpy colonies of *Gloeotrichia natans* (HEDW.) RABH. with a diameter of 2 – 4 mm were found on the leaf thorns of *Stratiotes aloides* L., collected in the environs of the beach of Fűzfő on the 24th of July, 1974. The appearance and rapid spreading of *Stratiotes aloides* L., and other reed-grass species in Lake Balaton produced new habitats making the appearance of new species possible. This fact has been proved by the presence of *G. natans*.

On the 3rd of September, 1974, blooms of *Anabaena flos-aquae* (LYNGB.) BRÉB. appearing in spots with a diameter of about 10 cm were observed above the littoral reed-grass stands between the pier of Keszthely and Büdös-canal. According to ELENKIN's description, the specimens in the material collected perfectly correspond to that of *Anabaena flos-aquae* f. *aptekariana*. Up to the present, *A. flos-aquae* f. *jacutica* and var. *gracilis* have been detected in Lake Balaton. These variants and forms distinguishable in nature had been combined by modern taxonomists into the species. This, however, seems to be incorrect, because the remote appearance in space and time of the three variants described from Lake Balaton conveys different information.

REFERENCES

H.-Bartha Zs. (1974): The occurrence of *Aphanizomenon issatschenkoi* (Ussaczew) Proschkina—Lawrenko in Lake Balaton. — *Annal. Biol. Tihany* **41**, 127—131.

Elenkin A. A. (1938): Monographie algarum Cyanophycearum aquidulciumet terrestrium infinibus URSS inventarum. — *Acad. Nauk. SSSR*, p. 984.

Hajdu L. (1975): A *Paraphysomonas vestita* (Stokes) De Saedeleer előfordulása hazánkban. — *Bot. Közl.* **62**, 9—12.

Hollerbach M. M., E. K. Kosinskaja, V. I. Poljanskij (1953): Голлербах, М. М., Е. К. Косинская, В. И. Полянский: Синезеленые водоросли. — *Определитель пресноводных водорослей СССР* **2**, *Москва*, стр. 652.

Hortobágyi T. (1943): Adatok a Balaton boglári sestonjában, psammonjában és lasionjában élő moszatok ismeretéhez. — *Magyar Biol. Kut. Int. Munk.* **15**, 75—127.

Hortobágyi T. (1962): Két vízvirágzás a Balatonban. — *Bot. Közl.* **49**, 233—237.

Komárek J., H. Ettl (1958): Algologische Studien. — Nakl. ČAV, Praha, 1—358.

Kondratjev N. V. (1968): Кондратьев, Н. В.: Визначник пресноводних водоростей украинськой РСР **2**, *Киев*, стр. 523.

Starmach K. (1966): Cyanophyta — Glaucophyta. — *Flora Słodkowodna Polski* **2**, 1—807.

Tamás G. (1959): Algenflora des Balatonsees 1938—1958. — *Annal. Biol. Tihany* **26**, 349—392.

Tamás G. (1964): Die Algenflora des Balaton-Sees (Zusammengestellt nach Angaben aus den Jahren 1959—1963). — *Annal. Biol. Tihany* **31**, 245—253.

Tamás G. (1972): The occurrence of *Rhizochrysis limnetica* G. M. Smith in the plankton of Lake Balaton. — *Annal. Biol. Tihany* **39**, 149—150.

Tamás G. (1974): The occurrence of *Rhaphidiopsis mediterranea* Skuja in the plankton of Lake Balaton. — *Annal. Biol. Tihany* **41**, 317—321.

Tóth L. (1972): A Balaton hinarasodásának jelenlegi állapotáról. — *VITUKI Vízm. Víztechn. Kut. Eredm.* **2**, 16—25.

KÉT KÉKALGA-FAJ ELŐFORDULÁSA A BALATONBAN

H.-Bartha Zsuzsanna

Összefoglalás

A dolgozat egy, a Balatonból eddig ismeretlen algafaj megjelenéséről számol be. A *Gloeotrichia natans* (Hedw.) Rabh. a fűzfői strand előtt 1974. VII. 24-én gyűjtött *Stratiotes aloides* L. leveleinek tüskéiről került elő, ahol 2—4 mm átmérőjű, kemény, kocsonyás telepeket alkotott. A *Stratiotes aloides* L. és a többi hínárfaj megjelenése és térhódítása a Balatonban új élőhelyeket teremtett, amelyek új fajok megjelenését teszik lehetővé, mint azt a *G. natans* megtelepedése is bizonyítja.

Az *Anabaena flos-aquae* (Lyngb.) Bréb. 1974. szept. 3-án a keszthelyi móló és a Büdös árok között, a parti hínár fölött 10 cm átmérőjű foltokban jelentkező vízvirágzást okozott. A gyűjtött anyag egyedei megjelenésükben tökéletesen megegyeztek az Elenkin által leírt *Anabaena flos-aquae* f. *aptekariana* Elenk.-nel. A Balatonból eddig az *A. flos-aquae* f. *jacutica*-t és a var. *gracilist* mutatták ki. Az újabb algarendszerezők ezeket a természetben megkülönböztethető változatokat és alakokat a tőfajba vonták, ez azonban nem látszik helyesnek, mert pl. a Balatonból leírt 3 változatnak helyben és időben egymástól távoli megjelenése különböző információ tartalmuk mellett szól.

ANNAL. BIOL. TIHANY	43	47–67	HUNGARIA 1976

THE GROWTH OF ASP *ASPIUS ASPIUS L.*) IN LAKE BALATON AND THE SELECTIVE EFFECTS OF COMMERCIAL FISHERIES ON POPULATION STRUCTURE

PÉTER BÍRÓ and GYÖRGY FŰRÉSZ

Biological Research Institute of the Hungarian Academy of Sciences, Tihany, Hungary, and University of Agriculture, Gödöllő, Hungary

Received: 27th February, 1976

Asp is widely distributed in North and Central Europe, as well as in the catchment basins of the Black, Caspian and Aral Seas. The only predatory cyprinida is common in Lake Balaton and inhabits almost all other Hungarian waters, too.

Due to deterioration of water quality having occurred especially during the last decade the fish fauna of Lake Balaton has significantly changed. According to studies on the most numerous species, modifications in their growth rate and population structure have been observed as compared to previous years (BÍRÓ, 1970; 1972; 1973; BÍRÓ and GARÁDI, 1974).

The growth of asp in Lake Balaton has not yet been studied. Since it is an important member of the fish fauna, the aim of our work was to determine its growth at different areas of the lake. Furthermore, the population structure, rates of mortality and production as well as the regulating effects of the fisheries on the stock have been studied.

Material and methods

The material of our scale investigations was sampled from among the fish caught with 1000 m long nets randomly on the fishery stations of Siófok, Tihany, Balatonszemes, Fonyód and Keszthely during July–October, 1974 – 75. The selected sampling places represent differently eutrophicated areas of the lake along its longitudinal axis. Their standard and total length and weight were measured; 15 – 20 scales were detached from the surface above the lateral line between the posterior margin of the pectoral and the first ray of the dorsal fins. 496 specimens were studied in 1974. In 1975 further 217 specimens were measured and scales from 107 fish were collected for ageing. During the two years altogether 713 fish were studied amongst them the age and growth of 599 specimens were analyzed in details. After cleaning, about 10 well-developed wet scales were placed between slides and studied with profile projector at a 40-times magnification. Ageing of fish was done by the number of winter marks developed on the scales. The total lateral radii (R) and the annual ring distances from the focus were measured. On the basis of measured length and weight data the length–weight relationship was calculated according to HUXLEY (1924) cit. BEVERTON and HOLT, 1957). The regression between the standard

lengths and the total lateral radii of scales was determined by the least square method. The intercept of the line on the abscissa was taken into consideration as a correction factor in the back-calculation of fish lengths (FRASER, 1916). Maximum standard length attained was estimated graphically according to FORD – WALFORD's method (WALFORD, 1946). BERTALANFFY's (1938, 1957) growth-model was applied for correct comparison of the growth rates using the back-calculated standard length of fish caught at different areas of Lake Balaton. Rates of mortality and survival were estimated according to age-composition of the sample (RICKER, 1958). Biomass and its relative production were assessed according to RICKER and FOERSTER (1948) and RICKER (1958) for the most intensively exploited age groups from 3+ to 10+. The instantaneous coefficients of growth in weight necessary to the assessment of production were calculated after CHAPMAN (1968) and TESCH (1968). On the basis of age distribution of fish in the sample "resultant" selection ogives were constructed (BEVERTON and HOLT, 1957). When estimating the age selection of 1000 m long nets of 3.5 – 4 cm mesh, the same method was applied.

Results

1. Length distribution

The standard lengths of 599 asps studied in 1974 – 75 varied between o0 – 62 cm. Length distribution histograms of fish collected at different areas 3f Lake Balaton apart from smaller differences were asymmetrical. In the

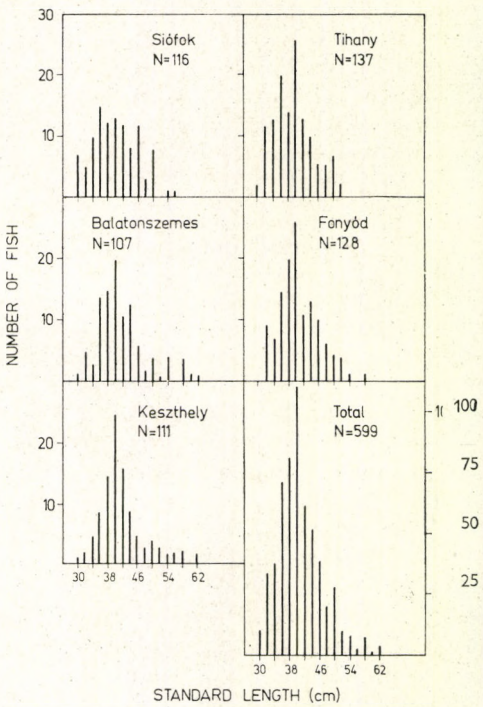


Fig. 1. Histograms of standard length distribution of asps caught at different areas of Lake Balaton

environs of Siófok the length of specimens ranged from 36 to 50 cm, while at other places of the lake fish about 40 cm predominated. According to the 599 specimens investigated, the average standard length of asps caught in Lake Balaton was 42.2 cm. Fish of greater length up to 62 cm can be caught more frequently at the south-western part (environs of Balatonszemes, Keszthely Bay) of the lake *(Fig. 1)*. Standard length of about 80–85 per cent of asps caught by fishermen in Lake Balaton ranges from 32 to 46 cm.

2. Length–weight relationship

The regression coefficient of the relationship was found to be b = 2.5985 according to the length and weight data collected at 5 different areas of Lake Balaton *(Fig. 2)*. Altough the length distribution of the fished stock is relatively uniform, territorial and seasonal differences of length–weight relationship

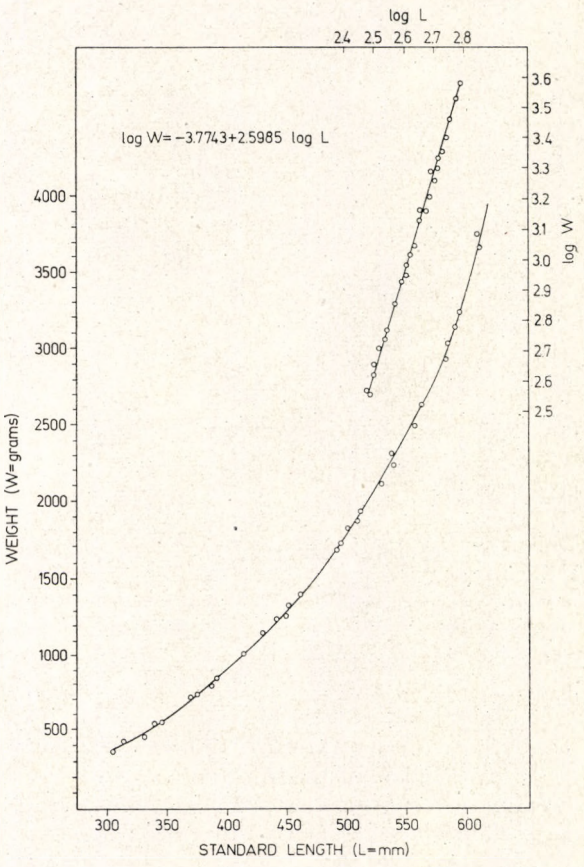


Fig. 2. Length–weight relationship in asp of Lake Balaton

should have been in relation to food consumed and condition. From the shape of the curve it seems that a greater specific weight belongs to the unit of growth in length especially above 40 – 45 cm standard length of asp.

3. Growth of scales in relation to the standard length and age

The majority of about 6000 scales examined taken from 599 asps was symmetrically developed. The annual marks developed on normal scales could be distinguished without difficulties in contrast to findings on the scales of other Balaton fish. Only in older fish about 30 – 40 per cent of the scales examined showed deformations, irregularly developed marks as well as damages and regenerated spots. The relationship between the standard lengths and the total lateral radii of scales is well represented by the calculated linear regression. Its intercept on the abscissa is 7.89 mm *(Fig. 3)*.

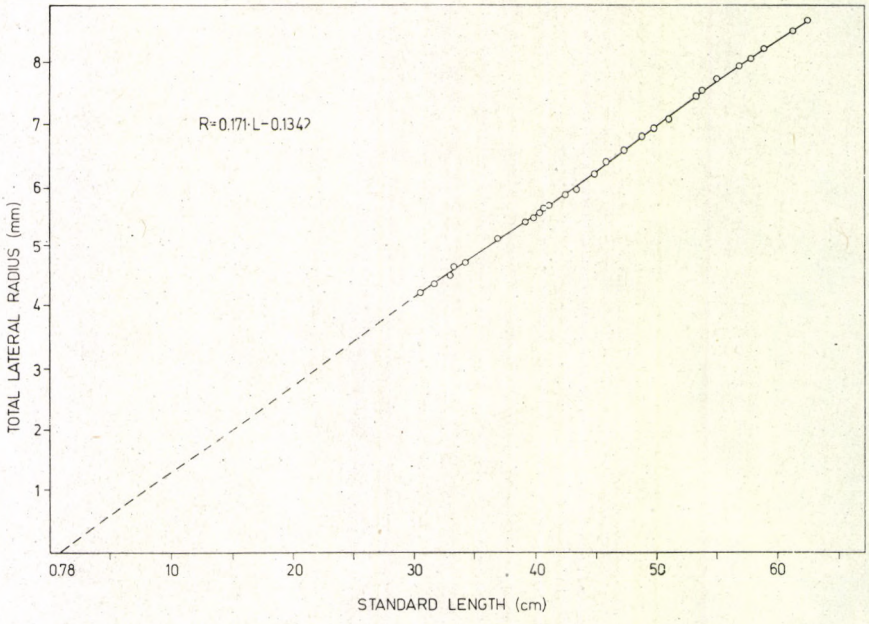


Fig. 3. Linear regression of average lateral radii of scales (R) in the function of standard lengths (L) established for selected specimens of asp

A stepped, gently S-shaped relationship seems to exist between the standard lengths and the average annuli distances established for specimens in age groups 3+ to 11+ collected at different areas of Lake Balaton. Their mean growth, however, is more balanced *(Fig. 4)*. Between age groups 3+ to 11+ the following averages were measured in mm: 4.69, 5.29, 5.69, 6.16, 6.76, 7.04, 8.40 and 8.66. Total lateral radii of scales of older fish (from age group 6+ upward) grow annually in a relatively smaller extent.

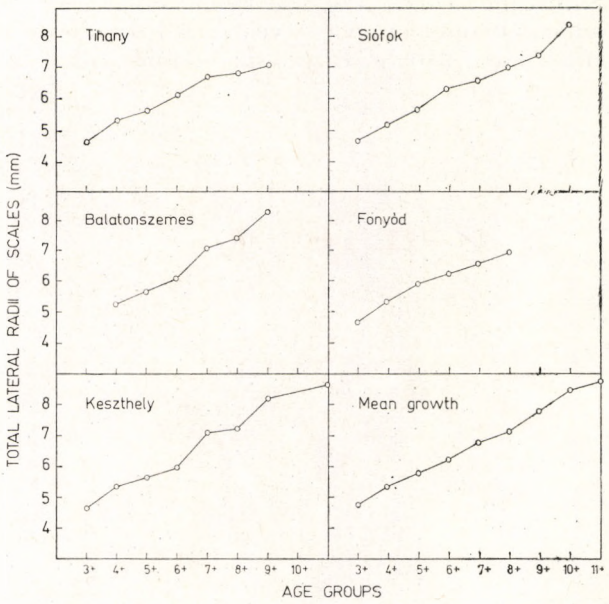


Fig. 4. Average lateral radii of scales measured by age-groups

4. Growth in standard length and weight

According to the measured standard lengths of specimens in different age groups their average growth seems to be uniform, nevertheless, definite areal deviations in rate of growth were observed especially in Keszthely Bay. Deviation from the mean in an age group resulted in about $\pm 1-7$ cm difference *(Fig. 5)*. Trends of changes in weight are just the same as in length.

TABLE I

Mean standard lengths back-calculated from scales of asps caught in the environs of Siófok

Age groups	Year class	N	Standard lengths (mm)									
			l_1	l_2	l_3	l_4	l_5	l_6	l_7	l_8	l_9	l_{10}
3+	1971/72	17	95	203	299	–	–	–	–	–	–	–
4+	1970/71	34	95	195	281	346	–	–	–	–	–	–
5+	1969/70	26	95	203	281	338	383	–	–	–	–	–
6+	1968/69	20	96	203	289	346	395	437	–	–	–	–
7+	1967/68	15	101	212	271	345	388	427	465	–	–	–
9+	1965/66	3	88	171	269	356	402	433	460	487	510	–
10+	1964/65	1	103	197	301	356	396	430	464	496	527	554
Average:			96	197	284	347	392	431	463	491	518	554
Total:		116										

In environs of Siófok and Tihany the growth in weight from the fifth year of age is faster when compared to previous years, and the weight of oldest specimens is between 2200 and 2800 g. In the surroundings of Balatonszemes, the

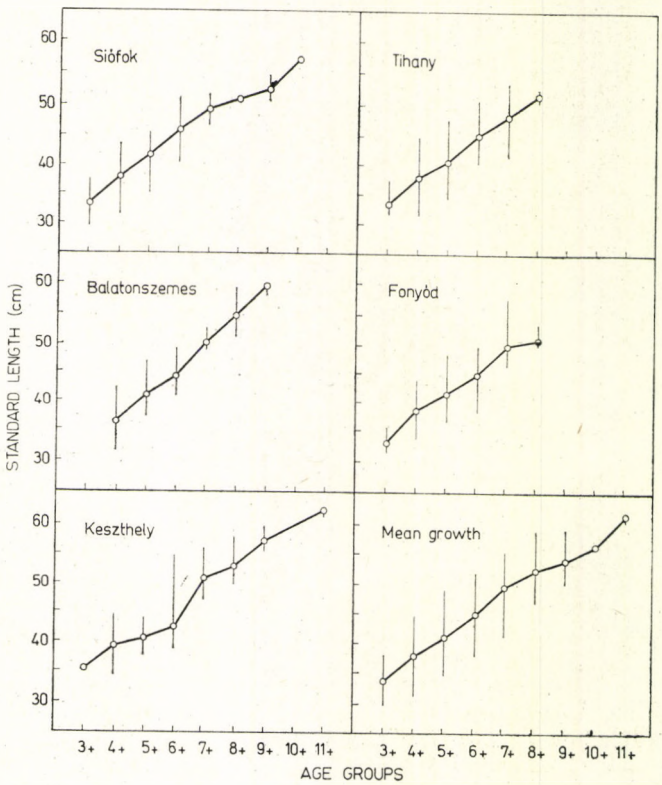


Fig. 5. Measured standard lengths in various age groups of asps caught at five different areas of Lake Balaton

TABLE II

Mean standard lengths back-calculated from scales of asps caught in the environs of Tihany

Age groups	Year class	N	Standard lengths (mm)								
			l_1	l_2	l_3	l_4	l_5	l_6	l_7	l_8	l_9
3+	1971/72	12	94	204	300	—	—	—	—	—	—
4+	1970/71	57	93	216	301	350	—	—	—	—	—
5+	1969/70	32	96	199	272	332	379	—	—	—	—
6+	1968/69	24	93	192	265	325	371	411	—	—	—
7+	1967/68	9	104	207	292	343	390	432	470	—	—
8+	1966/67	2	100	219	292	348	395	431	464	496	—
9+	1965/66	1	102	243	300	342	382	408	431	452	484
Average:			97	211	288	340	383	420	455	474	484
Total:		137									

rate of growth in weight is more rapid compared to other parts of the lake and asps in their fifth year of age usually have more than 1000 g body weight. From this time on their growth in weight is intensive and the greatest specimens attain about 3300 g. In the environs of Fonyód and Keszthely Bay the mean weight of fish grows at a more steady rate. In the vicinity of Fonyód the biggest asp had a weight of 2200 g and that in the Keszthely Bay about 3800 g. Here specimens of greater body weight often occur. By age groups

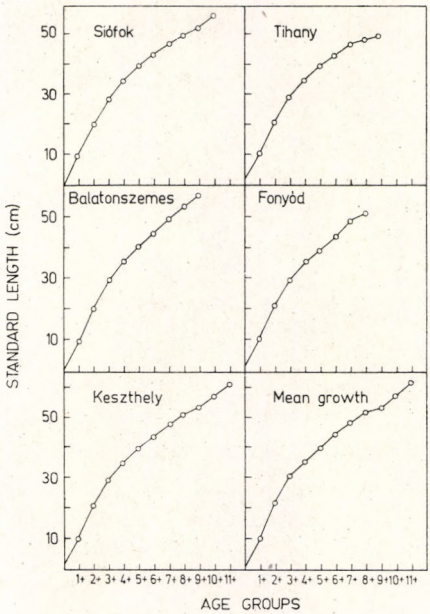


Fig. 6. Mean growth in standard length back-calculated from the annual marks developed on the scales of asps at different areas of the lake

TABLE III

Mean standard lengths back-calculated from scales of asps caught in the environs of Balatonszemes

Age groups	Year class	N	Standard lengths (mm)								
			l_1	l_2	l_3	l_4	l_5	l_6	l_7	l_8	l_9
3+	1971/72	5	—	—	—	—	—	—	—	—	—
4+	1970/71	31	93	206	275	349	—	—	—	—	—
5+	1969/70	31	95	205	285	344	388	—	—	—	—
6+	1968/69	25	97	211	290	345	388	426	—	—	—
7+	1967/68	6	98	218	296	348	398	440	480	—	—
8+	1966/67	4	108	226	314	374	420	261	496	528	—
9+	1965/66	4	91	217	309	373	422	465	503	535	566
Average:			97	213	294	355	403	448	493	531	566
Total:		106									

(from 3+ to 11+) the following annual mean growth in weight were registered in grams: 562, 809, 1008, 1337, 1866, 2261, 2788, 2840 and 3712.

On the basis of standard lengths back-calculated from the scales, the growth in length of asp at different areas of Lake Balaton is more smoothed than the measured averages *(Fig. 6, Tables I—VI)*. It is conspicuous that changes in body measurements of 8—11 year-old specimens are also intensive especially in the environs of Siófok, Balatonszemes and Keszthely Bay. Differences between measured and back-calculated average standard lengths are relatively small.

Analyzing the growth in length of different age groups by year class strengths, different rates of growth were observed in age-groups up to 6+ and then from 7+ upward. This deviation appeared chiefly in the Keszthely Bay in contrast to the environs of Siófok and Balatonszemes *(Fig. 7)*. The back-calculated standard lengths in different areas were graphically represented according to WALFORD's (1946) method and theoretically attainable maximum lengths (L_∞) were derived. For Lake Balaton on an average it was 68.2 cm.

TABLE IV

Mean standard lengths back-calculated from scales of asps caught in the environs of Fonyód

Age groups	Year class	N	Standard lengths (mm)							
			l_1	l_2	l_3	l_4	l_5	l_6	l_7	l_8
3+	1971/72	13	97	205	306	–	–	–	–	–
4+	1970/71	43	94	204	289	356	–	–	–	–
5+	1969/70	36	97	203	282	342	394	–	–	–
6+	1968/69	23	97	207	292	345	389	428	–	–
7+	1967/68	10	104	222	303	357	401	443	484	–
8+	1966/67	3	97	212	281	355	386	432	468	507
Average:			97	208	292	351	392	434	476	507
Total:		128								

TABLE V

Mean standard lengths back-calculated from scales of asps caught in the Keszthely Bay

Age groups	Year class	N	Standard lengths (mm)									
			l_1	l_2	l_3	l_4	l_5	l_6	l_7	l_8	l_9	l_{10}	l_{11}
3+	1971/72	7	83	205	337	–	–	–	–	–	–	–	–
4+	1970/71	23	93	213	298	367	–	–	–	–	–	–	–
5+	1969/70	34	93	204	280	336	381	–	–	–	–	–	–
6+	1968/69	29	93	195	268	321	362	403	–	–	–	–	–
7+	1967/68	9	108	210	283	337	391	444	487	–	–	–	–
8+	1966/67	4	108	217	298	358	395	435	474	512	–	–	–
9+	1965/66	3	96	199	286	361	414	458	496	528	556	–	–
11+	1963/64	2	108	205	302	368	414	453	487	517	545	576	602
Average:			97	206	294	349	392	438	486	519	550	576	602
Total:		111											

TABLE VI

Mean standard lengths back-calculated from scales of asps caught at five different areas of Lake Balaton

Age groups	Year-class	N	Standard lengths (mm)										
			l_1	l_2	l_3	l_4	l_5	l_6	l_7	l_8	l_9	l_{10}	l_{11}
3+	1971/72	54	92	204	310	–	–	–	–	–	–	–	–
4+	1970/71	188	93	206	288	353	–	–	–	–	–	–	–
5+	1969/70	159	95	202	280	338	385	–	–	–	–	–	–
6+	1968/69	121	103	201	280	336	381	421	–	–	–	–	–
7+	1967/68	49	103	213	289	346	393	437	477	–	–	–	–
8+	1966/67	13	103	218	296	358	399	439	475	510	–	–	–
9+	1965/66	11	94	207	291	358	405	441	472	500	529	–	–
10+	1964/65	2	103	197	301	356	396	430	464	496	527	554	–
11+	1963/64	2	108	204	302	368	414	453	487	517	545	576	602
	Average:		96	206	290	348	392	434	474	504	529	565	602
	Total:	599											

Parameters involved in BERTALANFFY's (1938, 1957) growth model were $t_0 = -0.63$ year and $K = 0.1518$. The last one in the asymptotic model *(Fig. 8)* indicates the rate of growth. Insignificant territorial differences in the K-values ($0.10 < P < 0.05$) have been observed. Higher K-constants combined with smaller L_∞-values represent a more intensive growth rate of younger age groups (up to 7+) in the environs of Tihany and Fonyód compared to other parts of the lake. Though, the annual growth in age groups 1+ to 11+

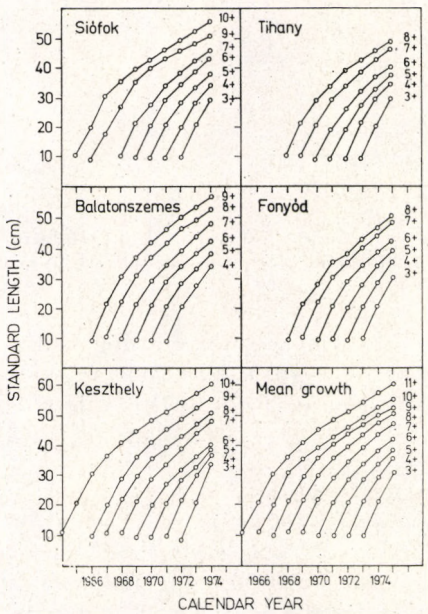


Fig. 7. Growth by year-class strength of various age groups in Lake Balaton

in the surroundings of Siófok, Balatonszemes and Keszthely is slower and more uniform, the attainable maximum lengths here surpass by some 10 – 17 cm those that could be registered in the vicinity of Tihany and Fonyód. Their deviation from the mean, however, have been insignificant. Comparing the

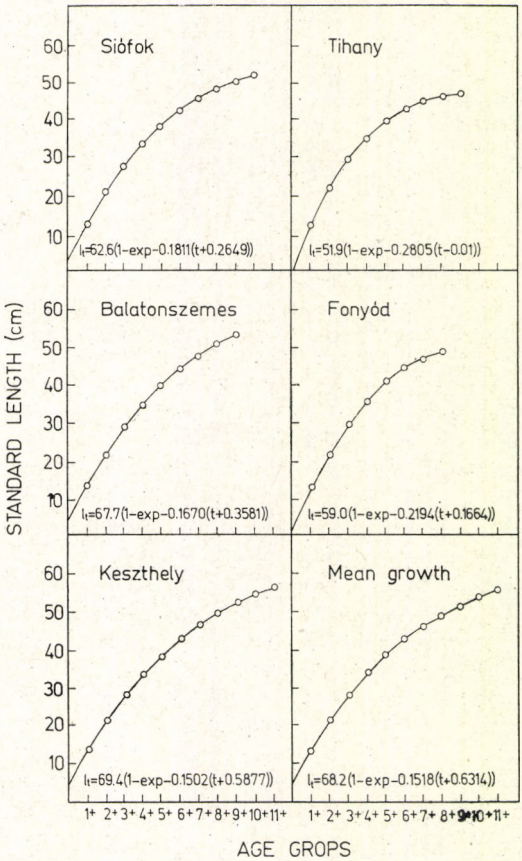


Fig. 8. Asymptotic growth in length of asp in Lake Balaton represented by BERTALANFFY's (1938, 1957) growth model; l_t = standard length in every t-period of time in cm, if t = 1 year

values back-calculated from the scales according to FRASER (1916) and those represented after WALFORD's (1946) and by BERTALANFFY's (1938, 1957) model, there is a maximum deviation of 4 cm in the different age groups.

5. *Age distribution*

From the asps studied in 1974 – 75, altogether 599 specimens were aged on the basis of the number of completely developed annuli and counted to age groups 3+ to 11+. The overwhelming majority of fish caught in Lake Balaton belonged to age groups 4+ to 6+. The age distribution of asps likewise that of the length was asymmetrical *(Fig. 9)*.

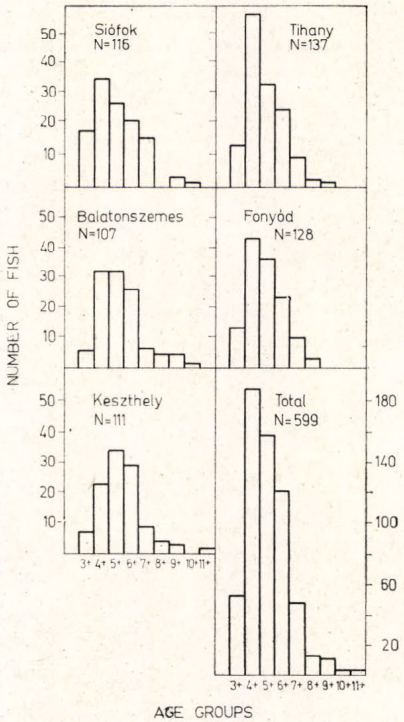


Fig. 9. Age distribution of asps originated from five different areas of the lake

According to samples originated from different areas of Lake Balaton the following percentual values are characteristic for the commercially exploited part of the population:

3+	9.0 %	6+	20.2 %	9+	1.8 %
4+	31.3 %	7+	8.1 %	10+	0.3 %
5+	26.5 %	8+	2.1 %	11+	0.3 %

6. Mortality

Individual numbers in various age groups was taken as representative ratio for the catchable part of the population of Lake Balaton. Instantaneous total mortality coefficient was calculated by the diminishing number of specimens by using their logarithms of natural base *(Fig. 10)*. This calculation refers to the most abundant age groups from 4+ to 9+. On the average, the instantaneous total mortality coefficient for the entire Lake Balaton proved to be $Z = 0.6460$. At the different areas of the lake this value varied between 0.5928 and 0.7969. Their differences were significant ($0.05 < P < 0.02$). Average survival rate was assessed to be $S = 52$ per cent, hence the average annual mortality rounded about $A = 48$ per cent. Both values fluctuated

TABLE VII

Rates of mortality and survival in asps caught at five different areas of Lake Balaton

Place of sampling	Age groups	Z	S	A
Siófok	4+ – 9+	– 0.6343	0.5326	0.4674
Tihany	4+ – 8+	– 0.7969	0.4493	0.5507
Balatonszemes	5+ – 9+	– 0,5928	0.5543	0.4457
Fonyód	4+ – 8+	– 0.6606	0.5169	0.4831
Keszthely	5+ – 9+	– 0.6837	0.5066	0.4934
Average:	4+ – 9+	– 0.6460	0.5220	0.4780

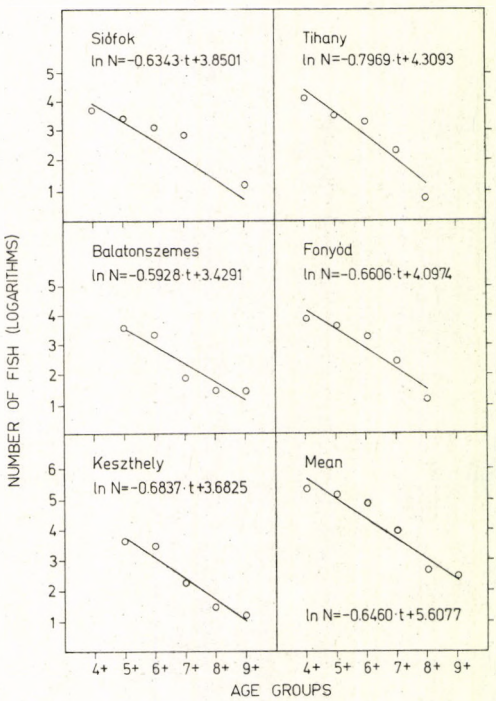


Fig. 10. Mortality of asp in age groups 4+ to 9+ at different areas of the lake. N = number of fish, t = time interval = 1 year

between 45 and 55 per cent by area *(Table VII)*. These estimated rates chiefly concern age groups intensively exploited by commercial fisheries. Because of the small number of young fish (age groups 0+ to 3+) in the catches, the rates of mortality and survival for the whole asp population of the lake cannot be assessed definitely.

7. Recorded commercial landings of asp

According to data on catch statistics, asp is of primary economic importance of Lake Balaton amounting to 0.9—1.5 per cent of the total annual catch. Though, this amount seems insignificant compared to that of bream comprising some 70—80 per cent of the total annual catch, nevertheless, it means about 5—6 per cent of the total noble fish caught. On an average, 11.5 metric tons of asp are harvested by the commercial fisheries. Presently about 5.5 to 6 metric tons of asp caught by sport fishermen yearly. This value have doubled as compared to the 1960's *(Fig. 11)*.

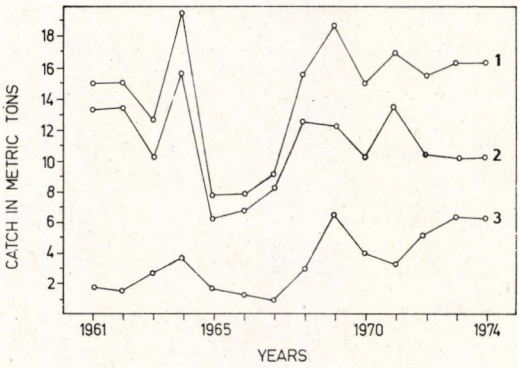


Fig. 11. Total recorded landings of asp during the period of 1961—74. 1 = Total fish landed; 2 = annual commercial landings; 3 = total fish caught by sport fishermen in metric tons

In some years during 1945—57 its total yield reached about 15—30 metric tons and from this time on a gradual decrease occurred. Due to the mass fish kill in 1965, the amount of asp landed had decreased by some 60 per cent. By 1968 the annual catch of aps approximated the average level existed prior to the fish kill. Following a fluctuation of about 3 metric tons, the yield seems to have stabilized between 1968—74.

Asp is chiefly caught in the surrounding waters of Tihany and Siófok, where its ratio to the other noble fish species varies between 8 and 10 per cent. Elsewhere, e.g. in the Keszthely Bay it has a smaller ratio around 3 to 4 per cent. In the vicinity of Tihany and Keszthely Bay of about 73 per cent of the catches consisted of individuals of more than 1 kg body weight. In the surroundings of Siófok and Balatonszemes their ratio is 68 per cent while at Fonyód it is 54 per cent.

Total recorded landings of asp at different areas of the lake during five years in the period of 1970—74 were as follows:

Keszthely	13,045 kg	23.9 %
Balatonszemes	11,177 kg	20.4 %
Fonyód	10,735 kg	19.6 %
Tihany	10,080 kg	18.4 %
Siófok	9,538 kg	17.4 %
Total:	54,576 kg	100.0 %

8. *Selective effects of commercial fisheries on the population structure*

The cod-end-mesh selection of the seine nets is one of the significant parameters in fish stock regulation. The commercial fishery directly influences the total mortality, density as well as age and length distribution of the catchable asp population.

The standard side-web-mesh of 1000 m long seine nets used in Lake Balaton is 45 mm, and their cod-end-mesh is 35 mm in summer time while 25 mm during autumn. Selectivity of the nets were estimated according to percentage length and age distribution of fish caught. The 50 per cent length

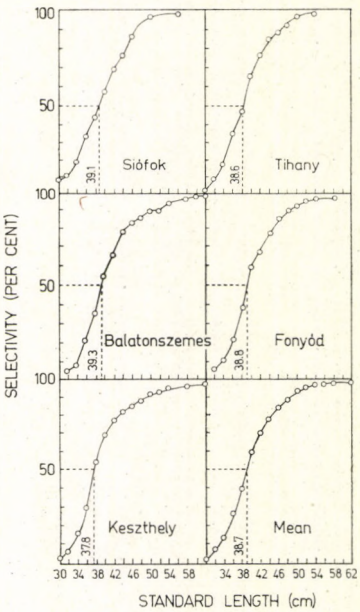


Fig. 12. Cumulative standard length selection ogives of 1000 m long seine nets used in Lake Balaton

retention of the nets was found at 38.7 cm standard length of the fish. These indexes calculated for different areas of the lake characterized by highly significant deviations from the mean of 1.3 cm as a maximum ($P \ll 0.001$) *(Fig. 12)*. Analyzing the selectivity of the nets by the age of fish, on an average 4.3 year of age retained in 50 per cent was obtained. Its territorial differences are highly significant ($P \ll 0.001$) *(Fig. 13)*. When comparing the cumulative ("resultant") selection ogives obtained for different areas of the lake their shape seems to be very similar. Only the ogive procumbent in its upper section obtained for the Keszthely Bay shows a certain divergence from the mean: a lower 50 per cent of age retention index has been accompanied by a higher mean age.

It appears from the indexes given that the seine nets above 38.7 cm standard length and 4.3 year of age of asp can be considered as non-selective ones.

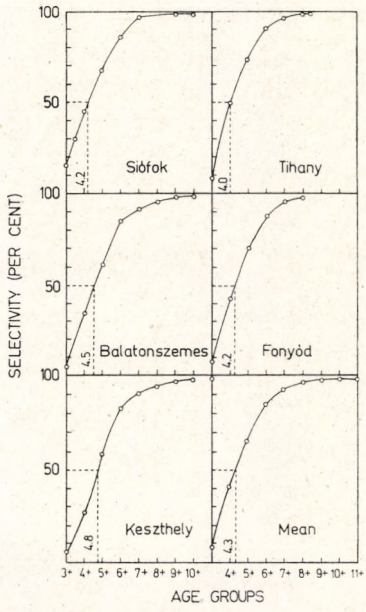


Fig. 13. Cumulative age selection ogives of the seine nets at different areas of the lake

Having calculated the regressions together the standard error of the regression coefficients between the selectivity indexes obtained for mean standard length ($\bar{L}$) and age ($\bar{t}$), and those of the instantaneous total mortality (Z) and average annual mortality (A) coefficients, the following relationships were derived:

(1) $Z = -0.0477 \cdot \bar{L} + 2.5197 \pm 0.077 \quad (P \ll 0.001)$
(2) $Z = -0.2688 \cdot \bar{t} + 1.8295 \pm 0.3652 \quad (0.02 < P < 0.01)$
(3) $A = -0.0246 \cdot \bar{L} + 1.4393 \pm 0.6708 \quad (0.2 < P < 0.1)$
(4) $A = -0.1375 \cdot \bar{t} + 1.1761 \pm 0.071 \quad (P \ll 0.001)$

Except relationship (3) all of them are significant or highly significant. Consequently, the selectivity of the seine nets strongly influences the mortality coefficients (Z and A) of the asp population modifying its size hierarchy and age composition.

9. *Biomass and production: the $P/\bar{B}$ ratio*

Initial (B_0) and average biomass ($\bar{B}$) of age groups 4+ to 10+ were assessed according to the asymptotic growth by using the number of fish in different age groups (N), their mean weight (W), the mortality (Z) and the instantaneous coefficients of growth (G) *(Table VIII)*. The average biomass in the sample was B = 526.7 kg, while its annual increase was about P = 150.6 kg. The average $P/\bar{B}$ ratio for the age groups given was 28.6 per cent. Annual net production rate was the highest in age group 4+ (36.4 per cent) and in

TABLE VIII

Mean biomass and production rate in age groups 4+ to 10+ of asp inhabiting Lake Balaton

Age groups	N (pc)	W (g)	$NW=B_0$ (kg)	Z	G	Z−G	$\overline{B}$ (kg)	$\overline{B}G = P$ (kg)	$P/\overline{B} \cdot 100 =$ = A. P. %
4+	188	809	152.1	0.6460	0.3643	0.2817	131.8	48.01	36.4
5+	159	1008	160.3	0.6460	0.2220	0.4240	129.7	28.79	22.2
6+	121	1337	161.8	0.6460	0.2827	0.3633	134.6	38.05	28.3
7+	49	1866	91.4	0.6460	0.3332	0.3128	77.9	25.96	33.3
8+	13	2261	29.4	0.6460	0.1895	0.4565	23.4	4.43	18.9
9+	11	2788	30.7	0.6460	0.2106	0.4354	25.1	5.29	21.1
10+	2	2840	5.7	0.6460	0.0178	0.6282	4.2	0.07	1.8
Total:	543		631.4				526.7	150.60	

$$\overline{B} = \frac{B_0(1 - \exp - (Z - G))}{Z - G}, \text{ if } Z > G \quad P/\overline{B} \cdot 10 \text{ C} = \text{A.P.} = 28.6\%$$

older groups (5+ to 7+) this rate varied between 22.2 and 33.3 per cent. Just the same rates were obtained for age groups 8+ to 9+, where the $P/\overline{B}$ ratio has been calculated for age groups intensively exploited by commercial fisheries, therefore the ratio of asps younger than 4+ (age groups 0+ to 3+) is excluded.

From the initial biomass (B_0 = 631.4 kg) of 4+ to 10+ aged fish 48 per cent was eliminated in consequence of natural mortality and exploitation while 52 per cent survived annually. The 48 per cent biomass of dead fish is balanced by the growth in weight and by the natural recruitment to the exploited phase so that the mean biomass attains about 28.6 per cent of surplus production.

Discussion

Studying the growth and population structure of asps caught at five different areas of Lake Balaton it was established that apart from smaller variations the fishable part of the population has the very same structure at various areas of the lake. By direct measurements within the age groups already significant size differences can be found indicating the diversity of food supplies of certain water areas. According to the mean standard lengths measured the annual growth in length of the age-groups is smoothed, but in the environs of Fonyód and especially in the Keszthely Bay it is stepped *(Fig. 5)*. The growth of age-groups up to 5+ and 6+ is slower as compared to previous years of age. From this fact the following conclusion can be drawn: the food supply of these areas fills the food requirement especially of older fish.

Annual marks on the scales of asp inhabiting Lake Balaton develop in a more distinguished manner than that of pike-perch and bream (Bíró, 1970; Bíró and Garádi, 1974). Such a distinct isolation of annuli explicitly indicates the seasonal growth of asp being a pelagic predator in Lake Balaton. It is highly probable that in winter time their food consumption decreases in contrast to the vegetation period when the availability of prey fishes is higher and

their distribution is more homogenous. For the intensive growth of asp its pelagic pattern of life is favourable as to the benthic and littoral species, because the competition for food in the pelagial is much less.

For the relationship between the standard lengths and the lateral radii of scales a linear regression have been calculated. By this relationship 7.89 cm was obtained for mean standard length, which gives the size measurable in time of "key-scale" formation. There were no significant differences found in the annual growth in standard length back-calculated from the scales of asp caught at five different areas of the lake. Their development is usually uniform. Analyzing the growth in length of different age groups by year class strengths different growth rates have been experienced in age groups up to 6+ and then from 7+ upward especially in the Keszthely Bay. This difference is probably due to feeding relations. Because the mean growth in length of asp can be described exactly by BERTALANFFY's(1938, 1957) model. Maximum standard length attained in Lake Balaton was $L_{\infty} = 68.2$ cm and the mean rate of growth was $K = 0.1518$. According to studies by BACKIEL (1964) and BAUCH (1955) the same values observed in River Vistula (Poland) and in Ammer- and Chiemsee (Germany) were 110 and 70 cm, and 0.0804 and 0.2059. In relation to these and other data published (ČIHAŘ, 1960; DYK, 1956; PUSHKIN, 1968; ZERNOV, 1961) the asp inhabiting Lake Balaton can be characterized by a moderate growth *(Table IX)*. Minor differences in parameters obtained for various areas of Lake Balaton apart from feeding can be in close connection with the quality of water. The relatively clear water in NE-basin of Lake Balaton seems to be more favourable for the rapid development of asp.

The overwhelming majority of 11 metric tons of asp harvested annually is represented by age groups 4+ to 6+. Their ratio at various areas of the lake is just the same. Total instantaneous mortality coefficient of age groups 4+ to 9+ was estimated according to the "catch curve". On an average, the annual mortality proved to be 48 per cent and hardly differs from that 47 per cent published by BACKIEL (1964) for River Vistula. Survival rate of age groups 4+ to 9+ was assessed to be 52 per cent, and varied between 45 and 55 per cent. The same rate in different age groups of asp living in River Vistula are greatly variable: between age groups 4+ and 5+ 89.7 per cent, in 5+ − 6+ year-old ones 77.5 per cent and finally in 7+ − 13+ year-old specimens 53 per cent. Rates of mortality and survival of asps inhabiting Lake Balaton and River Vistula hardly differ from one another indicating near production rate values of the fishable parts of the populations. By age groups 4+ to 10+ of asp living in Lake Balaton about 28.6 per cent of their average biomass is produced annually, while those 4+ to 12+ year-old ones consisting the catchable part of the population inhabiting River Vistula can produce about 39 per cent of their average biomass. Comparing the 28.6 per cent production rate to the data published on $P/\overline{B}$ ratio of pike-perch population (50 per cent) consisted of age groups 3+ to 9+ (BIRÓ, 1975a), or to that of bream (72.6 per cent) population represented by 3+ to 7+ yeard-old specimens (BÍRÓ and GARÁDI, 1974) even to that of bleak population (71.8 per cent) consisted of age groups 1+ to 5+ respectively (BÍRÓ, 1975b) by all means it seems to be low.

Production rate of the harvestable part of population through the modification of its structure, also influenced by the selectivity of the nets used. The regressions between the selectivity indexes obtained for mean length and

TABLE IX

Growth in standard length of asp in different waters

No.	Basin	l_1	l_2	l_3	l_4	l_5	l_6	l_7	l_8	l_9	l_{10}	l_{11}	Author, year of publication
1.	Ammersee and Chiemsee	15.0	27.0	37.0	46.0	53.0	59.0	64.0	67.0	70.0	72.0	–	BAUCH, 1955 after WAGLER
2.	Aral Sea	10.3	19.6	28.1	36.1	42.3	47.8	52.0	57.9	58.8	–	–	BERG, 1949 after NIKOLSKIJ 1940
3.	Dnieper	8.0	16.6	24.9	31.8	–	–	–	–	–	–	–	KOSTJUCHENKO, 1963*
4.	Don	11.1	21.9	31.3	38.4	–	–	–	–	–	–	–	ZERNOV, 1961
5.	Kama Reservoir	7.3	13.8	21.3	27.8	33.5	37.8	41.4	43.3	45.4	47.7	–	PUSHKIN, 1968
6.	Kujbishev Reservoir	8.5	25.8	33.0	38.9	45.9	–	–	–	–	–	–	KOPTEVA, 1964*
7.	River Neva	7.5	15.2	22.5	29.2	35.6	40.7	44.7	–	–	–	–	ZHUKOV, 1958*
8.	West-Dvina	7.4	15.0	22.1	29.0	36.0	40.8	45.5	49.9	54.4	57.8	–	PENAZ and SEVTSOVA, 1964*
9.	Rybinsk Reservoir	7.5	12.9	20.0	25.7	28.3	37.3	43.2	48.1	53.0	–	–	SVETOVIDOVA, 1960*
10.	Sapshug Reservoir	13.4	22.6	28.6	32.4	–	–	–	–	–	–	–	ZERNOV, 1961
11.	Seddin-See	12.0	22.0	40.0	50.0	57.0	64.0	65.0	–	–	–	–	BAUCH, 1955
12.	Slapy Reservoir	10.7	16.5	21.2	28.1	36.2	43.3	50.6	–	–	–	–	ČIHAŘ, 1960
13.	Stienitz-See	10.0	16.0	25.0	34.0	–	–	–	–	–	–	–	BAUCH, 1955
14.	Tsiksk Reservoir	12.3	25.9	36.2	44.9	52.5	57.3	–	–	–	–	–	SHAPOSHNIKOVA, 1959*
15.	River Ural	11.8	22.6	32.2	35.4	42.4	46.0	–	–	–	–	–	SHAPOSHNIKOVA, 1964*
16.	River Vistula	8.5	14.8	23.3	29.0	36.3	42.4	46.0	51.0	56.3	–	–	BACKIEL, 1964
17.	Middle-Volga	6.8	13.2	19.0	25.2	34.5	38.5	42.0	45.0	–	–	–	KOPTEVA, 1964*
18.	Lake Balaton	9.6	20.6	29.0	34.8	39.2	43.4	47.4	50.4	52.9	56.5	60.2	Present investigation (* cit. PUSHKIN, 1968)

age retained in 50 per cent, as well as the rates of mortality assessed for the exploited part of the asp population were found to be significant or highly significant. Knowing the selective effects of commercial fisheries on the size and age structure of the population, a desirable increase of the ratio of production to biomass can be achieved by the intensification of catches.

Summary

Length and age distribution of asps (496 specimens in 1974, and 217 specimens in 1975), caught at five different areas of Lake Balaton, as well as their growth have been studied. Mortality and production of the harvestable part of population and the selective effects of commercial fisheries on the population structure have also been studied.

1) Standard length of 80–85 per cent of asps caught in Lake Balaton ranged between 32 and 46 cm, on an average it was 42.2 cm. Length distribution or fish originated from different areas of the lake was asymmetrical.

2) The b regression coefficient included in the length–weight relationship was calculated to be 2.5985.

3) The linear regression between the standard lengths and the lateral radii of scales cuts 7.9 mm from the abscissa which indicates the size measurable in time of "key-scale" formation. Annual marks on the scales of fish in age groups 3+ to 11+ are definitely differentiated from each other, and the annual growth of lateral radii of scales is uniform. The growth both in measured and back-calculated standard lengths is also uniform. Different rates of growth were observed in age groups up to 6+ and then from 7+ upward especially in the Keszthely Bay. Maximum standard length that could be attained in Lake Balaton on an average was estimated to be $L_\infty = 68.2$ cm, and coefficient of rate of growth proved to be $K = 0.1518$. Their areal deviations have been insignificant.

4) The overwhelming majority of asps caught in Lake Balaton was represented by specimens belonging to age groups 4+ to 6+. Instantaneous total mortality coefficient calculated for the most intensively exploited part of the population (age groups 4+ to 9+) on an average was $Z = 0.6460$. Its areal deviations have been significant. The assessed rate of survival on an average was 52 per cent, hence the average annual mortality was 48 per cent.

5) Average biomass of asps in the sample covering age groups 4+ to 10+ was $B = 526.7$ kg which produced 150.6 kg a year, hence the $P/\bar{B}$ ratio on an average amounted to 28.6 per cent.

6) 50 per cent length retention of 1000 m seine nets used in Lake Balaton was found at 38.7 cm standard length of the fish, which has been accompanied by a mean age of 4.3 year. The regressions between the instantaneous total mortality coefficients (Z) and the 50 per cent selectivity index obtained for mean standard length ($\bar{L}$), as well as between the average annual mortality (A) and the selectivity index calculated for mean age ($\bar{t}$) are highly significant ($P \ll 0.001$).

REFERENCES

BACKIEL T. (1964): Wzrost i próba oceny śmiertelności boleni łowionych w Wisle. — *Roczn. Nauk. roln.* 84-B, 215—239.

BAUCH G. (1955): Die einheimischen Süsswasserfische. — *Neumann Verlag, Radebeul und Berlin*, p. 187.

BERG L. S. (1949): Берг, Л. С.: Рыбы пресных вод СССР и сопредельных стран. — *Изд-во АН СССР, Москва—Ленинград.* II. стр. 602—610.

BERINKEY L. (1966): Halak — Pisces. — *Akadémiai Kiadó, Budapest, Fauna Hungariae* **20,** p. 136.

BERTALANFFY L. (1938): A quantitative theory of organic growth. — *Hum. Biol.* **10,** 181—243.

BERTALANFFY L. (1957): Quantitative laws in metabolism and growth. — *Q. Rev. Biol.* **32,** 217—231.

BEVERTON R. J. H., S. J. HOLT (1957): On the dynamics of exploited fish populations. — *Fishery Invest. London* **19,** p. 533.

BÍRÓ P. (1970): Investigations of growth of pike-perch (*Lucioperca lucioperca* L.) in Lake Balaton. — *Annal. Biol. Tihany* **37,** 145—164.

BÍRÓ P. (1972): First summer growth of pike-perch (*Lucioperca lucioperca* L.) in Lake Balaton. — *Annal. Biol. Tihany* **39,** 101—113.

BÍRÓ P. (1973): The food of pike-perch (*Lucioperca lucioperca* L.) in Lake Balaton. — *Annal. Biol. Tihany* **40,** 159—183.

BÍRÓ P. (1975a): Observations on the fish production of Lake Balaton. — *Symp. Biol. Hung.* **15,** 273—279.

BÍRÓ P. (1975b): The growth of bleak (*Alburnus alburnus* L.) (Pisces, Cyprinidae) in Lake Balaton and the assessment of mortality and production rate. — *Annal. Biol. Tihany* **42,** 139—156.

BÍRÓ P., P. GARÁDI (1974): Investigations on the growth and population-structure of bream (*Abramis brama* L.) at different areas of Lake Balaton, the assessment of mortality and production. — *Annal. Biol. Tihany* **41,** 153—179.

CHAPMAN D. W. (1968): Production, pp. 182—196. In: RICKER W. E. (ed.) *Methods for Assessment of Fish Production in Fresh Waters. — IBP Handbook No.* **3,** *Blackwell Sci. Publ. Oxford.*

ČIHAŘ J. (1960): Zvýšení mnóžství dravých ryb je v zájmu rybářského obhospodařování Slapské údolní nádrže. — *Česk. Rybářství* **8,** 102.

DYK V. (1956): Nase ryby. — *Československá Akad. Věd. Praha*, p. 339.

FRASER C. MCL. (1916): Growth of the spring salmon. — *Trans. Pacif. Fish. Soc. Seattle, for* 1915, 29—39.

PUSHKIN JU. A. (1968): Пушкин, Ю. А.: О росте жереха *Aspius aspius* (L.) Камского водохранилища. — *Вопросы ихтиологии* **8,** 388—395.

RICKER W. E. (1958): Handbook of computation for biological statistics of fish populations. — *Bull. Fish. Res. Bd. Canada* **119,** p. 300.

RICKER W. E., R. E. FOERSTER (1948): Computation of fish production. — *Bull. Bingham Oceanogr.* Coll. **11,** 173—211.

TESCH F. W. (1968): Age and growth, pp. 91—120. In: RICKER W. E. (ed.) *Methods for Assessment of Fish Production in Fresh Waters. — IBP Handbook No.* **3,** *Blackwell Sci. Publ. Oxford.*

WALFORD L. A. (1946): A new graphic method of describing the growth of animals. — *Biol. Bull.* **90,** 141—147.

ZERNOV M. S. (1961): Зернов, М. С.: Ихтиофауна Щапсугского водорохранилища. — *Бюл. Ин-та биол. водохранилищ* **11,** 33—36.

A RAGADOZÓ ŐN (*ASPIUS ASPIUS* L.) NÖVEKEDÉSE A BALATONBAN ÉS A HALÁSZAT SZELEKTÍV HATÁSA AZ ÁLLOMÁNYSTRUKTÚRÁRA

Bíró Péter és *Fűrész György*

Összefoglalás

Vizsgáltuk a Balaton 5 különböző vízterületéről származó ragadozó őnök méret- és kormegoszlását (1974-ben 496 db-ot, 1975-ben 217 db-ot), pikkelyeik alapján növekedésüket. Tanulmányoztuk a halászható állomány mortalitását, produkcióját és a szelektív halászat állományt szabályozó hatását.

1. A Balatonból kifogott őnök 80—85%-a 32—46 cm törzshosszúságú, átlagméretük 42,2 cm. A különböző vízterületről származó halak méretmegoszlása aszimmetrikus.

2. A testhossz–testsúly relatív összefüggésében a regressziós együttható b = = 2,5985 volt.

3. A törzshosszak és laterális pikkely-rádiuszok lineáris regressziója kb. 7,9 mm-es törzshossznál jelzi a pikkelyképződés kezdetét. A 3+ — 11+ korcsoportú halak pikkelyein az évgyűrűk határozottan elkülönülnek, a pikkelyátmérők évenkénti növekedése egyenletes. Hasonlóan egyenletes a mért és a visszaszámított törzshosszak növekedése is. A 6+ korcsoportig, majd a 7+-tól fölfelé főleg a Keszthelyi-öbölben eltérés tapasztalható a méretgyarapodás sebességében. Az elérhető maximális méret a Balatonban átlagosan L_∞ = 68,2 cm, a növekedés-sebesség állandója K = 0,1518 volt, területi eltérésük nem szignifikáns.

4. A Balatonból kifogott őnök túlnyomó többségét a 4+ — 6+ korcsoportba sorolt példányok alkotják. A halászattal intenzíven kihasznált 4+ — 9+ állományrészre számított pillanatnyi teljes mortalitás együttható szignifikáns területi eltérésekkel Z = = 0,6460 volt. A túlélés becsült értéke átlagosan 52%, innét az átlagos éves mortalitás 48%.

5. Mintánkban a 4+ — 10+ korcsoporthoz tartozó őnök átlagos biomasszája B = 526,7 kg, évente 150,6 kg-ot termelt; a P/$\overline{B}$-arány átlagosan 28,6% volt.

6. A Balatonon alkalmazott 1000 méteres kerítőhálók 50%-ban a 38,7 cm törzshosszúságú őnöket tartják vissza, ezek kora átlagosan 4,3 év. A pillanatnyi teljes mortalitási együttható (Z) és az átlagméretre számított 50%-os szelektivitási index ($\overline{L}$), továbbá az éves átlagos mortalitás (A) és az átlagkorra meghatározott szelektivitási index ($\bar{t}$) regressziói igen erősen szignifikánsak ($P \ll 0{,}001$).

ANNAL. BIOL. TIHANY | 43 | 69–82 | HUNGARIA 1976

REGIONAL AND CIRCADIAN OXYGEN DETERMINATIONS IN LAKE BALATON CONCERNING THE EUTROPHICATION OF THE LAKE

BÉLA ENTZ

Biological Research Institute of the Hungarian Academy of Sciences, Tihany, Hungary

Received: 25th February, 1976

Eutrophication this-well known phenomenon in lakes surrounded by cultivated countryside is progressing in Lake Balaton. Attention has been called to this phenomenon repeatedly by SEBESTYÉN (SEBESTYÉN, 1952; 1973). The recent situation expressed as the changing rate of primary production was demonstrated by algal cell countings and by the ^{14}C methodics (HERODEK and OLÁH, 1973; HERODEK and TAMÁS, 1973; 1974; 1975). Similarly OLÁH conducted some measurements on primary production by oxygen determinations (OLÁH 1975; OLÁH 1976 – verb. comm.).

A wider application of this method seemed to be very meaningful because of its simplicity, fast performance and the possibility of the evaluation of the results on the spot (VOLLENWEIDER, 1969), to execute simultaneous or semi-simultaneous studies on wider lake areas in different biotopes, comparing the data immediately to each other and to obtain circadian data.

Purpose of the work was to clear whether extremely high oxygen saturation would appear during summer or autumn 1975, due to remarkable water bloom or water coloration (Vegetationsfärbung) indicating the possibility of a new winter fishkill. Another goal was to study the highly eutrophic south-western lake areas and to check more exactly their northern limits to state whether any expansion can be noticed for 1975 in comparison to the previous years.

Methods

Measurements have been carried out by the Dissolved Oxygen Meter Model 15A (Electronic Instruments Ltd. Richmond Surrey). Temperature and oxygen saturation values were recorded from the surface to the bottom at distances of 0.5 m each. By this way the absolute amounts of dissolved oxygen could be calculated for selected water layers and for the water column as a whole. From time to time control measurements have been conducted by the classical methods of WINKLER and MAUCHA (MAUCHA, 1945–47).

Regional measurements have been executed during windless periods following windy days. It is worth mentioning that in the open water of the lake on windy days the oxygen saturation of the whole water mass ranged

around 100 per cent. This situation could be used as comparison for our results during windless periods.

In the lake section near Keszthely (Keszthelyi-öböl, Keszthely-basin, Bay of Keszthely) showing very high productivity (HERODEK and TAMÁS, 1975), some circadian measurements have been carried out. The amounts of dissolved oxygen lost by respiration processes were calculated from samples taken from any depth at night by calm weather under unstratified conditions and in the afternoon from the lower aphotic water layer during stratification. Stability values (S) in mkg/m^2 were calculated according to RUTTNER (RUTTNER, 1962).

Data of semi-synchronic measurements obtained in the late afternoon within a short time period in different lake areas seem to be well comparable to each other as far as results on fixed stations under similar conditions did not show remarkable variations. The values of oxygen productions calculated are underestimated because of loss of dissolved oxygen by diffusion, especially by high O_2 saturation (e.g. 150 – 200 %). This loss is not included in our calculations.

Though application of this method is restricted in the open water to calm, almost windless periods, its great advantage is to reach comparative results of the lake by one person in the cross-section of Lake Balaton within about a half hour and in its length within 2 to 3 hours.

Results and conclusions

1. *Circadian measurements.* Studies on temperature and oxygen saturation have been performed on 22 – 23th July and 13 – 14th August 1975, at a fixed station in the Bay of Keszthely, near the point marked since years as Station M_0 (SEBESTYÉN, 1960). Measurements were carried on at some occasions in the evening and at night but regularly at one hour intervals from dawn till afternoon *(Figs 1* and *2)*.

From the temperature data the mean values for the upper water layer (layer "A" between surface and 1.25 m depth) and the lower water layer (layer "B" between 1.25 and 2.50 m depths) could be calculated. Form these mean values the stability values (S) became available *(Tables I* and *II)*.

It was evident that during a windless night following the temperature decrease at the surface a reverse temperature stratification occurred. This kind of stratification induced according its negative stability naturally convection currents due to differences in specific gravity. Starting at daybreak (form about 4^{30} a.m. in July and 6^{00} a.m. in August) caused by the warming up of the surface water layers, the temperature instability decreased but still persisted for some time. At this stage the slightest breeze can mix the total water column. Further increase of the surface temperature during the next period leads to positive stratification and in the meantime to increased thermal stability.

Yet in the morning the increased stability values remained low till 8 a.m. on July 23rd and till 10 a.m. on August 14th, not surpassing the values of 0.04 to 0.08 mkg/m^2. This weak stability still does not interfere the mixing of the layers A and B by gentle water movements. Stability conditions pictured above are in favour to supply the lower water layers (B) with oxygen suitable for fish life and possibly to avoid the development of oxygen-free zones in Lake Balaton near the bottom even at calm periods of longer durations.

TABLE I

Temperature (mean values °C) in A and B and stability (S = mkg/m²) in the Bay of Keszthely on 24th July 1975

Time	3	4	5	6	7	8	9	10	11^{30}	13	14	15	16h
A	22.20	22.04	22.34	22.52	23.01	23.18	23.70	24.08	24.19	24.57	24.42	25.45	25.33
B	22.36	22.20	22.56	22.60	22.65	22.54	22.66	22.84	22.77	22.43	22.38	22.91	22.81
S	−0.029	−0.027	0.041	0.014	0.072	0.040	0.192	0.233	0.267	0.405	0.384	0.498	0.492

A = Upper water layer between 0 and 1.25 m depths. B = lower water layer between 1.25 and 2.50 m

TABLE II

Temperature and stability values in the Bay of Keszthely on 13—14th August 1975

Time	17^{30}	6	8	9	10	11	14	15	15^{30}
A	23.34	21.48	21.70	21.28	21.72	22.42	23.76	23.52	22.68
B	23.38	21.50	21.60	21.18	21.32	21.62	21.76	21.86	21.78
S	−0.007	−0.003	0.017	0.017	0.069	0.141	0.363	0.302	0.343

Further explanation see *Table I*

The stability of the total water column increases during the following morning hours and early afternoon, forming a stratification strong enough to be disturbed only by wind speed above 2 to 4 m/sec (S = 0.3 to 0.5 mkg/m²).

During these hours by calm weather layer A corresponds to the euphotic zone and differs basically from layer B, the aphotic zone *(Figs 1* and *2)*. The oxygen saturation grows gradually in layer A. Because the saturation values in question surmount 100 %, the only explanation are the assimilation processes. On the other hand in layer B, where due to the absence of the necessary light intensity assimilation is negligible or completely blocked, decreasing oxygen saturation could be registered.

Suitable time to measure the rate of respiration (dissimilation) was before dawn between 3 and 4 a.m. (DVIHALLY, 1975), when total circulation could be supposed. The amount of oxygen consumption by organisms was assessed to

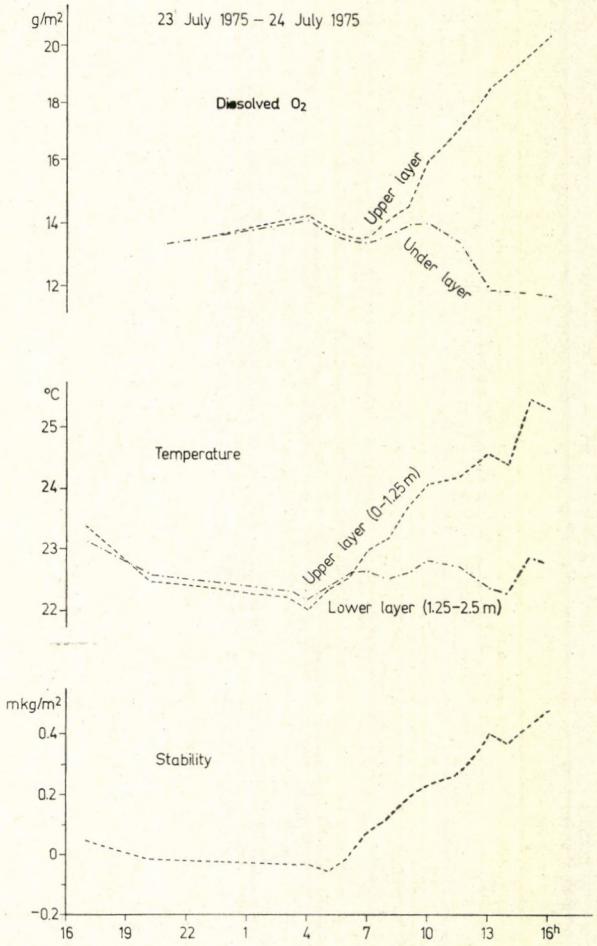


Fig. 1. Changes of temperature and dissolved oxygen in 2.5 m deep water in the upper and the lower water layers on 23—24th July 1975. Daily changes of thermal stability in the whole water column at the same time

be 0.4 g O_2/m^2/hour in each water layer (A and B). This value could not be determined separately in the two layers in the early morning hours because of vertical water movements of different intensity. Under well stratified conditions in the afternoon the respiration value could be determined again but only in the lower water layer (B) without assimilation. The result was the same as at night i.e. 0.4 g O_2/m^2/hour. Thus at the period studied and under conditions in question the estimated respiration values of the whole water column were round 0.8 g O_2/m^2/hour. Using this value as correction, beside the measured net oxygen production values of the gross production could be estimated.

The values of dissolved oxygen were increasing overday in the upper water layers as expected. There was only a slight but gradual increment between 4 and 7 a.m. followed by a rapid increase between 8 and 11 a.m. Afterwards the increase of oxygen saturation slowed down or ceased and even loss of oxygen could be stated. (Comp. DVIHALLY, 1975). A new increment was present in the afternoon. The same tendency appeared summing up the values of layers A and B together *(Tables III* and *IV)*.

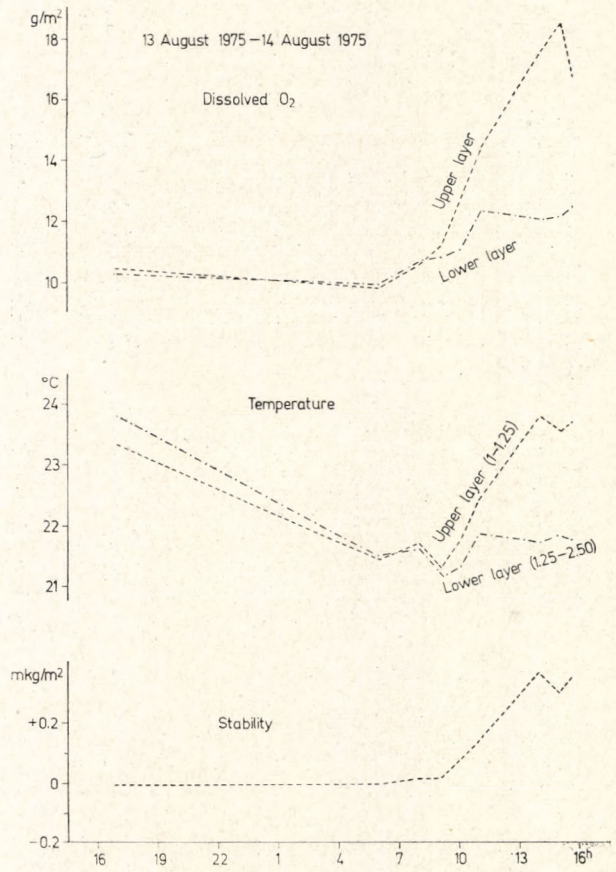


Fig. 2. Data on 13—14th August 1975 (Explanation see *Fig. 1*)

TABLE III

Dissolved oxygen values in the Bay of Keszthely on 24th July 1975 (O_2mg/l).

Time Depth m	4	5	6	7	8	9	10	11^{30}	13	14	15	16h
0.0	11.47	11.42	10.97	11.18	11.00	11.60	11.13	11.16	14.75	15.48	12.80	16.90
0.5	11.43	11.04	10.89	10.80	11.58	11.91	12.82	15.52	15.73	13.76	17.84	17.18
1.0	11.22	10.91	10.80	10.76	11.15	11.34	13.43	13.26	13.88	11.37	15.02	14.85
1.5	11.22	10.91	10.89	10.62	11.46	11.38	11.59	11.23	9.81	10.33	10.09	10.34
2.0	11.22	10.89	10.89	10.72	10.47	10.89	11.02	10.80	9.34	9.35	9.11	8.64
2.5	11.22	10.89	10.47	10.80	10.58	10.80	10.63	9.56	8.93	8.35	8.63	8.32

Dissolved oxygen in g/m² on 24th July 1975 (mean values)

Time	3	4	5	6	7	8	9	10	11^{30}	13	14	15	16h
A	14.59	14.19	13.83	13.59	13.58	14.12	14.53	15.91	16.98	18.94	16.41	19.63	20.24
B	14.43	14.03	13.62	13.51	13.37	13.61	13.84	13.96	13.41	11.81	11.92	11.76	11.57
A+B	29.02	28.22	27.45	27.10	26.95	27.73	28.36	29.87	30.39	30.21	28.33	31.39	31.81

A = upper layer; B = lower layer; A + B = total water column

TABLE IV

Dissolved oxygen in mg/l in the Bay of Keszthely on 14th August 1975

Time Depth m	6	8	9	10	11	14	15	15^{30}
0.0	7.89	8.49	8.84	10.31	11.67	13.71	15.51	13.84
0.5	7.88	8.49	8.90	10.60	11.67	13.86	15.63	13.86
1.0	7.92	8.45	9.04	9.52	11.46	14.36	13.74	12.74
1.5	7.96	8.50	8.78	9.30	10.56	10.75	11.48	11.43
2.0	7.96	8.59	8.65	8.69	9.80	9.02	8.58	9.35
2.5	8.01	8.55	8.54	8.30	8.35	8.59	8.44	8.35
Dissolved oxygen in g/m² on 14th August 1975 (mean values)								
A	9.87	10.59	11.18	12.64	14.48	17.54	18.56	16.76
B	9.96	10.68	10.85	11.07	12.27	12.03	12.14	12.48
A+B	19.83	21.27	22.03	23.71	26.75	29.57	30.70	29.24

Further explanation see *Table III*

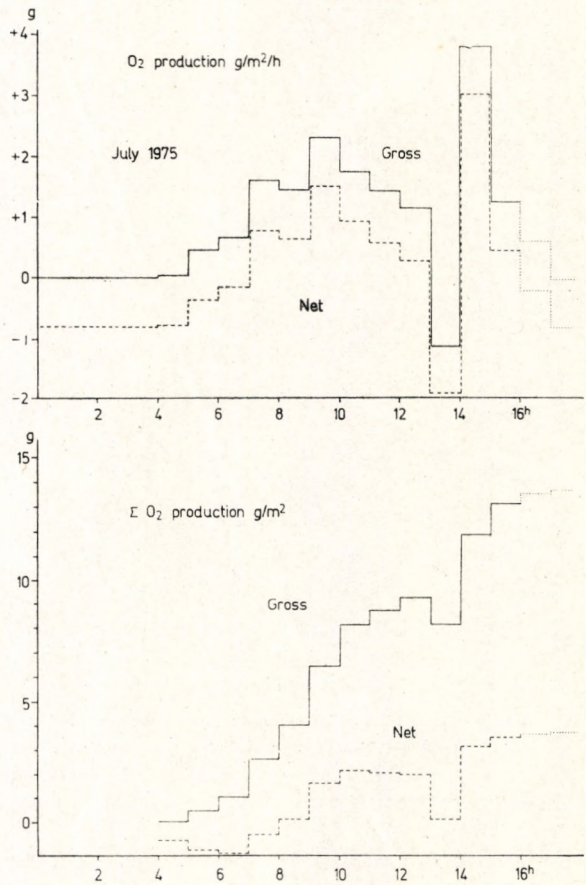


Fig. 3. Net and gross oxygen production in g/m²/hour in the Bay of Keszthely (Keszthely-Basin of Lake Balaton) — upper part. Summarized production from morning till afternoon on 24th July 1975 — lower part

Based on these data the net values of oxygen production could be calculated for time units (hours) and these values could be summed up from dawn till afternoon *(Figs 3* and *4; Tables V* and *VI)*. It became evident that after a strong oxygen consumption at night, there followed after daybreak a decrease of the net value of oxygen consumption in the upper water layer (A), which

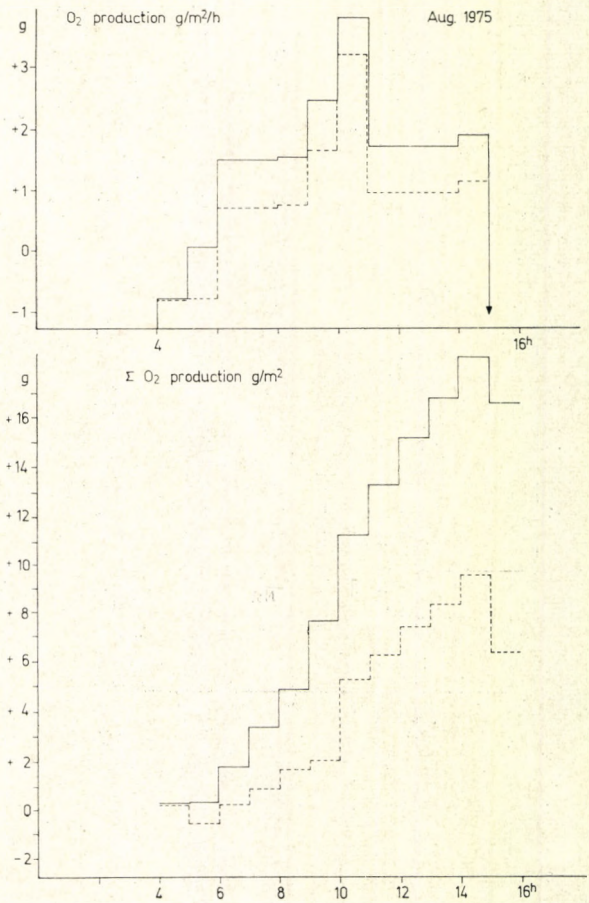


Fig. 4. Oxygen production on 14th August 1975 (Explanation see *Fig. 3*)

affected layer B in a similar way through vertical currents. The stability values (S) increased gradually. As soon as S equalled 0.1 mkg/m², the mixing of layers A and B stopped by calm weather *(Figs 1* and *2)*. Finally the sum of oxygen accumulated from daybreak till afternoon reached in the layer A about 8 to 11 g O_2/m^2 *(Figs 3* and *4)*.

To study the conditions in a different way, the total water column was divided into three layers (0 to 1; 1 to 2; 2 to 3 m). The course of the oxygen curves based on these three layers are represented in *Fig. 5*. Accordingly there is during midday a remarkable decrease of the oxygen content in the uppermost

TABLE V

Values of oxygen production in g/m² on 24th July in the Bay of Keszthely

Time	3—4	4—5	5—6	6—7	7—8	8—9	9—10	10—11³⁰	11³⁰—13	13—15	15—16
Net	−0.80	−0.77	−.035	−0.15	+0.78	+0.64	+1.50	+0.52	−0.09	+1.09*	+0.43
Gross	0.00	+0.03	0.45	0.65	1.58	1.44	2.30	1.32	0.71	1.89*	1.23
Sum Net	−0.80	−1.57	−1.92	−2.07	−1.29	−0.65	+0.85	+1.37	+1.28	+2.37*	+2.80
Sum Gross	0.00	+0.03	0.48	1.13	2.71	4.15	6.45	7.77	8.48	10.37*	11.60

* Mean values from measurements at 13, 14 and 15 hours

TABLE VI

Data on 14th August 1975 (See Table V)

Time	6—7	7—8	8—9	9—10	10—11	11—12	12—13	13—14	14—15	15—16
Net	0.72	0.72	0.76	1.68	3.02	0.94**	0.94**	0.94**	1.13	−2.92***
Gross	1.52	1.52	1.56	2.48	3.82	1.74**	1.74**	1.74**	1.93	−2.12***
Sum Net	0.72	1.44	2.20	3.88	6.90	7.84**	8.78**	9.72**	10.85	7.93***
Sum Gross	1.52	3.04	4.60	7.08	10.90	12.64**	14.38**	16.12**	18.05	15.93***

** Interpolations. *** Extrapolations

water layer, apparently caused by superoptimal light intensities (light inhibition). The oxygen content of the same layer shows increasing tendency in the afternoon. The conditions are different in 1 to 2 m depths where the morning maximum is followed by a gradual diminution till evening. Within 2 to 3 m depth assimilation is not probable, consequently overday only a slight fluctuation of the oxygen values can be expected. This example shows in which important manner circumstances for life can differ in shallow water caused by stratified light and temperature conditions even in huge water masses.

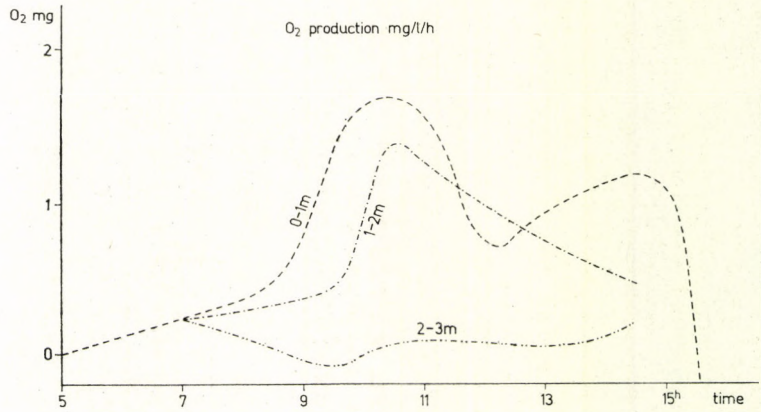


Fig. 5. Oxygen production in the Bay of Keszthely on 24th July 1975. Separately calculated values of the water layers 0 to 1m, 1 to 2m and 2 to 3m

Results of September and October are different from those of the summer months, showing in daytime on calm days only very slight differences in O_2 saturation unsuitable to be evaluated by the method in question.

Comparing the results of the present and the previous years, the recent data seemed to be definitely lower, making autumn or winter alga invasions accompanied by fishkill unprobable. This expectation was confirmed by observations and the fact that noticeable fishkill did not happen during the winter half year 1975 – 76.

2. Horizontal studies. Numerous determinations taking place in the Bay of Keszthely (to be published later) showed that the method discussed is suitable at any time for measurements in wind-protected areas. Semi-synchronic determinations at nearby open water stations (distances not over 200 – 300 m) showed valuable differences, consequently detailed circadian studies should be carried out at fixed stations.

Surprising low O_2 saturation values were achieved in River Zala, just above its estuary (42 – 46 %). On the contrary in the open water of the lake at a distance of a few hundred meters from the station mentioned above, already high saturation could be observed at the same time (e.g. 169 % on 14/8/1975).

The actual underwater river flow of the River Zala could be followed besides the well-known determinations of conductivity or Ca^{++} content, by the oxygen conditions. Quite different values could be obtained in the littoral zone, among dense macrophytic underwater vegetation, amidst reed stands etc. These conditions should be studied in the future in details.

The highest O_2 saturation recorded was 220 %. This value indicated together with the moderate green coloration of the water no further eutrophication of the area in 1975.

The differences within the open-water in the Bay of Keszthely, except the areas under the immediate influence of the River Zala, were much smaller than those of the data of the semi-synchronic collections between Keszthely and Tihany *(Fig. 6, Tables VII* and *VIII)*. From these tables – as expected

TABLE VII

Dissolved oxygen in mg/l between Keszthely and Tihany on 23rd July 1975 between 16h and 19h

Station Depth m	M_0	Györök	Szigliget	Badacsony	Szepezd	Udvari	Tihany
0.0	16.90	12.56	11.69	10.40	10.39	10.69	10.97
0.5	17.18	12.26	11.79	10.80	10.92	10.69	11.18
1.0	14.85	12.94	11.52	10.78	10.85	10.69	11.18
1.5	10.34	13.03	11.74	10.69	10.86	10.53	10.83
2.0	8.62	12.90	11.59	10.83	10.25	10.57	10.15
2.5	8.32	12.30	11.72	10.00	10.12	10.09	9.91
3.0		11.27	11.04	10.05	9.81	9.69	9.63
3.5			9.71		8.52	7.99	9.02
Dissolved oxygen in g/m² at the same station and time							
0 – 1.25	20.24	15.74	14.58	13.39	13.49	13.37	13.93
1.25 – 2.5	11.56	16.04	14.60	13.26	13.09	13.08	12.97
0 – 2.5	31.80	31.78	29.18	26.65	26.58	26.45	26.90

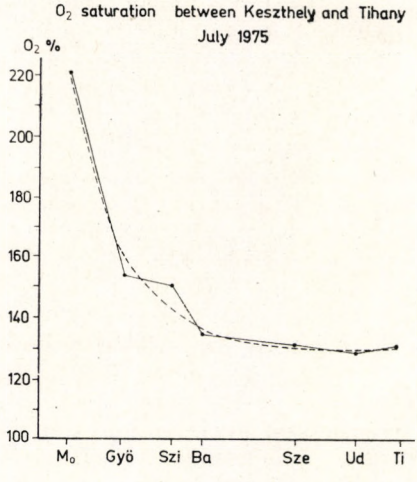


Fig. 6. Data on 24th July 1975 of stations arranged according to their distance from the SW end of Lake Balaton. (M_0 = Keszthely-Basin; Gyö = Balatongyörök; Sz = Szigliget; Ba = Badacsony; Sze = Balatonszepezd; Ud = Balatonudvari; Ti = Tihany). ——— actual values, — — — — ideal curve

TABLE VIII

Dissolved oxygen in g/m² between Keszthely and Tihany on 14th August 1975 between 16h and 19h

Station Depth m	M_0	Berény	Györök	Ederics	Szigliget	Badacsonylábdi	Badacsonytomaj	Zánka	Tihany
0 – 1.25	16.76	15.64	15.22	13.81	13.80	11.59	11.57	11.29	10.92
1.25 – 2.5	12.50	10.25	11.13	11.06	11.27	10.31	10.28	10.50	10.94
0 – 2.5	29.26	25.89	26.35	24.87	25.07	21.90	21.85	21.79	21.86

from previous investigations by authors quoted above – it is evident that the oxygen saturation and naturally the rate of primary production in the upper water layer is the highest at the south-western end of the lake, the Bay of Keszthely. There was a gradual decrease of these values during our studies from Keszthely until Badacsony. From there almost uniform results could be achieved till Tihany or based on measurements at other occasions, up to the north-eastern end of Lake Balaton *(Fig. 6)*.

In the meantime there were the lowest saturation values in the lower water layers around Keszthely and Balatonberény. A slight increase could be demonstrated within the area of Balatongyörök and Szigliget followed by newly decreasing values towards NE. Though these decreased values benorth of Szigliget remained always higher than those of the deep water in the Bay of Keszthely.

All previous data on primary production from Tihany in 1972 – 73 (HERODEK and TAMÁS, 1974), the Bay of Keszthely in 1973 – 74 together with those of the Szigliget area in 1974 – 75 (HERODEK and TAMÁS, 1975; HERODEK and TAMÁS, unpublished data), further on the 1974 phosphorus distribution data by TÓTH (TÓTH, 1975), indicate that the highest eutrophy in Lake Balaton is present near Keszthely in the Bay of Keszthely, decreasing from here till the Badacsony area from where on the trophity is at a lower but fairly even level all over the rest of the lake. It could be concluded that there was a definite borderline between the even but less eutrophic lake section to the north and the south-western part of the lake with its gradually increasing eutrophy towards Keszthely. This borderline was situated between Badacsony and Fonyód. It was understood, that there was no remarkable change in the location of this line during the year in question as compared to previous records. That means there was no expansion on behalf of the strongly eutrophic water into the "clear water section" of Lake Balaton in 1975.

Summary

1. The method to determine the productivity of different sections of Lake Balaton by oxygen measurements is suitable due to its simplicity, fastness and valuation in situ by semi-synchronic studies.

2. The thermal stability of Lake Balaton has been studied for the first time. It could be stated that by calm weather due to surface cooling down at night, the thermal stability conditions changed basically in summer-time in the shallow lake, causing vertical mixing of the whole water column. This

process is in particular promoting a suitable oxygen supply of the deeper water layers and is in spite of its short duration an important limnological factor. As soon as the thermal stability (S) surpasses by calm weather overday 0.1 mkg/m², the vertical water movements are blocked and microstratification appears. This stratification can be only dissolved by wave action at a windspeed of 2 to 4 m/sec.

3. The value of thermal stability in the open water was at night occasionally negative (−0.029 mkg/m² was measured in July and −0.007 mkg/m² in August). During daytime by calm weather the stability values increased gradually up to 0.5 mkg/m² in a water column not deeper than 250 cm.

4. The amount of dissolved oxygen reached in July 10.8−16.0 mg/l at a temperature of 22.0−25.5 °C. The corresponding values were in August 8 − 15.5 mg/l at 21.5 to 23.8 °C.

5. It is worth mentioning how important life effecting differences (microstratification) can develop within a few hours in shallow (2 to 3 m deep) calm water due to temperature and light conditions in huge water masses.

6. The oxygen saturation values were low in autumn 1975 indicating no alga invasions accompanied by fishkill in the winter half year 1975−76. This hypothesis was assured in time.

7. The rate of oxygen production was decreasing gradually from the Keszthely area till the line between Badacsonytomaj and Fonyód. From thereon even and relatively low values could be noticed up to the NE end of the lake. It could be concluded that there was no further expansion of the highly eutrophic lake section in 1975 as compared with previous years.

REFERENCES

Dvihally S. T. (1975): Data on the O_2 household and primary production of the Nagyszéktó Lake near Kistelek (S. Hungary). —*Annal. Univ. Sci. Budapestinensis Sec. Biol.* **17,** 5−20.

Herodek S., J. Oláh (1973): The primary production in the frozen Lake Balaton. — *Annal. Biol. Tihany* **40,** 197−206.

Herodek S., G. Tamás (1973): The primary production of phytoplankton in Lake Balaton April–September 1972. — *Annal. Biol. Tihany* **40,** 207−218.

Herodek S., G. Tamás (1974): The primary production of phytoplankton in Lake Balaton October 1972−March 1973. — *Annal. Biol. Tihany* **41,** 205−216.

Herodek S., G. Tamás (1975): The primary production of phytoplankton in the Keszthely Basin of Lake Balaton in 1973−1974. — *Annal. Biol. Tihany* **42,** 175−190.

Herodek S., G. Tamás (1976): A fitoplankton tömege, termelése és a Balaton eutrofizálódása. — *Hidrol. Közl,* 219−228.

Maucha R. (1945−47): Hydrochemische Halbmikro Feldmethoden. — *Arch. f. Hydrobiologie* **41,** 352−391.

Oláh J. (1975): A Balaton évi energiaháztartása. — *Halászat Tud. Melléklet* 1975, 2−4.

Oláh J. (1976): Verbal communication.

Ruttner F. (1962): Grundriss der Limnologie. — Walter de Gruyter *and Co. Berlin* 1−332.

Sebestyén O. (1952): Mennyiségi plankton tanulmányok a Balatonon II. Évtizedes változások. — *Annal. Biol. Tihany* **21,** 63−89.

Sebestyén O. (1960): Horizontális planktonvizsgálatok a Balatonon I. — *Annal. Biol. Tihany* **27,** 115−130.

Sebestyén O. (1973): A Balaton közérdekű problémáiról. — *Szerző Kiad. Tihany* 1−21.

Tóth L. (1975): A Balaton vízminőségi vizsgálata. — *VITUKI Tájékoztató* 1973, 51−56.

Vollenweider R. A. (1969): A manual on methods for measuring primary production in aquatic environments. — *IBP Handbook* (Ed.: Vollenweider R. A.) *No.* **12,** *Blackwell Sci. Publ. Oxford and Edinbourgh.* (XVI) 1−213.

A BALATON OXIGÉNVISZONYAINAK REGIONÁLIS ÉS NAPSZAKOS KUTATÁSA, FIGYELEMMEL A TÓ EUTROFIZÁLÓDÁSÁRA (GYORSMÓDSZER ALKALMAZÁSA)

Entz Béla

Összefoglalás

1. Az oxigénmeghatározáson alapuló módszer egyszerűsége, gyorsasága és helyszíni értékelhetősége révén alkalmas hullámzásmentes vízben a Balaton különböző vízterületei termelési értékeinek összehasonlító vizsgálatára, különösen rövid időn belül végzett „szinkron" vizsgálatokkal.

2. A Balaton hőstabilitási viszonyait eddig nem tanulmányozták. A sekély vizű tóban a nyári időszakban a felszíni éjjeli lehűlés a hőstabilitási viszonyok alapvető megváltoztatása révén konvekciós vízáramlásokat, vagyis vízkeveredést idéz elő. Ez jelentősen hozzájárul a tó mélyebb vízrétegei kedvező oxigénellátásához és mint ilyen, tavi limnológiai szerepe rövid időtartama ellenére is jelentős. Nappal, amikor a stabilitás értéke (S) megnő és meghaladja a 0,1 mkg/m²-t, csendes időben mikrorétegzettség keletkezik, melyet csak 2—4 m/sec-os szél okozta hullámzás képes feloldani.

3. Éjjel a nyílt vízben a hőstabilitás értéke néha negatív lehet (júliusban — 0,029, augusztusban pedig — 0,07 mkg/m²-t mértünk). Nappal szélmentes időben a stabilitás értéke fokozatosan megnő, így a 2,5 m-nél nem mélyebb vízoszlopban 0,5 mkg/m²-es értéket is mértünk.

4. Az oldott oxigén mennyisége júliusban 20,0, ill. 23,5 °C mellett 10,8, illetőleg 16,0 mg/l volt. Az augusztusi hasonló értékek 8,0 és 15,5 mg/l, illetőleg 21,5 és 23,8 °C voltak.

5. Érdekes, hogy milyen említésre méltó, limnológiai jelentőségű mikrorétegzettség alakulhat ki néhány órán belül egy sekély (2—3 m mély) tó nyílt vizében csendes időben a hőmérséklet és a fényviszonyok hatására.

6. Az őszi oxigéntelítettségi értékek 1975-ben alacsonyak voltak, ami egy újabb, az előző évihez hasonló téli algainváziót, illetőleg halpusztulást nem tett valószínűvé. A tények a feltevést igazolták.

7. Az oxigéntermelés nettó értéke Keszthely térségétől Badacsonytomaj—Fonyód vonaláig egyenletesen csökkent és onnan szinte változatlan volt a tó északkeleti végéig. Eszerint 1975. év folyamán az előző évhez viszonyítva nem növekedett az erősen eutróf tófelület nagysága.

ANNAL. BIOL. TIHANY	43	83–92	HUNGARIA 1976

ENERGY TRANSFORMATION BY *TANYPUS PUNCTIPENNIS* (*MEIG.*) (CHIRONOMIDAE) IN LAKE BALATON

JÁNOS OLÁH

Fish Culture Research Institute, Szarvas, Hungary

Received: 17th April, 1976

The chironomid larvae have an important role in the energy flow of the open water sediment of Lake Balaton. According to the first quantitative analysis (ENTZ, 1954), 60 biomass-per cent of zoobenthos comprise chironomid larvae. Besides ENTZ's later work (1965) PONYI et al. (1971) carried out quantitative investigation on the chironomid populations of the lake. It was shown already by early, semiquantitative investigation (MOON, 1934) that in the open water sediment larvae of *Tanypus punctipennis* (MEIG.) were predominant. According to the present results (PONYI and FRANKO, personal communication) covering all the lake, larvae of *Tanypus punctipennis* (MEIG.) remained predominant in the open water sediment, excluding Keszthely Bay and its surroundings where the larvae of *Chironomus plumosus* were dominant. Some places of the littoral zone are characterized by the larvae of *Cladotanytarsus mancus* and *Procladius* sp. (PONYI et al., 1971). The review of published results shows that our knowledge is very limited on the dynamics of chironomid populations especially on the energy transformation of important species.

In the years of 1973–74 in the open water sediment in front of the Biological Research Institute (Tihany) a detailed analysis was carried out on the seasonal dynamics, the age composition, the weight relation and the carbon content of the different size groups of the *Tanypus punctipennis* population for production evaluation, on the gut content for the evaluation of food consumption, and on the respiration of larval instars at different temperatures for evaluating the annual respiration at population level.

Materials and methods

The analyses were carried out on samples from the open water sediment in front of the Biological Research Institute (Tihany). The samples were collected by HARGRAVE (1969) sampler at about 500 metres from the littoral. Depending on larval density, $2-5\times225$ cm^2 sediment surface with 10 cm depth and at least 5 cm of overlying water was put in a plastic tank, diluted by filtered lake water, homogenized and screened by a 0.1 mm mesh size bronze screen. The living animals caught up on the screen after collecting and screening were selected under a microscope. The size of larvae (body length, body width,

width of head capsule) was read on an objective micrometer. All samples of every collection (altogether 9620 larvae) were selected to size groups.

The wet weight of larvae was measured by individuals blotted on-filter-paper. The dry weight was determined after a 24-hour drying at 105 °C. The carbon content was measured by bichromate wet oxidation. The gut content was washed into distilled water, analyzed under microscope then the dry matter content was measured after drying at 105 °C. The respiration of larvae was measured in a closed bottle containing filtered and aerated lake water, in each measurements 15 to 50 larvae were used depending on size. The oxygen content was measured by Winkler method in 50 ml sample. During the experiments the oxygen content in the bottles never decreased below 6 mg/l, and a complete mixing was produced by the larvae.

Results and discussion

Age composition

The most successful method for determining the age composition of chironomid populations is based on measuring the width of head capsule (CZECZUGA et al., 1968). The age composition of the *Tanypus* populations was not measured earlier by this method. PRUS (1969) used the length of larvae for determining the age composition of *Tanypus kraatzi* KIEFF. population in Lake Wilkus. KAJAK and RYBAK (1966) distinguished only large, medium, and small-sized larvae in *Tanypus punctipennis* populations. In the population of Lake Balaton the larval instars are well selectable on the basis of the width of head capsule, and there are not overlappings *(Fig. 1)*. The head capsule can be used well for determining the age of this chironomid species. It was surprising that in the sediment only larvae of third and fourth instars were found. We have found only four individuals of second instar in a sample collected under ice in February *(Fig. 2)*. In the ice-free period the larvae of the first and second instars live in the plankton and it is possible that these few larvae collected under ice preferred the water-sediment surface with higher temperature. Although the planktonic life of young larval instars is known (ALEKSEJEV, 1955; MORDUHAJ-BOLOTSKOJ and SILOVA, 1955), the parallel quantitative analysis of planktonic and benthic samples would be very useful, especially

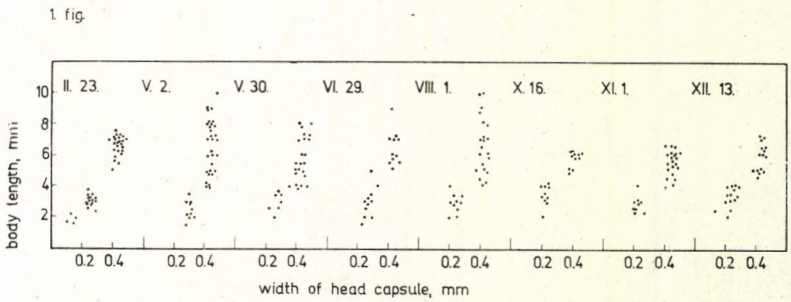


Fig. 1. Seasonal change of relationship between the width of head capsule and body length, on the basis of representative part of the total sample

at the predatory membiers of Tanypodinae subfamily. The width of the head capsule of larval instars was constant all the year round, but the length of larvae changed significantly.

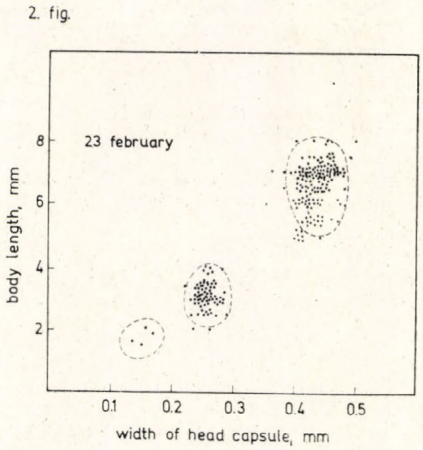


Fig. 2. Age composition of the under-ice total sample

The length of fourth instar in the autumn and winter samples showed less variation than the length of larvae collected in spring and summer times. The age composition of spring and summer populations is very complicated because there is a constant egg-laying and hatching in the entire vegetation period, and at the higher water temperature the uneven growth is more significant.

Population density

The number of larvae was highest in February in both years *(Fig. 3)*. According to KAJAK and RYBAK (1966) values higher than 1×10^4 m^{-2} characterize eutrophic lakes. In February the high larval density was connected not only with the better food condition, but also with the lower grazing activity of the fishes. The total number of larvae decreased quickly in the second half of February and in March. The under-ice decrease in absence of emerging imago could be explained by natural mortality and overgrazing. The thick diatom layer covering the sediment surface of the Lake Balaton in winter has a high daily primary production (HERODEK and OLÁH, 1973) supplying a favourable food condition for the large chironomid population. According to the gut content analyses the larvae feed actively in winter period grazing the thick diatomic carpet. Therefore the decrease of larvae in January and February can be explained by fish overgrazing and later by swarm of imagos. The summer population density compared to winter, under-ice values is very low. During the large swarm in June there are only few larvae of the last instar.

In the sediment we have found only two larval instars and so for the production estimation we had to form size-groups on the basis of body length. Larvae from 1 to 3 mm body length belong to the first size group, from 3 to

5 mm ones to the second size group and from 5 to 10 mm ones to the third size group. Larvae of the first size group appear first during the spring swarm and the larvae of this group can be found all the summer. Their highest number was found in December and in February, they practically disappeared from the sediment samples, that means they outgrew from this size group. This directly proves the active winter feeding and growing of larvae. The number of larvae of the third size group is low all the summer.

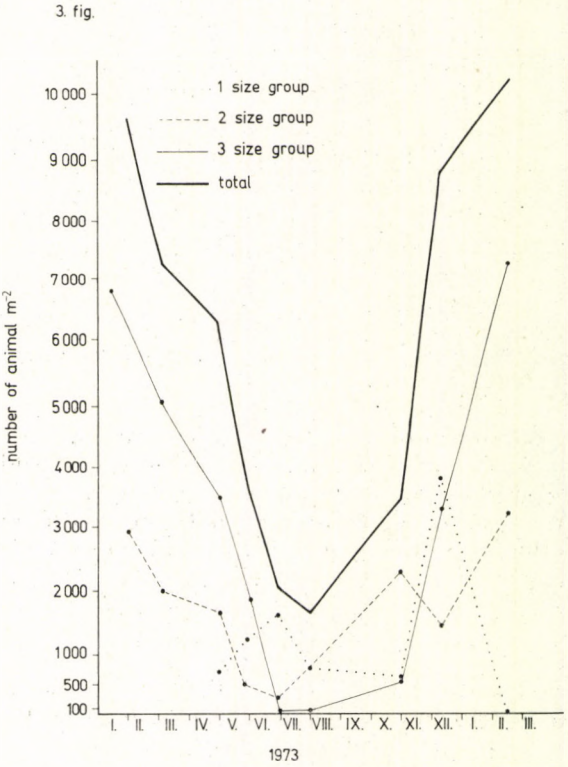


Fig. 3. Quantitative seasonal change of the size groups

Gut content

The members of Tanypodinae subfamily are generally considered as predators. ZILAHI-SEBES (1932) writing about *Tanypus punctipennis* population of Lake Balaton, stated that diatoms and plant detritus dominated in the gut of the larvae. TARWIN (1969) found a lot of plant food in the gut of the populations living in lakes of Poland. All these findings support LUFEROV's statement that the larvae of chironomids have high feeding plasticity.

According to our own gut content analyses the larvae of *Tanypus punctipennis*, especially the winter population consumes mainly diatoms in Lake Balaton. A population transforming the larger part of energy in the benthic community must be fed on plant food basis. According to our measure-

TABLE I

Weight, carbon content and gut content of the different size groups µg/individual (average)

	1. (1—3 mm)	2. (3—5 mm)	3. (5—10 mm)
	Size groups		
Wet weight	122	407	2270
Dry weight	20	64	392
Organic C	11	35	199
Gut content			
Dry weight	4	15	48

ments the ratio of gut content compared to body weight is different at the larval instars. On the basis of average data *(Table I)* the gut content is 4/8 part of body weight. The daily ratio of food consumption of chironomids is generally higher than 100 per cent and at higher temperature they can reach several hundreds per cent (PCHELKINA 1950; BELJAVSKAJA and KONSTANTYNOV 1956; 1961).

On the basis of measured gut content and the generally high daily ratios of chironomids the digestion time is very short, in water of 20—25 °C it is about two hours. On the basis of all these we can be informed only about the magnitude of food entering the digestive tract of *Tanypus punctipennis*.

Respiration

For the estimation of total respiration of the population we had to measure the respiration of larvae of different size groups at different temperature values. The relationship between the body length and respiration of

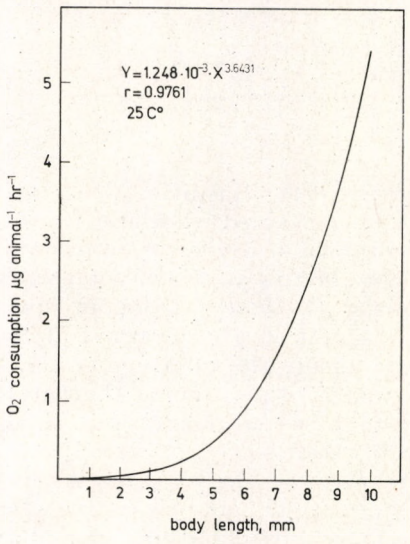


Fig. 4. Relationship between body length and respiration

larvae is followed by power function *(Fig. 4)*. This relationship was analyzed by ERMAN and HELM (1970) in several species of chironomids with the aim to determine the oxigen consumption of larvae only from the body length. The respiration of different body length larvae increased when the temperature had been increased up to 25 °C *(Fig. 5)*. At 30 °C the respiration of the second

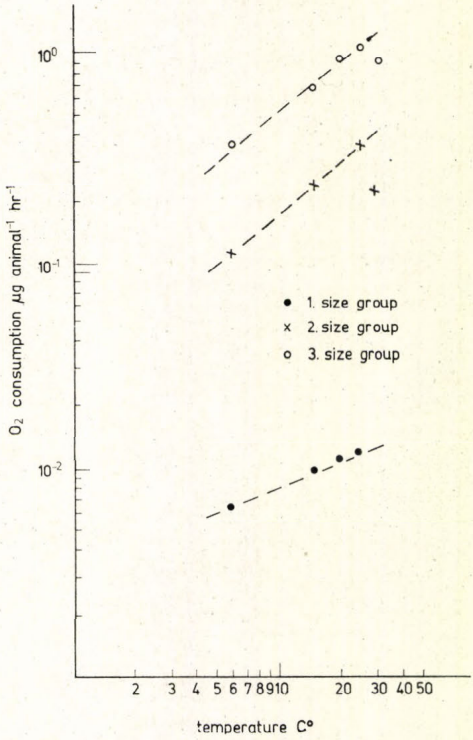


Fig. 5. Relationship between temperature and respiration, at the different size groups

and third size group decreased significantly. The relationship between temperature and respiration was analyzed by winter larvae after 24 hour temperature adaptation. The respiration depressing effect of high temperature at the summer larvae possibly occurs at higher temperatures. In the larvae of *Proclaudius nigriventris* and *P. choreus* living in open water sediment the decrease in intensity of respiration also occurred at 30 °C (LUFEROV, 1958). In EDWARDS (1958) experiments the intensity of respiration of *Chironomus riparius* MEIG. at 20 °C was 2.6 times higher than at 10 °C.

The estimation of total respiration of the population was lightened, because the relationship between body length and respiration was influenced slightly by temperature *(Fig. 5)*. The total respiration was evaluated from data of age composition, average monthly water temperature, population density and respiration of the different size groups at the given temperature *(Fig. 6)*. The respiration of the whole population was highest in May, and the

respiration of the very high biomass at the low water temperature in February was much less. In July and August both biomass and respiration were low. According to our earlier analyses (PONYI et al., 1971) besides chironomids the biomass of most members of zoobenthos reached its minimum in August.

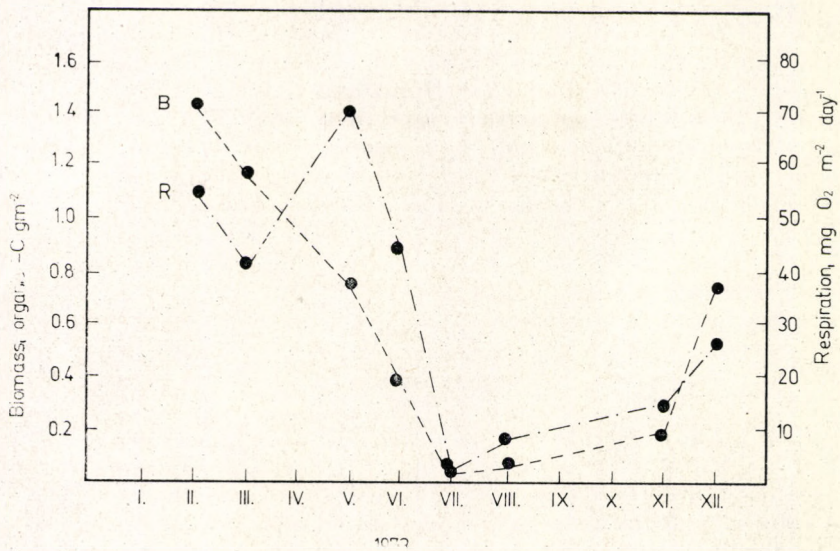


Fig. 6. Seasonal variation of the total population respiration (R) and of the average monthly biomass (B)

Growth and production

Originally we planned to estimate the production of the whole population by following detailed size groups analysis. But in summer months the age composition of the population was very complicated because of continuous egg-laying and hatching and so the selection of groups hatched at the same time was doubtful. The winter population originating from hatching after the autumn swarm forms a well-selectable size group with long, six months of growing period. After the large spring swarm (May or June) of this group the growing period was shortened very quickly. According to KAJAK and RYBAK (1966) at the northern Polish lakes the life cycle is two months in spring and one month in summer. Presumably the summer growing period at the population of Lake Balaton is less than the above-mentioned one. In autumn with decreasing water temperature the groups hatched nearly at the same time come to synchron and this results in the large autumn outswarm. The winter population with the long growing period originates from eggs of these imagos. On the basis of these in Lake Balaton annually there are at least five generations of *Tanypus punctipennis*.

The biomass of summer generations is very low, and the growing is quick, so the energy flowing through the population during a given time is approaching the other periods.

Because of complicated summer age composition, and at the same time in the knowledge of total respiration of population the equation of McNeill and Lawton (1970) was applied for the estimation of the annual production of *Tanypus punctipennis*. The ratios in the equation of the computed energy budget (A,59.3 = R,41.5 + P,17.8 Kcal m^{-2} $year^{-1}$) is similar to ratios of energy budget of *Glyptotendipes barbipes* (Staeger) gained by another method (Kimerle and Anderson, 1971). The basis of production estimation from the respiration is that the ratio of production and respiration of different invertebrate populations is fairly similar (McNeill and Lawton, 1970).

In Lake Balaton the annual energy flow through *Tanypus punctipennis* populations is about four per cent of the primary production of the lake, and the production of population is 1.2 per cent of the primary production. From the total respiration of the benthic populations 8 per cent is given for the population of *Tanypus punctipennis* (Oláh, 1975). The production of this chironomid species alone in the lake approaches the energy required for the total fish population (A, fish, Biró, 1974).

Conclusions

1. The age composition of population was determined seasonally on the basis of the width of head capsule of larvae. In the sediment there were found only the third and fourth larval instars and so it is reasonable to consider the first and second instars to be planktonic. In summer the age composition is very complicated owing to the almost continuous egg-laying and hatching.

2. The population density reached its maximum in February with a biomass higher than 1.4 g organic-C m^{-2}. In summer the biomass was very low, in July and August it was below 0.1 g organic-C m^{-2}. The high winter biomass is connected with the high, under-ice benthic primary production and the low grazing by fish.

3. *Tanypus punctipennis* considered to be predator consumes mainly diatoms in Lake Balaton. The measured gut content and the daily ratios known from the literature suggest high food consumption.

4. The relationship between body length and respiration of larvae: $y(\mu g\ O_2\ larvae^{-1}\ hour^{-1}) = 1.248 \cdot 10^{-3} \cdot \times (\text{body length, mm})^{3.6431}$.

The total respiration of population was estimated on the basis of data of age composition, average monthly water temperature, population density and respiration data of the given temperature and size group.

5. The winter population originating from hatching after the large autumn swarm has a six month long growing period. The growing period of summer populations shortens for one month. According to energy budget estimated by McNeill and Lawton equation (A,59.3 = R,41.5 + P,17.8 Kcal m^{-2} $year^{-1}$) the annual energy flow through the population is about four per cent of the primary production of the lake. The production of *Tanypus punctipennis* alone approaches the energy required for the fish population.

REFERENCES

Aleksejev N. K. (1955): Алексеев Н. К.: О расселении личинок хирономид по водоему. — *Вопр. Ихтиол.* **5,** 145—149.

Beljavskaja L. I., A. S. Konstantinov (1956):Белявская Л. И., Константинов А. С.: Питание личинок *Procladius choreus* Meig. (Chironomidae, Diptera) и ущерь, наносимый ими кормовой базе рыб. — *Вопр. Ихтиол.* **7,** 193—203.

Biró P. (1974): On the fish production of Lake Balaton. Proc. — In: *Lymnology of Shallow Waters.* Eds.: J. Salánki and J. Ponyi. *Symp. Biol. Hung.* **15,** pp. 273—279. *Akadémiai Kiadó, Budapest.*

Czeczuga B. E., Bobiatynska-Ksok, E. Niedzwiecki (1968): On the determination of age structure of the larvae of Tendipedidae (Diptera). — *Zool. Pol.* **18,** 317—328.

Edwards R. W. (1958): The relation of oxygen consumption to body size and to temperature in the larvae of *Chironomus riparius* Meigen. — *J. Exp. Biol.* **35,** 383—395.

Entz B. (1965): Untersuchungen an Larven von *Chironomus plumosus* Meig. im Benthos des Balatonsees in den Jahren 1964—1965. — *Annal. Biol. Tihany* **32,** 129—139.

Entz B. (1954): A Balaton termelésbiológiai problémái. — *MTA Biol. Orv. Tud. Oszt. Közl.* **5,** 433—461.

Erman D. C., W. T. Helm (1970): Estimating oxygen consumption from body length for some Chironomid larvae. — *Hydrobiologia* **36,** 505—512.

Hargrave B. T. (1969): Epibenthic algal production and community respiration in the sediment of Marion Lake. — *J. Fish. Res. Bd. Canada* **26,** 2003—2026.

Herodek S., J. Oláh (1973): Primary production in the frozen Lake Balaton. — *Annal. Biol. Tihany* **40,** 197—206.

Kajak Z., J. I. Rybak (1966): Production and some trophic dependences in benthos against primary production and zooplankton production of several Masurian lakes. — *Verh. Internat. Verein. Limnol.* **16,** 441—451.

Kimerle R. A., N. H. Anderson (1971): Production and bioenergetic role of the midge *Glyptotendipes barbipes* (Staeger) in a waste stabilization lagoon. — *Limnol. Oceanogr.* **16,** 646—659.

Luferov V. P. (1956): Луферов В. П.: Некоторые данные о хищном питании личинок Tendipedidae. — *ДАН СССР* **111,** 466—469.

Luferov V. P. (1957): Луферов В. П.: Питание личинок *Ablabesmyia monilis* L. (Diptera, Tendipedidae). — *ДАН СССР* **116,** 1036—1038.

Luferov, V. P. (1958): Луферов В. П.: Влияние температуры на газообмен личинок некоторых Pelopiinae (Tendipedidae, Diptera). — *ДАН СССР* **119,** 1229—1232.

Luferov V. P. (1961): Луферов В. П.: О питании личинок Pelopiinae (Diptera, Tendipedidae). — *Тр. Инст. Биол. Водохр.* **4,** 232—245.

McNeill S., J. H. Lawton (1970): Annual production respirations in animal populations. — *Nature* **225,** 472—474.

Moon H. P. (1934): A quantitative survey of the Balaton mud fauna. — *Magy. Biol. Kutatóint. Munk.* **7,** 170—189.

Morduhaj-Bolotskoj F. D., A. I. Silova (1955): Мордухай-Болотской Ф. Д., А. И. Шилова: О временно-планктонном образе жизни личинок *Glyptotendipes* (Diptera, Tendipedidae). *ДАН СССР* **105,** 163—165.

Oláh J. (1975): A Balaton évi energiaháztartása. — *Halászat, Tud. mell.* **1,** 2—4.

Pchelkina N. V. (1950): Пчелкина Н. В.: О питании некоторых водных личинок двукрылых. — *Тр. Всес. Гидробиол. Общ.* **2,** 150—168.

Ponyi J., J. Oláh, P. Biró, K. Biró (1971): Comparative investigations on the benthic fauna at two sewage inflows of Lake Balaton. Annal. Biol. Tihany 38, 199—226.

Prus T. (1969): Distribution and age structure in population of *Pelopia kraatzi* Kieff. (Tendipedidae, Pelopiinae) in Lake Wilkus Pol. Arc. Hydrobiol. 16, 67—78.

Tarwin M. (1969): Analysis of the contents of the alimentary tract of predatory Pelopiinae larvae (Chironomidae). — *Ekol. pol. Ser. A* **17,** 125—131.

Zilahi-Sebes G. (1932): Chironomiden-Studien. — *Magy. Biol. Kutatóint. Munk.* **5,** 77—84.

A *TANYPUS PUNCTIPENNIS* (MEIG.) ÁRVASZÚNYOG ENERGIATRANSFORMÁLÁSA A BALATONBAN

Oláh János

Összefoglalás

1. A lárvák fejtok szélessége alapján évszakosan meghatároztuk a populáció korösszetételét. Az üledékben csupán a harmadik és negyedik lárvastádium él, az első és döntően a második is planktonikus életmódot folytat. Nyáron a korösszetétel a közel folyamatos peterakás és kelés miatt nagyon bonyolult.

2. A populáció-sűrűség februárban éri el maximumát, ekkor a biomassza valamivel meghaladja az 1,4 g szerves-C/m²-t. Nyáron a biomassza nagyon alacsony, július és augusztus hónapkban 0,1 g szerves-C/m² alatt van. A nagy téli biomassza összefügg a Balatonra jellemző jelentős téli, jégalatti bentikus elsődleges termeléssel.

3. A ragadozónak tartott *Tanypus punctipennis* a Balatonban döntően kovamoszatokkal táplálkozik. A mért béltartalom és az irodalomból ismert napi arányok jelentős táplálékfelvételre utalnak.

4. A lárvák testhossza és légzése közötti összefüggés: $Y = 1{,}24 \times 3{,}64$. A populáció összlégzését a korösszetétel, az átlagos havi vízhőmérséklet és populáció-sűrűség, valamint az adott hőmérséklet és méretcsoport légzés adatainak a felhasználásával számítottuk.

5. A nagy őszi rajzást követő kelésből származó téli populáció hosszú, hat hónapos fejlődési ciklussal bír. A nyári populációk fejlődési ideje egy hónapra lerövidül. A McNeil- és Lawton-egyenlettel számított energia háztartási mérleg (A,59,3 = R,41,5 + P,17,8 Kcal m^{-2} $év^{-1}$) szerint a populáción évente átfolyó energia a tó elsődleges termelésének mintegy 4 százaléka. Összességében a tóban egyedül a *Tanypus punctipennis* produkciója megközelíti a halállomány számára szükséges energiamennyiséget.

ANNAL. BIOL. TIHANY	43	93–104	HUNGARIA 1976

ON THE FOOD OF PIKE-PERCH FRY (*STIZOSTCDION LUCIOPERCA L.*) IN LAKE BALATON IN 1970

ISTVÁN TÁTRAI and JENŐ E. PONYI

Biological Research Institute
of the Hungarian Academy of Sciences Tihany, Hungary

Received: 20th March, 1976

Having applied stomach content analyses in fish food studies a reliable picture on qualitative and quantitative feeding relations of certain fish species can be obtained. Hence, the living conditions of the fish and their changes may be recorded to some extent.

Research on the feeding of pike-perch fry inhabiting Lake Balaton is very deficient, because the papers published on this topic contain few and more or less informative data (HANKÓ, 1928; UNGER, 1927; cit. TÖLG, 1959). The feeding relations of pike-perch fry have been explored in TÖLG's (1959) paper more profoundly. According to his statement, the pike-perch fry in Lake Balaton scarcely consume the benthic organisms following the plankton feeding stage. A great number of individuals above 35 mm of body length remain plankton feeder and probably this stock becomes mostly extinct during the winter.

The aim of this paper is to estimate changes having occurred in the food and food-supply of pike-perch of Lake Balaton since 1958.

Material and method

Pike-perch fry for food investigations had been collected by BÍRÓ (1972) using an otter-trawl of 5 mm mesh and a beam-trawl of 2 mm mesh respectively, mounted on a frame of 100×35 cm. The material studied was collected in the environs of Balatonfüred–Tihany, Balatonalmádi–Balatonfűzfő, Balatonakali and Bozsai Bay in the period from 5th June to 24th July, 1970 *(Fig. 1)*. The fish caught were fixed instantly on the site in 4–5 per cent formaldehyde solution (BÍRÓ, 1972). After taxonomic determination, the length and weight of the individuals were measured and the internal organs were prepared. Alimentary tract contents were transferred and preserved in vials until the analysis. The stomach contents were analyzed under stereomicroscope and their taxonomic status, quality and number, as well as percentual composition of the food organisms found were determined.

According to various collecting sites, the food of fry and the percentual composition of food supply of habitats were compared. To facilitate the determination of species, the food organisms were cleaned after SHERBININ's (1955)

leaching method with sodium hydroxide for 20 minutes in a maximum according to the quantity of gut content. If the weight of gut content is 0.05 g or less, the quantity of sodium hydroxide needed for hydrolysis is only 3 – 4 drops. The leaching was finished with washing by distilled water. The material studied was divided into five size-groups on the scale of 10 mm and in the appraisal of stomach contents this division was followed.

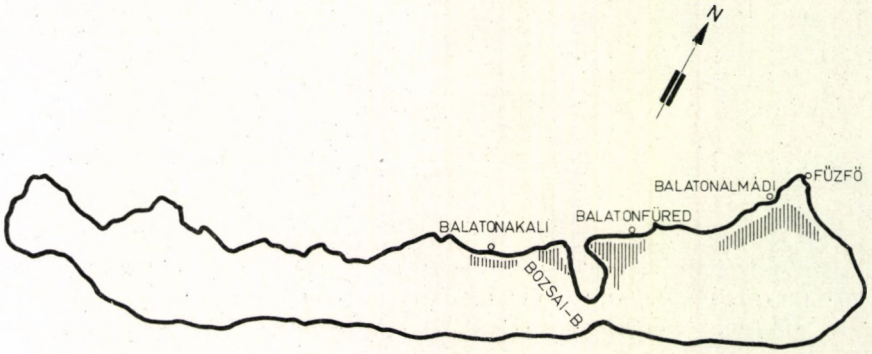


Fig. 1. Collecting sites in Lake Balaton

The present paper summarizes the results on the stomach content analyses of pike-perch fry collected in summer of 1970 (studied in 1975). At the same time it has been connected with BÍRÓ's (1972) growth studies made on the same specimens.

Results

1. Individuals originating from the water area between Balatonfüred and Tihany belonged to size-groups of 11 – 20 mm and 41 – 50 mm *(Table I)*.

The main food items for the specimens belonging to size-group of 11 – 20 mm were *Diaphanosoma brachyurum* occurring in 60 per cent, and *Eudiaptomus gracilis*, as well as *Mesocyclops leuckarti* both in 18.8 per cent. Among crustaceans of greater body dimensions only the *Leptodora kindtii* occurred in 2.4 per cent.

For the other size-group it is characteristic that more *Diaphanosoma brachyurum* was found in the stomachs, and *Daphnica cucullata* was also observed; compared to the previous group the number of *Leptodora* also increased *(Fig. 2b)*. In the case of both size-groups the main food item was *Diaphanosoma* which according to the frequency of occurrence was followed by *Daphnia*, *Eudiaptomus*, *Leptodora* and *Mesocyclops*. No fish remains were found.

2. Specimens of 11 – 20 mm length collected in the environs of Balatonalmádi and Balatonfüzfő mainly consumed *Eudiaptomus* and *Diaphanosoma*. According to their frequency of occurrence, the secondary food organism consumed were as follows: *Daphnia* (8.1 per cent), *Leptodora* (7.6 per cent), *Mesocyclops* (4.2 per cent), *Limnomysis* (0.8 per cent) and tubificids (0.5 per cent) *(Fig. 3a)*.

In the food spectrum of fry belonging to size-group of 21 – 30 mm, the same species were present as in the case of the previous group *(Fig. 3b)*. The only difference is that the pike-perch fry of greater length and mean weight consumed more food. *Diaphanosoma* (19 per cent) and *Eudiaptomus* (32.8 per cent) served as main food supply for them. The remaining 13 per cent comprised mainly *Daphnia*, *Mesocyclopos*, *Limnomysis*, *Leptodora*, as well as larvae of chironomids in a sequence of decreasing frequency. Increasing number of bigger food organisms *(Lymnomysis* 79 per cent) could be observed.

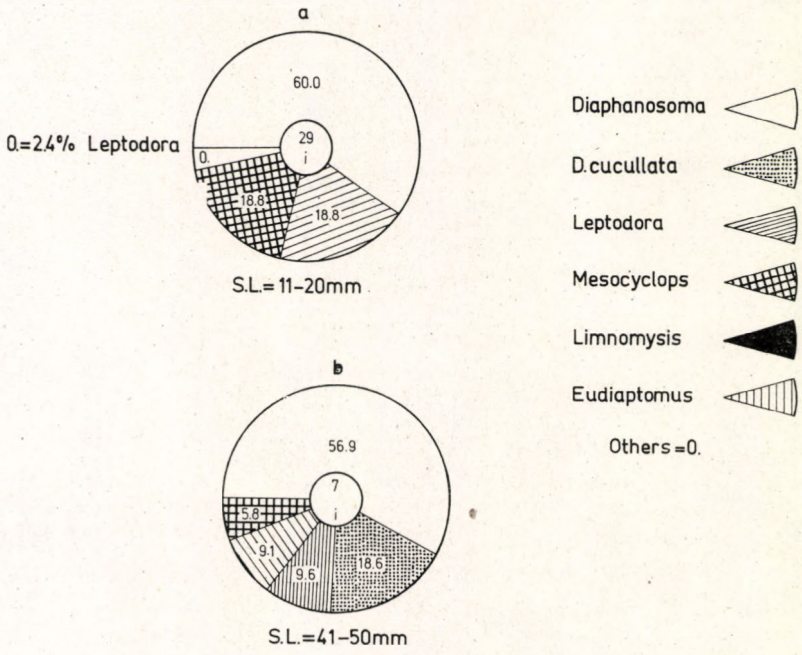


Fig. 2. Percentual composition of stomach content of pike-perch fry (Balatonfüred—Tihany, 5th June, 1970)

For the fry of largest body dimensions (31 – 40 mm) a more intensive food consumption is characteristic, proved by numerous food organisms in the stomach contents *(Table I)*. We did not find any sign of predation in these size-groups of fry.

3. Pike-perch fry collected in the environs of Balatonakali were arranged in three size-groups: 31 – 40 mm, 41 – 50 mm and 51 – 60 mm *(Table I)*.

The primary food of pike-perch fry of 31 – 40 mm body length were *Eudiaptomus* (35.8 per cent) and *Diaphanosoma* (34.1 per cent) *(Fig. 4a)*. Apart from these a great amount of *Daphnia* (26.5 per cent) was also found in their stomachs. *Mesocyclops*, *Leptodora* and pupae of chironomids also occurred in some per cent.

Some 0.2 per cent of the fry of 31 – 40 mm were infected by nematodes which on the basis of their frequency of occurrence is said to be insignificant. In the stomach of a specimen a branchial arch with lamellae belonging to percids was found.

TABLE I

Data on the food composition of pike-perch fry collected during the summer of 1970

Site and date of collection in 1970	Standard length (mm)	No. of samples	Mean weight (g)	Food organisms		
				Item	Total no. of indiv.	Average no. of indiv. stomach
Balatonfüred – Tihany	11 – 20	29	0.08	*Diaphanosoma*	51	1.76
				Eudiaptomus	16	0.55
5th VI.				*Mesocyclops*	16	0.55
				Leptodora	2	0.08
	41 – 50	7	1.23	*Diaphanosoma*	483	69
				D. cucullata	153	21.86
				Leptodora	82	11.71
				Eudiaptomus	82	11.71
		36		*Mesocyclops*	49	7
Balatonalmádi – Balatonfűzfő 23rd VI.	11 – 20	21	0.08	*Eudiaptomus*	73	3.48
				Diaphanosoma	72	3.43
				D. cucullata	15	0.71
				Leptodora	14	0.67
				Mesocyclops	8	0.38
				Limnomysis	2	0.10
				Oligochaeta	1	0.05
	21 – 30	138	0.25	*Diaphanosoma*	1883	13.64
				Eudiaptomus	1139	9.25
				D. cucullata	167	1.22
				Mesocyclops	143	1.04
				Limnomysis	79	0.57
				Leptodora	63	0.46
				Chironomus sp.	1	0.01
	31 – 40	13	0.45	*Diaphanosoma*	419	32.23
				Eudiaptomus	184	14.15
				D. cucullata	36	2.77
				Leptodora	26	2
				Mesocyclops	14	1.09
		172		*Limnomysis*	9	0.69
Akali 10th VII.	31 – 40	20	0.76	*Eudiaptomus*	864	43.20
				Diaphanosoma	822	41.10
				D. cucullata	640	32
				Leptodora	38	1.90
				Mesocyclops	17	0.95
				Nematodas	4	0.20
				Chironomu sp.	3	0.15
				Fry	1	
	41 – 50	28	1.18	*Diaphanosoma*	1372	49
				D. cucullata	1356	48
				Eudiaptomus	1034	37
				Leptodora	211	8
				Limnomysis	24	0.86
				Mesocyclops	11	0.40
				Nematoda	5	0.18
				Chironomus sp.	4	0.14
				Fry	4	

TABLE I *(continued)*

Site and date of collection in 1970	Standard length (mm)	No .of samples	Mean weight (g)	Food organisms		
				Item	Total no. of indiv.	Average no. of indiv. stomach
Akali 10th VII.	51 – 60	3	1.89	*D. cucullata*	232	77.33
				Eudiaptomus	168	56
				Diaphanosoma	107	35.60
				Leptodora	13	4.30
				Limnomysis	3	1
				Chironomus sp.	2	0.66
		51		Fry	2	
Bozsai Bay 24 th VII.	31 – 40	50	0.75	*Mesocyclops*	711	15.40
				Diaphanosoma	365	7.30
				Limnomysis	322	6.40
				Eudiaptomus	83	1.70
				D. cucullata	38	0.80
				Chironomus sp.	24	0.50
				Nematoda	10	0.20
				Leptodora	4	0.10
				Oligochaeta	3	0.06
				Fry	18	
	41 – 50	272	1.25	*Diaphanosoma*	6357	23
				Eudiaptomus	3378	12.40
				D. cucullata	2683	10
				Limnomysis	1789	6.50
				Mesocyclops	1057	3.90
				Leptodora	342	1.30
				Chironomus sp.	186	0.70
				Nematoda	62	0.20
				Oligochaeta	30	0.10
				Fry	63	
	51 – 60	109	2.03	*Limnomysis*	1730	15.80
				Diaphanosoma	1362	12.50
				D. cucullata	923	8.50
				Eudiaptomus	353	3.20
				Mesocyclops	155	1.42
				Leptodora	92	0.80
				Chironomus sp.	89	0.80
				Nematoda	27	0.30
				Oligochaeta	7	0.06
		431		Fry	26	

In the stomachs of pike-perch fry of 41 – 50 mm, increased individual number of *Diaphanosoma* (34.1 per cent), *Daphnia* (33.8 per cent), as well as *Leptodora* (18.9 per cent) were found, as compared to previous size-group *(Fig. 4b)*. The large-sized *Limnomysis benedeni* have also appeared in the meal of pike-perch fry, altough in a small number (0.6 per cent). Larvae and pupae of *Chironomus* sp. also occur in the food spectrum of this size-group (0.1 per cent). Ctenoid scales and epithelial tissue as well as muscle remains of ruff were observed in the stomachs of pike-perch fry in four instances. It means that about 14 per cent of the individuals in this size-group apart from invertebrates of larger body dimensions also feeds on fish.

Stomach content analyses of the 3 specimens belonging to 51 – 60 mm size-group showed that only *Limnomysis* occurred in the stomachs. Nevertheless, pupae of chironomids were found in two of the three specimens. In addition to this, the amount of plankton-crustaceans primarily *Daphnia* and *Eudiaptomus* is henceforth significant *(Fig. 4c)*.

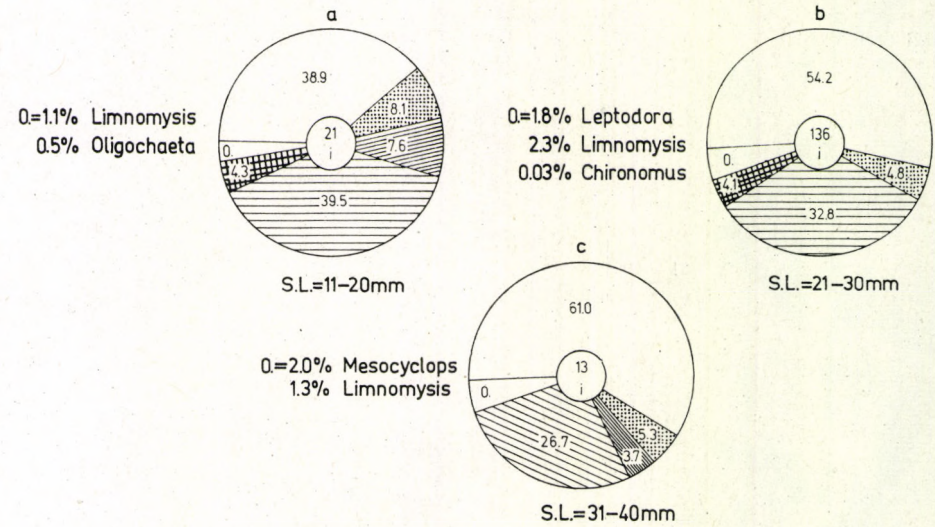


Fig. 3. Percentual composition of stomach content of pike-perch fry (Balatonalmádi—Balatonfűzfő, 23rd June, 1970) (Explanation as in *Fig. 2*)

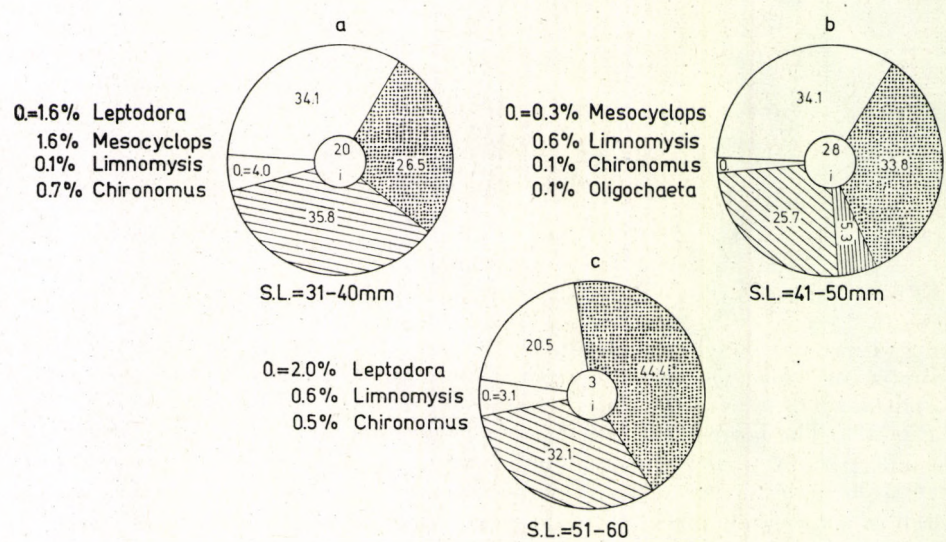


Fig. 4. Percentual composition of stomach content of pike-perch fry (Balatonakali, 10th July, 1970) (Explanation as in *Fig. 2*)

4. In the stomachs of 31 – 40 mm sized fry originating from Bozsai Bay *Limnomysis* in much greater number was observed (20.0 per cent) in contrast to previous collecting places *(Fig. 5a)*. It is important to note that pupae and larvae of *Chironomus* sp., as well as Oligochaetes were found in the stomachs of every second fry. The ratio of secondary food consisted of species of crustacean-plankton, however, is much less compared to other collecting places (Tihany – Balatonfüred, Balatonalmádi – Balatonfűzfő) *(Table I)*.

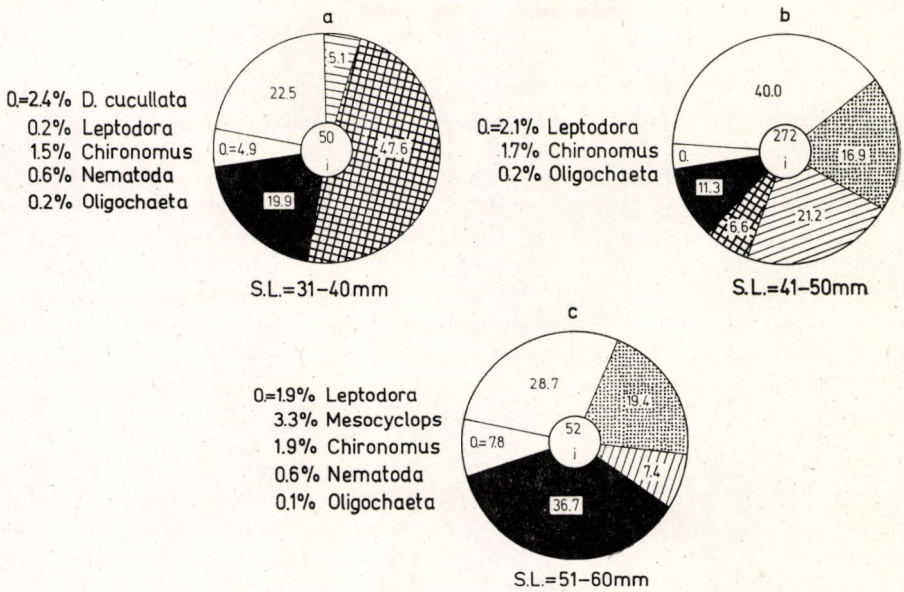


Fig. 5. Percentual composition of stomach content of pike-perch fry (Bozsai Bay, 24th July, 1970) (Explanation as in *Fig. 2*)

Infestation of the digestion tract by nematodes was most intensive in this size-group; i.e. almost every fifth specimen was infected.

In every third digestion tract studied (33 per cent) heavily digested tissues, as well as fragments of the body of ruff and pike-perch fry were observed.

Most of the stomach analyses were made on specimens of 41 – 50 mm. The ratio of *Limnomysis* in the stomach-content further increased compared to the previous group. The number of larvae and pupae as well as oligochaetes per one fish has also increased. The number of plankton-crustaceans in a stomach has further decreased. In spite of this fact, the occurrence of *Diaphanosoma*, *Eudiaptomus* and *Daphnia* cannot be ruled out *(Fig. 5b)*.

The intensity of infestation by nematodes is about the same as in the previous group.

Fish (ruff, pike-perch) and more or less digested organs of them were found in 63 stomachs of the 272 analyzed. On an average almost every fourth pike-perch fry consumed fish-food.

According to analyses of digestion tract of pike-perches belonging to size-group of 51 – 60 mm the following was established: *Limnomysis benedeni*

occurred in the greatest number (36.7 per cent) in this group *(Fig. 5c)*. As compared to the previous size-group, the frequency of occurrence of larvae and pupae of *Chironomus* sp. has increased further, and almost all pike-perch stomachs contained one specimen of each. The ratio of plankton-crustaceans in the food-spectrum is insignificant. As compared to the previous size-group the intensity of predation in fish did not change; about 25 per cent of fry consumed prey-fish.

Discussion

The primary question is whether the specimens caught with the otter-trawl suitably represent the entire stock of fry originating partly from the reed-grass zone having rich food-supply, and partly from open water areas without vegetation. Due to its structure the otter-trawl cannot be used within the extensive, dense reed-grass. At most it can adequately be used between reed-grass spots. Consequently, specimens usually caught at water areas far-off the reed-grass zone and more deficient in fish food were studied. TÖLG (1959) made no mention of such a case that *Limnomysis* or any other Amphipoda had been observed in the stomach, although at this time the large-sized *Limnomysis* have already been observed in great quantities in the entire littoral reed-grass zone *(Myriophyllum)* of Lake Balaton (PONYI, 1956). Some hundreds of pike-perch fry feeding on the relatively rich fauna of the littoral area covered by reed-grass were also caught. An example from our studies: the food composition of the 31—40 mm long pike-perch fry collected at open water areas in the environs of Balatonalmádi—Balatonfűzfő (23rd July, 1970) according to the number of food organisms was as follows: 61 per cent of *Diaphanosoma*, 27 per cent *Eudiaptomus*, 5 per cent of *Daphnia cucullata*, 4 per cent of *Leptodora*, 2 per cent of *Mesocyclops* and 1 per cent of *Limnomysis*. At the same time, in the case of the same-sized specimens collected at areas with more available food for fish: 38 per cent of *Mesocyclops*, 22 per cent of *Diaphanosoma*, 20 per cent of *Limnomysis*, 5 per cent of *Eudiaptomus* and 5 per cent of miscellaneous items *(Daphnia cucullata, Leptodora, Chironomus,* Nematoda, *Tubificids)*. These data refer to the fact that inshore areas covered by reed-grass provide better possibility for pike-perch fry to turn over the consumption on larger invertebrates after their plankton-feeding stage. It is also proved by literature data (ENTZ, 1947; BÍRÓ and GULYÁS, 1974) that the reed-grass stands are abundantly inhabitated by differently sized members of the fauna.

In evaluating the food-spectrum the individual weight of various organisms is indispensable. Although, during the analyses *Limnomysis* was present in a smaller quantity compared to plankton-crustaceans, still its biomass may be relatively more significant. For instance, in the stomach of a 31—40 mm sized fry about 25 plankton-crustaceans and 6 *Limnomysis* were present. Simultaneously, their biomass assessed in dry weight were 0.02 mg and 0.96 mg, respectively.

Lastly we gather from the results that only a certain part of the fry stock is able to inhabit the relatively narrow zone with rich food-supply, while the other part is driven out to water areas deficient in appropriate food. As a result of this, one part of the population is well developed, while the other is stunted in growth. This can be an explanation for the phenomenon of "diverse growth"

in length of pike-perch fry (BIRÓ, 1972). The same phenomenon was observed in Soviet reservoirs (i.e. Kujbishev Reservoir) (SHARONOV, 1963). Similar observation was also made among invertebrates. In the case of *Bosmina longirostris* it was found (WEGLENSKA, 1964) that the measurement of animals inhabiting the littoral zone with rich food supply was larger (290 μ) compared to members of the population living in open water areas (250 μ). Time factor also plays a part in this, because three–four weeks may pass between the birth of specimens. To settle this question further studies are needed.

The food of pike-perch fry driven out to open water theoretically is partly the curstacean-plankton, and above 25 mm body length, partly the various species of larger-sized macrozoobenthos (LJASHENKO, 1961). In the case of Lake Balaton these studies unanimously show that for pike-perch fry the open water chironomids are unavailable. The food analysis of ruff (PONYI et al., 1972) also proves the occurrence of Diptera in a required number. The light deficiency at the mud surface is the probable reason why the pike-perch fry is unable to consume this type of food. TÖLG's (1959) and our results show that Diptera and Oligochaeta occurred in the digestion tract of 30—50 mm sized specimens originating from the open water areas in an insignificant number. They probably reached the upper layers of the water when the lake was troubled and so they became available for the fish. The ratio of chironomids in the food of fry inhabiting the reed-grass zone is much higher (2.4—3.9 mg in dry weight per stomach; Bozsai Bay).

The food supply of pike-perch fry in the open water are exclusively the species of crustacean-plankton. Comparing the qualitative and quantitative composition of crustacean-plankton samples *(Table II)* being at our disposal

TABLE II

Average number of individuals per litre of crustacean-plankton samples collected during June and July of 1967 and 1972 (PONYI, *1975)*

Crustacean plankton	Standard sections		
	"E"	"A"	"G"
Diaphanosoma brachyurum	7.28	6.12	4.73
Daphnia cucullata	1.22	1.37	1.46
Leptodora kindtii	0.07	0.08	0.15
Eudiaptomus gracilis	4.31	5.75	3.26
Mesocyclops leuckarti	4.72	3.32	4.69
Cyclops sp.	1.97	1.14	1.17
Total:	19.57	17.78	15.46

and originating from areas near to the collecting places of fry, it is clear that the food supply cannot be ranked as a rich one. On the basis of individuum per litre values the *Leptodora kindtii* occurred in a small number. Consequently, it did not play a significant role in the food of pike-perch fry.

Having compared the percentual composition of gut contents and crustacean-plankton samples taken from three collecting sites at the open water areas *(Table III)* it was established that *Diaphanosoma* (body length of ♀ = about 1 mm) occurring in high percentage every time was also present

TABLE III

The percentual distribution of crustacean-plankton along the "E" section (Balatonalmádi—Balatonfűzfő) and in the stomach content of pike-perch fry

Food animals	Section "E"	Pike-perch fry		
		11—20 mm	21—30 mm	31—40 mm
Diaphanosoma brachyurum	41.4	40.0	54.2	61.0
Daphnia cucullata	6.9	8.1	4.8	5.2
Leptodora kindtii	0.4	7.6	1.8	3.7
Eudiaptomus gracilis	24.5	39.5	37.8	26.7
Mesocyclops leuckarti	26.8	4.3	4.1	2.0

in a high ratio in the food of fish, as well. As regards the frequency of occurrence of *Eudiaptomus* (length of ♀ = 1—1.5 mm) it occupies the second or third place in the plankton and accordingly it can also be found in a high percentage in the food of pike-perch fry. Simultaneously, the relatively same sized *Mesocyclops* (length of ♀ = 1.3 mm) occurring in great numbers can hardly be found in the gut. According to out data the occurrence of *Leptodora* varies between 0.4 and 1.0 per cent, at the given areas of the lake, nevertheless, in the gut amounts to its manifold value *(Tables II* and *III)*. In summing up our observations it can be stated that pike-perch fry selectively consumes the plankton-crustaceans in the open water; though for the final solution of this question simultaneous investigations are needed.

Having compared our and TÖLG's (1959) data it was found that the amount of plankton-crustaceans observed in the digestion tract of 11—20 mm long pike-perch fry had decreased to its half.

While in 1958 *Eudiaptomus* occupied the first place of the food spectrum, during our studies it was replaced by *Diaphanosoma*. This can be explained by those results (PONYI et al., 1975) according to which the biomass of *Eudiaptomus* population has greatly decreased probably due to the high density of fish. We suppose that the habitat of pike-perch fry is concentrated to about a 500 m wide littoral zone. Considering the density of fry of various fish species inhabiting the littoral zone of Lake Balaton, an overgrazing of the crustacean-plankton food supply is an existing problem. It may well be true, because all species of fish inhabiting Lake Balaton feed on zooplankton during a certain phase of their juvenile stage. This insufficiency of planktonic food afflicting the pike-perch fry also proves that the biomass of zooplankton and their consumers are balanced in Lake Balaton. Obviously this should not be increased with new consumers.

Summary

Stomach contents of 690 pike-perch fry caught at four collecting sites in Lake Balaton during the summer of 1970 were analyzed by the authors and the following were established.

Specimens of 11—20 mm length consume *Diaphanosoma brachyurum* in 60 per cent and *Eudiaptomus gracilis* in 18 per cent, while this ratio was 50—50 per cent in 1958.

As compared to data of 1957—58, the amount of total crustacean-plankton in the stomach content had decreased to its half. It means that the deterioration of feeding possibility of fry (10—20 mm size-class) continued.

According to the quality of food consumed a part of pike-perch fry surpassing 20 mm body length inhabit water areas free from reed-grass stands. This results in a displacement from the relatively narrow reed-grass stands having rich food-supply. The other part consuming rich macrofauna grows faster and change to predation in time. The "diverse growth" of pike-perch fry in Lake Balaton can be explained by this phenomenon.

Based on the present studies we came to the conclusion that the bulk of previous analyses were made on groups of fry displaced to the open water. With the use of collecting technique applied in earlier the fry inhabiting open water areas were chiefly caught because of the dense reed-grass. Owing to this an inaccurate statement was put forth saying that large-sized organism is lacking in Lake Balaton being necessary during the changing period of feeding habit.

According to data of the summer period of 1967 and 1972, *Leptodora kindtii* amounted to 0.4—1.0 per cent only in the crustacean-plankton of Lake Balaton. This is why it occurred only in an insignificant quantity in the food of fry inhabiting the open water.

Authors are anxious concerning the density of fry in the littoral zone of Lake Balaton, since it is unfavourable, consequently a sharp competition may occur there.

REFERENCES

Bíró P. (1972): First summer growth of pike-perch (*Lucioperca lucioperca* L.) in Lake Balaton. — *Annal. Biol. Tihany* **26**, 85—99.

Bíró K., Gulyás P. (1974): Zoological investigations in the open water *Potamogeton perfoliatus* stand of Lake Balaton. — *Annal. Biol. Tihany* **41**, 181—203.

Entz B. (1947): Qualitative and quantitative studies in the coatings of *Potamogeton perfoliatus* and *Myriophyllum spicatum* in Lake Balaton. — *M.B.K.M.* **17**, 17—37.

Hankó B. (1928): Megfigyelések a fogassüllő (*Lucioperca sandra* Cuv. et Val.) ivadékán. — *Arch. Balatonikum* **2**, 84—91.

Ljashenko A. F. (1961): Ляшенко А. Ф.: Материали по биологии молоди судака Каховского водохранилища в первые два года его существования. — *Вопр. ихтиол.* **17**, 56—67.

Ponyi J. (1956): A balatoni hínárosok Crustaceainak vizsgálata. — *Állattani Közlemények* **45**, 107—121.

Ponyi J. E. (1975): The biomass of zooplankton in Lake Balaton. — *Symp. Biol. Hung.* **15**, 215—224.

Ponyi J., P. Bíró, É. Murai (1972): A balatoni vágódurbincs *(Acerina cernua)* táplálékáról, növekedéséről és belső parazita férgeiről. — *Parasit. Hung.* **5**, 383—408.

Ponyi J., J. N.-Horváth, N. P.-Zánkai (1975): Investigations on planktonic Crustacea in Lake Balaton VI; Quantitative changes in the *Euciaptomus gracilis* population at various regions of Lake Balaton. — *Annal. Biol. Tihany* **42**, 203—218.

Sherbinin I. A. (1955): Щербинин И. А.: К методики обработки содержимого кишечника рыб. — *Вопр. ихтиол.* **4**, 178—180.

Sharonov I. V. (1963): Шаронов И. В.: Динамика возрастного состава и роста судака в Куйбишевском водохранилище. — Биологические аспекты изучения водохранилищ. — *Труды Института биологии внутренных вод АН СССР.*, вып. **6**, 201—216.

Tölg I. (1959): A balatoni fogassüllő-ivadék (*Lucioperca sandra* Cuv. et Val.) táplálékának vizsgálata. I. Adatok a plankton és fenékfaunafogyasztó időszak táplálékanalíziséhez. — *Annal. Biol. Tihany* **26**, 85—99.

Unger E. (1927): A magyar folyók és tavak természetes haltápláléka. — *Kísérletügyi Közl.* **30,** 8.
Weglenska T. (1964): Variation of incidence, size and fertility of plankton Crustacea in space and time. — *Bull. Acad. Pol. Sci.* **12,** 385—390.

A FOGASSÜLLŐ-IVADÉK (*STIZOSTEDION LUCIOPERCA* L.) TÁPLÁLÉKA A BALATONBAN 1970-BEN

Tátrai István és *Ponyi Jenő*

Összefoglalás

A szerzők 1970. év nyarán a Balaton négy gyűjtőhelyéről befogott 690 db süllő-ivadék gyomortartalmát vizsgálták és a következőket állapították meg.

A 11—20 mm-es példányok 60%-ában *Diaphanosoma brachyurum*-ot és 18%-ban *Eudiaptomus gracilis*-t fogyasztanak, míg 1958-ban ez az arány 50—50% volt.

Az össz-Crustacea plankton mennyisége a gyomortartalomban az 1957—58-as adatokhoz képest a felére csökkent. Ez azt jelenti, hogy a 10—20 mm-es ivadék táplálék-feltétele tovább romlott.

A 20 mm feletti fogassüllő-ivadék egy része — a felvett táplálék minősége alapján — továbbra is hínármentes vízben él, melynek oka a viszonylag keskeny, táplálékban gazdagabb hínármezőből való kiszorulás. A másik része a gazdag makrofaunát fogyasztva gyorsabban nő, és át is tér a halragadozásra. Ezzel a jelenséggel magyarázható a balatoni süllőivadék ún. szétnövése is.

Vizsgálataink alapján arra a következtetésre jutottunk, hogy a korábbi analízisek kizárólag a nyíltvízre kiszorult ivadékcsoportokon történtek. Ugyanis az eddigiek során alkalmazott gyűjtési technika segítségével, a hínármező miatt főleg a nyíltvízi ivadékot foghatják ki. Ennek következtében született az a nem pontos megfogalmazás, miszerint a Balatonból hiányzik egy nagytestű szervezet, amely az ún. táplálékváltási periódusban szükséges.

Az 1967., 1972. évek nyári átlag adatai alapján a Balaton Crustacea-planktonjában a *Leptodora kindtii* csupán 0,4—1,0%-ban szerepelt. Ez az oka annak, hogy a nyíltvízi ivadék táplálékában kis mennyiségben fordult elő.

A szerzők kifejtik azon aggodalmukat, hogy a Balaton parti övében a halivadékok sűrűsége kedvezőtlen, így éles táplálékkonkurrencia esete állhat elő.

ANNAL. BIOL. TIHANY | 43 | 105–116 | HUNGARIA 1976

SEASONAL CHANGES IN THE FILTERING RATE OF *EUDIAPTOMUS GRACILIS* (*G. O. SARS*) IN LAKE BALATON

NÓRA P.-ZÁNKAI and JENŐ E. PONYI

Biological Research Institute of the Hungarian Academy of Sciences Tihany, Hungary

Received: 15th March, 1976

The only filter feeding copepod of Lake Balaton, *Eudiaptomus gracilis* was first found by RICHARD in 1891 (ENTZ, 1897). From that time on this species is mentioned in all papers dealing with the crustacean plankton of this lake. However, only a few quantitative data are available on the nutrition, filtering rate, food uptake and incorporation of this species in other lakes, and until recently hardly any investigations of this type have been carried out in our lake. In 1972–73 we fed *E. gracilis* on algae obtained from pure cultures and determined the food incorporation in function of alga species, food concentration and season (ZÁNKAI and PONYI, 1974a, b; ZÁNKAI, 1975). Detailed investigations on the population of *E. gracilis* were carried out by PONYI et al. (1975). In order to get some estimate of the food uptake and the role of this population in the ecosystem of the lake, this paper deals with the filtering rate of adults under natural conditions.

Material and methods

20–28 hours before the experiments 2 litres of water were sampled from 0.5 m depth in the pelagial 300–500 m off shore in front of our Institute. From the sample 1.5 litre was filtered through a No. 8 net (pore size 300–320 μm) in order to remove larger for nutritional purposes unavailable animals, algae and other particles.

After this treatment 200 μCi $NaH^{14}CO_3$ (Isotope Institute of the Hungarian Academy of Sciences, spec. activity 57.1 mCi/mmole) was added to the water, and the bottle was replaced and incubated in the lake for 20–28 hours at a depth of 0.3–1.0 m depending on turbidity. In the laboratory this water was then portioned per 100 ml into smaller bottles. The latter had glass stoppers and were wrapped into aluminia sheets to prevent further photosynthesis. Of the same water 100 ml was passed through GF/C glass fibre filter and the particulated organic carbon content was determined by the wet oxidation techniques (OSTAPENJA, 1965).

In order to determine the specific activity of the food 3×50 ml water was filtered through membrane filters (Sartorius Membranfilter GMBH, pore size 0.2 μm), then the filters were washed by previously filtered, inactive lake

water. This rinsing continued till the effluent became absolutely inactive. According to previous experiments rinsing with 250 ml was necessary.

The animals were collected immediately prior to the experiments by No. 6 net from the same area whence the water was sampled. Male and female adults were separated under stereomicroscope, and 8–20 individuals (males and females mixed) were placed into the bottles, containing 100 ml water. These bottles were then replaced into the lake.

In all experiments the feeding period lasted for 40–41 minutes. This time interval was chosen on the basis of the data of RICHMAN (1964) and KIBBY (1971) and of our experiments. Before the experiments on the filtering rate 15–15 *E. gracilis* adults were placed into 100–100 ml previously filtered (0.2 μm pore size) lake water, containing carmine pulver to determine the shortest time necessary for the food particles to pass through the alimentary tract (minimum Erneuerungskoefficient) (NAUMANN, 1921; RIGLER, 1971). The feeding periods were 40, 50 and 60 minutes. Most of the animals (10, 13 and 11 from the 15–15–15 individuals and 10 from 10 individuals) fed on the carmine particles, and the passage of these particles in the alimentary tract could be traced under a stereomicroscope. After feeding with carmine particles the animals were placed in Balaton water, filtered through No. 25 net. None of the animals released carmine within the first hour. In the third hour about half of the animals, after the sixth hour all depleted their guts. This was the 40-minute feeding period in our experiment was short enough to avoid loss of radioactivity through defecation.

After the feeding period the crustaceans were rinsed, killed by hot water and placed into scintillation vials, containing Bray solution. The radioactivity was measured by Isocap/300 and Packard Tri-Carb liquid scintillation detectors. In the case of the particles, filtered from the water the absolute radioactivity (dpm) was obtained by the channel ratio method, while in the case of animals a correction factor of 1.38 for self-absorption was also used (ZÁNKAI and PONYI, 1974b).

The filtering rate was calculated according to the following formula:

$$F = E \frac{R_2 \times 24}{R_f \times t},$$

where

F = filtering rate in ml.cop^{-1}.day^{-1},
E = self-absorption of adult animals,
R_2 = radioactivity of one animal,
R_f = radioactivity of food in one ml water,
t = time of feeding in hours.

Results

The investigations were carried out in fortnightly–monthly intervals from March 1974 to November 1975. This way the changes in filtering rate were followed throughout nearly two years by natural food and temperature conditions *(Table I)*. The minimum filtering value per animal per day was 0.01 ml water (0.4 °C; 1.43 μg C/ml), the maximum one 3.27 ml (21 °C; 0.8 μg C/ml). The seasonal (astronomical seasons) average filtering rates were the

TABLE I

Changes in the filtering rate of Eudiaptomus gracilis

Date	Water temperature °C	Organic C µg/100 ml	Number of samples	Filtering rate ml/cop./day ± S. D.
12. III. 1974.	5.6	89.7	4	0.28 ± 0.08
28. III.	10.0	–	4	0.04 ± 0.00
18. IV.	10.2	173.1	4	1.19 ± 0.38
9. V.	14.0	103.7	6	2.15 ± 0.78
31. V.	19.5	47.5	5	1.22 ± 0.72
13. VI.	15.0	80.6	5	1.04 ± 0.42
28. VI.	20.5	90.7	5	0.92 ± 0.29
16. VII.	23.0	144.2	5	0.83 ± 0.11
5. IX.	2.14	104.4	3	1.94 ± 0.39
11. IX.	18.0	80.5	2	0.62
26. IX.	15.0	79.1	4	0.87 ± 0.34
30. X.	6.5	87.0	5	0.75 ± 0.15
5. XI.	6.0	–	5	0.31 ± 0.04
10. XII.	5.0	99.4	5	0.16 ± 0.05
23. XII.	3.0	97.5	5	0.13 ± 0.04
9. I. 1975.	2.5	107.2	5	0.08 ± 0.06
22. I.	3.0	101.9	5	0.15 ± 0.05
13. II.	2.0	96.9	5	0.12 ± 0.07
5. III.	5.0	–	4	0.08 ± 0.01
21. III.	9.0	186.4	5	0.11 ± 0.07
27. III.	7.0	189.7	7	0.22 ± 0.03
15. IV.	9.0	153.7	7	0.12 ± 0.04
8. V.	17.5	91.9	7	1.61 ± 0.39
22. V.	22.3	95.2	8	2.36 ± 0.74
5. VI.	17.2	172.8	8	0.33 ± 0.12
25. VI.	27.0	60.8	8	1.27 ± 0.28
9. VII.	26.0	–	8	1.23 ± 0.35
25. VII.	23.5	112.4	8	2.18 ± 0.32
14. VIII.	24.0	42.2	8	1.34 ± 0.42
5. IX.	23.0	57.6	8	1.95 ± 0.43
19. IX.	21.0	76.0	7	2.93 ± 0.34
8. X.	14.5	155.2	8	1.48 ± 0.29
23. X.	12.0	67.3	8	0.47 ± 0.08
4. XI.	8.5	58.1	6	0.77 ± 0.19
28. XI.	0.4	142.9	8	0.12 ± 0.06

following: spring 0.96; summer 1.44; autumn 0.63; winter 0.11 ml/copepod/day. The difference between the summer and winter values is highly significant ($P \ll 0.001$).

The filtering rate of *E. gracilis* depends on water temperature, on the concentration of food and on the physiological state of the animals. A comparison of the filtering rate and the water temperature *(Fig. 1)* shows the two factors to be connected. This connection is especially close in periods with rapid temperature changes, i.e. in spring and autumn. In winter, parallel with low temperature, filtration is likewise slow. In summer filtration is usually intensive, but it varies much, and does not follow the changes in temperature.

By the statistical analysis (t – statistic) of the temperature effect on the filtering rate the direction of the temperature changes was disregarded.

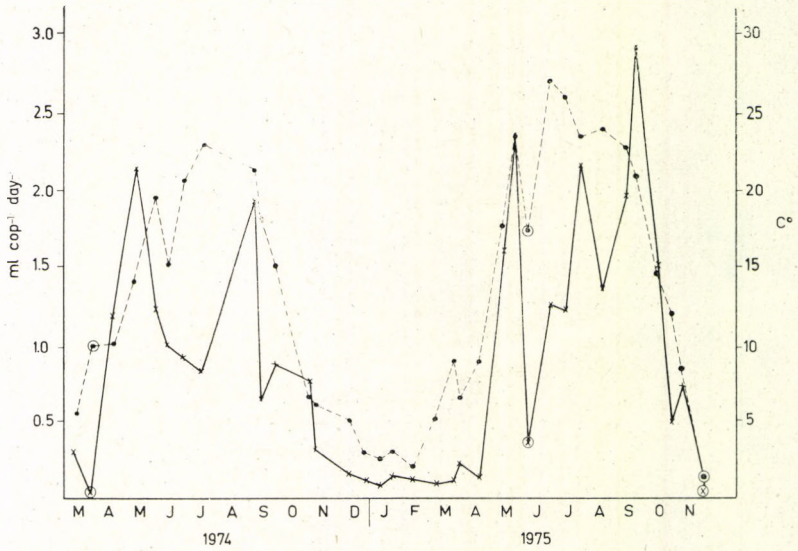


Fig. 1. The filtering rate of *Eudiaptomus gracilis* and the temperature of the lake during the experiments. (———— filtering rate, — — — — temperature, O storm)

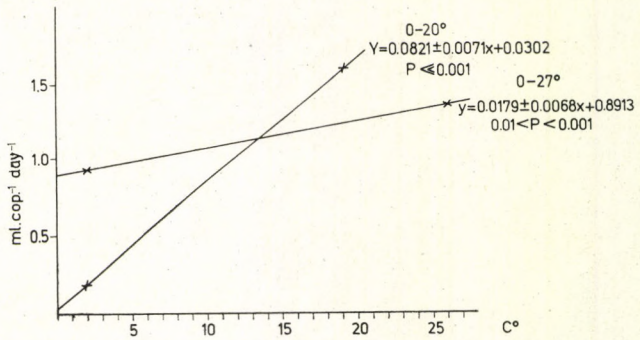


Fig. 2. The filtering rate in the function of temperature

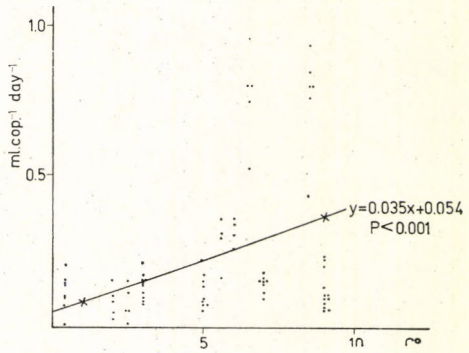


Fig. 3. Regression between filtering rate and temperature within the range of 0—10 °C

Taking into calculation the total temperature range of the lake (0—27 °C) the effect of temperature was significant ($0.01 > P > 0.001$) *(Fig. 2)*. For the 0—20 °C interval the two components are even more closely connected ($P < 0.001$). By dividing the total temperature range to intervals of 5 °C amplitude, it was found, that for a temperature change of 5 °C the filtration does not change unequivocally, and only a difference of 10 °C resulted in signif-

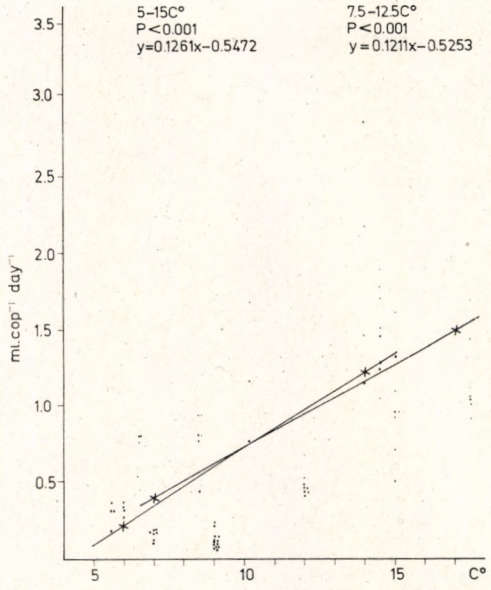


Fig. 4. Regression between filtering rate and temperature within the ranges of 5—15 and 7.5—17.5 °C

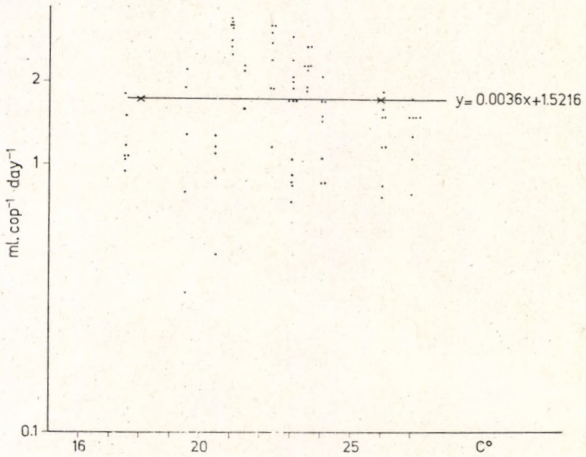


Fig. 5. Regression between filtering rate and temperature within the range of 17.5—27 °C

icant increase or decrease of the filtration. This statement is valid for the temperature intervals of 0–10, 5–15, 7.5–17.5 °C *(Figs 3–4)*. In the intervals of 15–25 °C and 17–27 °C filtering rate does not follows temperature changes, but it appears to be absolutely independent from it *(Fig. 5)*.

To get information on the concentration of food available to crustaceans, the particulated organic carbon content of the water was determined. This is proportional with the amount of algae and the suspended detritus, and thus

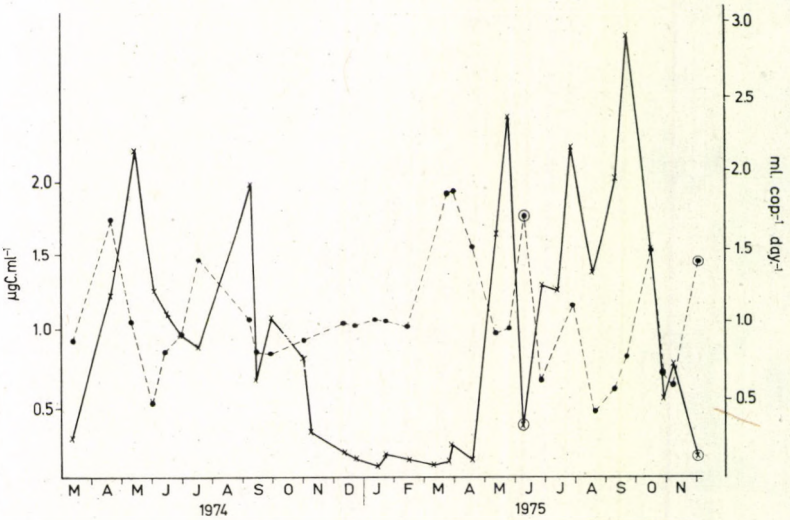


Fig. 6. The filtering rate of *Eudiaptomus gracilis* and the particulated organic carbon content of the water during the experiments. (———— filtering rate, — — — — organic C, O storm)

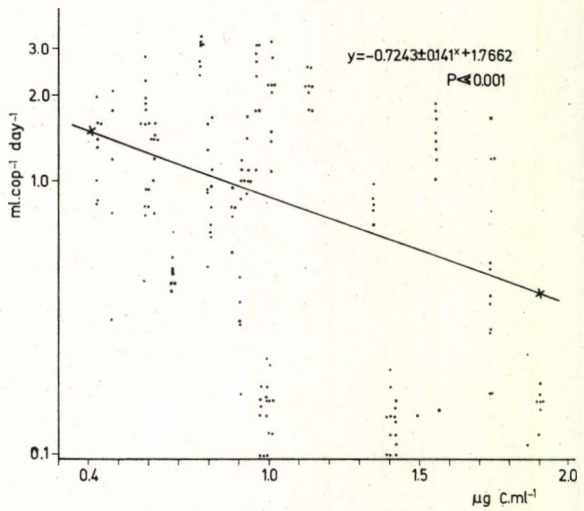


Fig. 7. The effect of food concentration of filtering rate

depends on the water movement. In the present study it varied within the range of 0.42 – 1.90 mg C/litre with an average of 1.05 mg C/litre *(Table I)*. In both years the lowest values were found in summer during long calms. During phytoplankton rises in spring (March, April) and autumn the organic carbon content attained a value of 1.5 – 1.9 mg/litre. The fairly constant autumnal and winter values fell within the range of 0.9 – 1.0 mg C/litre. This was doubled during storms. Disregarding the effect of temperature a negative correlation was found between food concentration and filtering rate: $y = (-0.7249 \pm 0.141) \times +1.7662$ ($P < 0.001$) *(Fig. 7)*.

Filtration is influenced both by temperature and food concentration, however, sometimes these effects can be separated. In late autumn and in winter the temperature (0 – 5 °C) slows down the filtration (continuous line in *Fig. 1*) to an extent, that food concentration in this period (0.97 – 1.43 mg C/litre) had no effect on it. The effect of food concentration prevails in stormy periods (e.g. 4 – 5 June 1975 in *Fig. 6*). Before this experiment there were already strong waves for two days. The temperature did not change significantly, but the amount of organic and inorganic materials increased in the water, strongly inhibiting filtration. In summer (20 – 27 °C) the organic carbon content of the water varied from 0.42 to 1.12 mg/litre with the single exception of 16 July 1974 when it attained 1.44 mg/litre. In summer both low food concentration and high temperature contribute to low filtering rate.

The effects of body size and physiological conditions on the filtering activity are reflected by the high variability of the parallel values in summer *(Fig. 5)*. In addition the number of animals and the ratio of males to females varied too in the samples. In order to demonstrate physiological effects, in some experiments the filtering rate of females with and without eggs were separately studied *(Table II)*. After the experiment the animals were killed

TABLE II

The filtering rate of Eudiaptomus gracilis females with and without eggs

Date	Water temperature °C	Cop./100 ml	Filtering rate ml/cop./day
5. Sept. 1974	21.4	10	2.48 with eggs
		15	2.43 with eggs
		18	1.50 without eggs
		16	2.21 without eggs
		11	2.13 without eggs
11. Sept. 1974	18	16	0.79 with eggs
		11	0.71 with eggs
		18	0.64 without eggs
		17	0.62 without eggs
26. Sept. 1974	15	6	1.72 with eggs
		18	1.08 without eggs

in hot water and the eggs were removed to obtain crustaceans of the same size and self-absorption. The activity of egg carrying females proved to be 20 – 25 per cent higher.

Discussion

The quantitative aspects of the nutrition of filter feeding crustaceans can be characterized by their filtering and feeding rates (GUTELMACHER, 1974). The method of filtering rate measurement, used also in our experiments was described by NAUWERCK (1959). He demonstrated its usefulness in the case of *Diaptomus graciloides*, living in Lake Erken. The error of the method is supposed to be less than 20 per cent. Since that time the filtration and feeding of crustaceans were studied in many lakes (BELL and WARD, 1970; BURNS and RIGLER, 1967; SAUNDERS, 1969; 1972; DUNCAN, 1975). These works deal mainly with cladocerans, while until now the nutrition of only four fresh water calanoid species was studied under natural conditions *(Table III)*.

TABLE III

Filtering rates of fresh water calanoids feeding on natural foods

Species	Water temperature °C	Filtering rate ml/cop./day	Lake	Author
Diaptomus oregonensis	18±1	1.91±1.25–12.9±1.98	Lake Marion	McQUEEN 1970
Diaptomus oregonensis	22–23	0.067±0.014	Lake Winnebago	RICHMAN 1964
Diaptomus oregonensis	3–24–2	0.0 –1.4 2.1 –2.2	Lake Heart Drowned Bog Lake	HANEY 1973
Diaptomus siciloides	10 20	1.0 2.0	Lake Severson	COMITA 1964
Eudiaptomus graciloides	0.2–17–0.2	0.3 –2.8	Lake Erken	NAUWERCK 1959
Eudiaptomus graciloides	17.9 21.1	3.67 –4.00 1.60 –2.40	Lake Krivoe	GUTELMACHER 1973
Eudiaptomus gracilis	4–18 7–15	0.83 –2.40 1.09 –1.97	Queen Elizabeth II King George VI	KIBBY 1971
Eudiaptomus gracilis	5.6–27–0.4	0.04±0.00–2.93±0.34	Lake Balaton	ZÁNKAI, PONYI 1976

Our results are similar to the filtering rates obtained by KIBBY (1971) for *E. gracilis*, by NAUWERK (1959) for *E. graciloides*, by COMITA (1964) for *D. silicoides* and HANEY (1973) for *D. oregonensis*. GUTELMACHER (1973) found a higher filtering rate, but he used a self-absorption coefficient of 1.88, while this coefficient is only 1.42 according to KIBBY (1971) and 1.38 according to our measurements (ZÁNKAI and PONYI, 1974b). By correcting GUTELMACHER's data for our self-absorption coefficient the filtering rate for phytoplankton is 2.69–2.94 and for bacterioplankton 1.17–1.76 mg/cop./day. These data fit already into the range obtained by the authors listed above and also by us.

On the other hand RICHMAN (1964) published much lower and MCQUEEN (1970) higher values.

The effect of temperature on the filtering rate of cladocerans was studied by BURNS (1966), BURNS and RIGLER (1967), MCMAHON (1965), IVANOVA (1965) and DUNCAN (1975) under natural conditions. They found the filtration to increase up to a critical temperature, then to decrease again. This critical temperature varied between 20 and 27°C depending on the species. On the other hand, according to IVANOVA (1965) temperatures above 5 °C have no effect on the filtering rate of *Daphnia pulex*.

In case of fresh water calanoids no work is known to us aiming to establish correlation between temperature and filtration. However studies, carried out for many months on the feeding of these crustaceans under natural conditions refer to the effect of temperature. KIBBY (1971) measured the filtration of *E. gracilis* from March (4° C) to October (14.5 °C) and found it to depend more on temperature than on food. NAUWERCK (1959) studied the annual cycle and mentioned the effect of temperature on the filtering rate, too. On the contrary HANEY (1973), who studied *D. oregonensis* a whole year through, has found no correlation between filtering rate and body size or temperature. Our two-year experiences support the findings of NAUWERCK (1959) and KIBBY (1971) with the addition, that only temperature changes higher than 10 °C result in significant increase or decrease of the filtering rate. In our experiments the critical temperature was 19 $\pm$ 1 °C.

Filtering and feeding rates depend also on the quality, size, concentration and chemical composition of the food. It remains for further experiments to determine which materials and to what extent are available as food under natural conditions, and whether the feeding is selective or not.

In the case of *E. gracilis* such problems were studied by feeding the animals on algae, obtained from pure cultures, and determining the filtering and feeding rates and the incorporation of the food (MALOVICKAJA and SOROKIN, 1961; SCHINDLER, 1971; KIBBY, 1971; INFANTE, 1973; ZÁNKAI and PONYI 1974a, b). Another method to obtain information on the composition of the natural food is the analysis of the intestinal content. By this method other fresh water calanoids, e.g. *E. graciloides*, *E. coeruleus* (BOGATOVA, 1965), *Acanthodiaptomus denticornis* (BOGATOVA, 1965; INFANTE, 1973), *Mixidiaptomus laciniatus* (INFANTE, 1973), *Diaptomus shoshone* and *Diaptomus coloradensis* (MALY and MALY, 1974) have been investigated, but no data on *E. gracilis* are available.

As proved by NAUWERCK (1962) *E. gracilis* can be cultured in lake water free of algae. SEBESTYÉN (1959) detected $CaCO_3$ and detritus particles in the gut of *E. gracilis* collected from the stormy Balaton. These observations prove, that this species ingests besides algae also organic and inorganic particles, and obviously bacteria adhering to the surface of these particles may serve as food. GUTELMACHER (1973) demonstrated that *E. graciloides* can utilize the bacterioplankton. According to HANEY (1973) all suspended particles of the size of 0.45 – 30 μm are to be regarded as potential food for crustacean plankton. The nutritional value depends of course on the quality of the particles. NAUWERCK (1959) and RICHMAN (1964) regarded materials passing the No. 25 net as food. In these experiment we followed the method of KIBBY (1971) and removed only the particles larger than 300 μm by filtration. According to RIGLER (1971), since the presence of phytoplankton influences the filtering

rate of *Daphnia*, a suspension of nannoplankton cannot be regarded as natural food supply. This statement may also be applicable to *E. gracilis*.

In this paper the quantity of natural food is expressed in terms of organic carbon. This is a rough estimate, but not less informative than the dry weight or caloric value of the seston, used by RICHMAN (1964) and KIBBY (1971). The dry weight would be very misleading in the case of Lake Balaton, because except for the frozen period this lake is frequently swirled up by waves and the water is rich in inorganic particles. Ingestion of such particles of low nutritional value is to be regarded as ballast feeding. In our opinion the organic carbon content includes all the materials that are regarded as food in the papers cited above. It can be used to demonstrate the correlation between the amount of natural food and filtering rate.

The effect of food concentration on the filtering rate of cladocerans was investigated by several authors. GUTELMACHER (1974) found a correlation, that could be described with an inverse S-shaped curve. The concentration limits were determined by IVANOVA (1970) as follows:

below 0.1 mg dry weight/litre filtration is maximal; from 0.1 to 7.5 mg weight/litre the filtering rate is inversely proportional to food concentration; above 7.5 mg dry weight/litre the filtering rate is constantly low. In Lake Balaton we found 0.4 – 1.9 mg organic carbon per litre. According to WINBERG's (1971) correction factor these values fall within the medium or normal range. Our experiments demonstrated that in this range, like in the case of cladocerans, the increase of food concentration decreased the filtering rate of the calanoid *E. gracilis*.

Summary

The filtering of *Eudiaptomus gracilis*, consuming natural food was measured in two–four weekly intervals in Lake Balaton from March 1974 till November 1975.

The filtering rate varied within the range of 0.01 – 3.27 ml.cop.$^{-1}$.day^{-1}. The seasonal averages showed in spring 0.96, in summer 1.44, in autumn 0.64, in winter 0.11 ml.cop.$^{-1}$.day^{-1}. The summer and winter values differ significantly ($P \ll 0.001$).

Filtering rate depends on temperature. The correlation is especially strong between 0 and 20 °C ($P \ll 0.001$). Temperature changes lower than 5 °C do not result in unequivocal changes in filtering rate. Temperature changes of 10 °C result in significant increase or decrease of filtration. The critical temperature is around 18 – 20 °C.

In order to get some idea of food concentration, the particulated organic carbon content of the water was determined. Its average was 1.05 mg C/litre, and varied within the range of 0.42 – 1.90 mg C/litre. An inverse relationship was found between this food concentration and filtering rate.

Egg carrying females showed 20 – 25 per cent higher filtering rates than females without eggs.

Acknowledgement

For the radioactivity measurements we are indebted to Dr. D. SZY physicist and his co-workers in the Radiophysical Department of Radiological Clinic, Semmelweis Medical University, Budapest.

REFERENCES

Bell K. R., F. J. Ward (1970): Incorporation of organic carbon by *Daphnia pulex*. — *Limnol. Oceanogr.* **15**, 713—726.

Bogatova I. B. (1965): Богатова И. Б.: Питание Дафнии и Диаптомусов в прудах.— *Вопросы прудового рыбоводства.* **13**, 165—178.

Burns C. W. (1966): The feeding behavior of Daphnia under natural conditions. — *Ph. D. Thesis, Univ. of Toronto.* **89** p.

Burns C. W., F. H. Rigler (1967): Comparison of filtering rates of *Daphnia rosea* on Lake water and in suspension of yeast. — *Limnol. Oceanogr.* **15**, 495—502.

Comita G. W. (1964): VI. zooplankton. The energy budget of *Diaptomus siciloides* Lilljeborg. — *Verh. Internat. Verein. Limnol.* **15**, 646—653.

Duncan A. (1975): The importance of zooplankton in the ecology of reservoirs. — *Proceed. Symp. The Effects of Storage on Water Quality.* **9**, 247—272.

Entz G. (1897): A Balaton faunája. — *A Balaton tud. tanulmányozásának eredményei II.* 1. *Budapest.*

Gutelmacher B. L. (1973): Гутелмахер Б. Л.: Относительно значение фито- и бактериопланктона в питании планктонных. — *Гидробиол. Журн.* **9**, 20—25.

Gutelmacher B. L. (1974): Гутельмахер Б. Л.: Питание пресноводных планктонных ракообразных. — *Усп. Совр. Биол.* **78**, 294—312.

Haney J. F. (1973): An in situ examination of the grazing activities of natural zooplankton communities. — *Arch. Hydrobiol.* **72**, 87—132.

Infante A. (1973): Untersuchungen zur Ausnutzbarkeit verschiedener Algen durch Zooplankton. — *Arch. Hydrobiol. Suppl.* **42**, 340—405.

Ivanova M. B. (1965): Иванова М. Б.: Влияние температуры и активной реакции воды на дыхание и скорость фильтрации *Daphnia pulex*. — *Гидробиол. Журн.* **1**, 15—19.

Ivanova M. B. (1970): Иванова М. Б.: Влияние концентрации пищи на фильтрации у Cladocera. — *Журн. общ. биол.* **31**, 721—731.

Kibby H. V. (1971): Energetics and population dynamics of *Diaptomus gracilis*. — *Ecol. Monogr.* **41**, 311—327.

Maloviczkaja L. M., Yu. I. Sorokin (1961): Маловицкая Л. М., Ю. И. Сорокин: Экспериментальное исследование питания Diaptomidae (Crustacea, Copepoda) с помощью ^{14}C. — *Трав. Инст. Биол. Водохр.* **4**, 262—272.

Maly E. J., M. P. Maly (1974): Dietary differences between two co-occurring calanoid copepod species. — *Oecologia (Berl.)* **17**, 325—333.

McMahon J. W. (1965): Some physical influencing the feeding behavior of *Daphnia magna* Straus. — *Can. J. Zool.* **43**, 603—611.

McQueen D. J. (1970): Grazing rates and food selection in *Diaptomus oregonensis* (Copepoda) from Marion Lake, British Columbia. — *J. Fish. Res. Bd. Canada* **27**, 13—20.

Naumann E. (1921): Spezielle Untersuchungen über die Ernährungsbiologie des tierischen Limnoplanktons. II. Über die Technik des Nahrungserwerbs bei den Cladoceren und ihre Bedeutung für die Biologie der Seewässertypen. — *Lunds. Univ. Arsskr. N. F.* **17**, 1—27.

Nauwerck A. (1959): Zur Bestimmung der Filtrierrate limnischer Planktontiere. — *Arch. Hydrobiol. Suppl.* **25**, 83—101.

Nauwerck A. (1962): Nicht-algische Ernährung bei *Eudiaptomus gracilis* (Sars). — *Arch. Hydrobiol. Suppl.* **25**, 393—400.

Ostapenja A. P. (1965): Остапеня А. П.: Полнота окисления органического вещества водных беспозвоночных методом бихроматного окисления. — *Докл. Акад. Наук. БССР.* **9**, 273—276.

Ponyi J. E., J. N. Horváth, N. P. Zánkai (1975): Investigations on planktonic Crustacea in Lake Balaton. VI. Quantitative changes in the *Eudiaptomus gracilis* population at various regions of Lake Balaton. — *Annal. Biol. Tihany* **42**, 203—218.

Richman S. (1964): Energy transformation studies on *Diaptomus oregonensis*. — *Verh. Int. Limnol.* **15**, 654—659.

Rigler F. H. (1971): 6.2. Feeding rates. In: W. T. Edmondson (ed). *IBP Handbook* **17** 229—269.

Saunders G. W. (1969): Some aspects of feeding in zooplankton. — In: *Eutrophication Causes, consequences, correctives.* — *Nat. Acad. Sci. Washington, D. C.* 556—573

Saunders G. (1972): The transformation of artification detritus in lake water. — *Mem. Ist. Ital. Idrobiol.* **29**, *Suppl.* 261—288.

Schindler J. E. (1971): Food quality and zooplankton nutrition. — *J. Animal. Ecol* **40**, 589—595.

SEBESTYÉN O. (1959): Társulási kapcsolatok a nyíltvízi planktonban. — Balatoni tanulmányok alapján. — *Annal. Biol. Tihany* **26**, 277—316.
WINBERG G. G. (1971): Symbols, units and conversion factors in studies of fresh water productivity. — *IBP Central Office* 1—21.
ZÁNKAI N. P., J. E. PONYI (1974a): On the feeding of *Eudiaptomus gracilis* in Lake Balaton. — *Annal. Biol. Tihany* **41**, 363—371.
ZÁNKAI N. P., J. E. PONYI (1974b): On the seasonal fluctuation in the food incorporation of *Eudiaptomus gracilis*. — *Annal. Biol. Tihany* **41**, 357—362.
ZÁNKAI N. P. (1975): Quantitative Untersuchungen zur Nahrungsausnutzung durch *Eudiaptomus gracilis*. — *Symp. Biol. Hung.* **15**, 225—231.

AZ *EUDIAPTOMUS GRACILIS* (G. O. SARS) SZŰRÉSÉNEK SZEZONÁLIS VÁLTOZÁSA A BALATONBAN

P.-Zánkai Nóra és *Ponyi Jenő*

Összefoglalás

A szerzők 1974 márciusától 1975 novemberéig 2—4 hetes időközökben mérték az *Eudiaptomus gracilis* szűrési rátáját a Balatonban, természetes táplálék fogyasztása mellett.

A szűrés sebessége 0,01—3,27 ml/cop./nap között változott. Évszakosan a következőképpen alakult: tavasz 0,96; nyár 1,44; ősz 0,63; tél 0,11 ml/cop./nap. A nyári és a téli évszakokban mért értékek szignifikánsan különböznek egymástól ($P \ll 0{,}001$).

A szűrés sebessége hőmérsékletfüggő, különösen szoros a kapcsolat 0—20 °C között ($P \ll 0{,}001$). 5 C fokonkénti hőmérsékletváltozásra a szűrés mértéke nem változik egyértelműen. A 10 °C-os hőmérsékletkülönbség szignifikáns növekedést ill. csökkenést okoz. 19 $\pm$ 1 °C felett a hőmérséklet növekedése hatástalan a szűrés mértékére.

A táplálékként számításba jövő anyagok mennyiségéről a víz particulált szerves szén tartalmának meghatározása útján tájékozódtak. Ennek mennyisége átlagosan 1,05 mg/liter, legkisebb érték 0,42; legnagyobb 1,90 mg C/liter volt. Az átszűrt víz mennyisége fordítva aránylik a táplálék koncentrációhoz.

A petezacskót hordozó nőstények 20—25%-kal nagyobb vízmennyiséget szűrnek át, mint a petenélküli egyedek.

VERZÁR FRIGYES 90 ÉVES

Ez év szeptember 18-án töltötte be VERZÁR FRIGYES, a tihanyi Biológiai Kutatóintézet első igazgatója, a Magyar Élettani Társaság egyik alapítója, a Magyar Tudományos Akadémia tiszteleti tagja 90. életévét.

Megemlékezésünk olyan embernek szól, akinek élete elválaszthatatlanul összeforrt a kísérleti biológiával, de aki nemcsak mint kutató alkotott maradandót, hanem kitűnő szervező készségével a magyar biológia fejlődéséhez is nagyban hozzájárult. Egyik irányítója volt az első világháború után Debrecenben megnyílt orvosi fakultásnak, majd 1926-ban, éppen 50 éve igazgatója lett a tihanyi Biológiai Kutatóintézetnek.

VERZÁR FRIGYES Budapesten LENHOSSÉK MIHÁLY Anatómiai Intézetében kezdte tudományos pályafutását, de még egyetemi hallgató korában az élettan felé fordult. A zsíranyagcsere és energiaforgalom kutatása mellett az akkor kialakuló új módszertani irányzat, az elektrofiziológia is felkeltette érdeklődését, s szenvedéllyel dolgozott előbb MANSFELD GÉZA és TANGL FERENC budapesti tanszékein, majd 1910—1912 között külföldön JULIUS BERNSTEIN, JOSEPH BARCROFT és KEITH LUCAS laboratóriumaiban. A debreceni Egyetem Élettani- és Kórtani Intézetének vezetőjeként (1918—1930-ig) neurofiziológiával, továbbá vitaminokkal és hormonokkal foglalkozott, utóbbiak vonatkozásában különösen a mellékvesekéreg és a B-vitamin összefüggéseit kutatta. Ugyanezen időben kezdte tanulmányozni a bélbolyhok működését, a cukrok szelektív felszívódását, mely területen később jelentős eredményeket ért el.

Széles látóköre, nagy kutatási és szervezési gyakorlata gazdagon kamatozott, amikor azt a feladatot kapta, hogy szervezze meg és vezesse az első Magyar Biológiai Kutatóintézetet, Tihanyban. A cél az volt, hogy a Nápolyban, Plymouth-ban, Woods Hole-ban és másutt működő biológiai intézetek mintájára a kísérleti biológia és a balatonkutatás számára teremtsenek otthont Magyarországon, ahol a biológia tudománya addig igen mostoha feltételekkel rendelkezett. Az intézet egy év alatt épült fel, 1927 szeptemberében nyitotta meg kapuit a kutatók számára és 1951 óta működik a Magyar Tudományos Akadémia keretei között. A festői környezetben megépült Intézet ugyan a felszabadulás előtt inkább állomásként működött, kevés állandó személyzettel, de kitűnő lehetőségeket biztosított vendégkutatók számára, valamint hazai biológus kutatók összefogására. Utóbbit mutatja az is, hogy Tihanyban alakult meg 1931-ben a Magyar Élettani Társaság, melynek első, alakuló kongresszusát VERZÁR FRIGYES szervezte.

VERZÁR FRIGYES 1930-ban a baseli Egyetem meghívására Svájcba költözött, ahol az Élettani Tanszéket vezette. Itt írta meg 1936-ban, későbbi feleségével JEAN MCDOUGAL-

lal együtt a felszívódásra vonatkozó addigi munkásságának összefoglalását: „*Absorbtion from the intestine*" címmel. Ezt követte 1939-ben, „*Die Funktion der Nebennierenrinde*" című könyve és más munkái. 1956-ig, az egyetemről történt nyugállományba vonulásáig mintegy 400 közleménye jelent meg. Tudományos tevékenysége azonban ekkor sem fejeződött be, hanem új irányba fordult. Megalapította Baselben a Kísérleti Gerontológiai Intézetet és 1957-ben megindította a *Gerontológia* című folyóiratot. Munkatársaival, akik között számos magyar vendégkutató is volt, új utat nyitott az öregedés élettani folyamatainak megismerésében.

VERZÁR FRIGYES még kezdeti svájci tartózkodása alatt is igazgatója maradt a tihanyi Biológiai Kutatóintézetnek. Erről az állásáról csak 1938-ban, az Anschluss idején mondott le, de azóta is támogatója és érdeklődő barátja maradt egykori intézetének és a magyar tudományos közéletnek. Tudományos eredményei mellett ennek elismerését is jelentette az, hogy a Magyar Tudományos Akadémia 1973-ban tiszteleti tagjává választotta.

Most 90. születésnapja alkalmából a tihanyi intézet jelenlegi munkatársai köszöntik megbecsüléssel és tisztelettel VERZÁR FRIGYEST, akinek fiatalos lendületét és tudományszeretetét ma is érezzük, amikor időről időre hazalátogatva körünkben is megfordul.

(Salánki János)

FRITZ VERZÁR IS 90

On the 18th September of this year celebrated his 90th birthday FRITZ VERZÁR, first Director of the Biological Research Institute at Tihany, one of the founders of the Hungarian Physiological Society, honorary member of the Hungarian Academy of Sciences.

Our commemoration is devoted to a man whose life has been welded inseparably with experimental biology creating lasting values not only as a scientist but also as an excellent organizer who contributed a great deal to the development of biology in Hungary. He was one of the leading figures of the new medical faculty in Debrecen opened after World War I, and in 1926, 50 years ago, he became the Director of the newly established Biological Research Institute at Tihany.

FRITZ VERZÁR began his scientific carrier in the Department of Anatomy in Budapest headed by Prof. MIHÁLY LENHOSSÉK, but soon still as a medical student he turned his interest toward physiology. He worked with great devotion at the Departments of Professors GÉZA MANSFELD and FERENC TANGL in Budapest and between 1910—1912 abroad with JULIUS BERNSTEIN, JOSEPH BARCROFT and KEITH LUCAS on problems of fat transport and energy metabolism, furthermore a rather new field of research, electrophysiology also raised his interest. As a Professor of Physiology and Experimental Pathology of the Debrecen University (1918—1930) his research was focused upon neurophysiology, the study of vitamins and hormones, especially as far asthe relation bet ween adrenals and vitamin B was concerned.

At this time he started also investigations on the function of intestinal villi and selective absorbtion of sugars, research fields in which he later obtained significant results.

His broad outlook, great research and organizing practice contributed largely to the solution of the task to organize and direct the first Hungarian Biological Research Institute founded at Tihany. The intention was to create in Hungary, where at that time biology was provided with very poor resources, a home for experimental biology and Balaton-research, similar to the Institutes in Naples, Plymouth and Woods Hole. The Institute was opened for scientists in September 1927; since 1951 it has been functioning as the Biological Research Institute of the Hungarian Academy of Sciences. The Institute, situated in picturesque surroundings was working before World War II as a station with a low number of permanent staff, but it offered excellent opportunities for visiting scientists, and for uniting Hungarian biologists. This latter is proved by the fact that the Hungarian Physiological Society was founded in 1931 at Tihany, and the constituent assembly was led by FRITZ VERZÁR.

FRITZ VERZÁR, accepting the invitation of the Basel University, moved to Switzerland in 1930, where he became the head of the Department of Physiology. Here he summarized his experimental results on intestinal epithelium in the book written with JEAN

McDougall (who later became his wife) "*Absorbtion from the intestine*" (1936). This was followed by "*Die Funktion der Nebennierenrinde*" (1939) and other publications. Up to 1956, when he retired from the University, he published nearly 400 papers. His scientific activity however, did not close with his retirement, but turned to a new field of research. He founded in Basel the Institute of Experimental Gerontology, and launched an international journal: Gerontology. Together with his collaborators, among them a number of Hungarian research visitors, he opened new perspectives in the investigations of physiological processes of ageing.

During the early period of his Basel professorship Fritz Verzár continued to be Director of the Biological Research Institute. He gave up this post only in 1938 at the time of the Anschluss, but he remained the supporter and sincere friend of his former Institute and of the scientific community of Hungary. His election as the honorary member of the Hungarian Academy of Sciences in 1973 was besides the appreciation of his scientific achievements also the recognition of these frank relations.

On the occasion of his 90th birthday the present staff of the Tihany Institute congratulates with great respect and sincere appreciation Professor Fritz Verzár, whose youthful energy and devotion to science deeply impress us even now when from time to time he visits his native land and our Institute.

(J. Salánki)

CHRONICLE

The research activity of the Institute was conducted during 1975 according to the middle-distance research plan approved for 1972—1975 being part of the main topics of research of the Hungarian Academy of Sciences in the themes "*Bioregulation*" and "*Biosphere*". Accordingly the researches carried out at the *Department of Experimental Zoology* were focused on the neurohumoral regulation in invertebrate animals, within the main topic entitled "*Regulatory mechanisms of life processes*", while at the *Department of Hydrobiology* hydrobiological investigations on Lake Balaton were conducted within the topic "*Investigations on the Lake Balaton and its catchment area*" being the part of the main theme "*Protection of human being and its natural environment*".

Results of the research work performed by the members of the two Departments were published partly in *Annal. Biol. Tihany* Vol. *42*, and partly in various Hungarian and foreing journals (see *Annal. Biol. Tihany*, 1976. *43*, p. 129). The list of scientific lectures held in 1975 by the staff of the Institute is published in *Annal. Biol. Tihany 43*, pp. 130—131.

In 1975 on the competition for the "Prize of Research Work" proposed by the Secretary General of the Hungarian Academy of Sciences the following scientific work won the prize: Biró P., Garádi P.: Investigations on the growth and population-structure of bream (*Abramis brama* L.) at different areas of Lake Balaton, the assessment of mortality and production. — *Annal. Biol. Tihany* (1974), *41*, 153—179.

On the 16th of December János Nemcsók, assistant scientific worker, on the basis of his dissertation, entitled: "The role of monoamines in the regulation of periodic activity of *Anodonta cygnea* L." got the title of University Doctor at the József Attila University, Szeged.

This year Mrs. S. Komáromi the secretary, was honoured with the Order of Outstanding worker in appreciation of her prominent work.

The Institute's permanent staff comprises 56 persons as follows: 21 scientific research workers, 1 technical councillor, 14 technical assistants, 6 administrative and 14 other workers.

The following changes took place in the scientific staff of the Institute: András Frankó, assistant scientific research worker of the Hydrobiological Department left on the 31st of March for the Department of Microbiology of the József Attila University at Szeged. Ida V.-Szőke, assistant scientific research worker of the Department of Experimental Zoology left on the 1st of May for the Pioneer Camp in Zánka. Ilona B.-Muskó, assisstant scientific worker of the Department of Experimental Zoology was discharged on the 30th of June, 1975. As it was announced in *Annal. Biol. Tihany* Vol. *42*, on the 19th of August 1975, Dr. Gizella Tamás, scientific research worker suddenly died after a short illness. Three new scientific workers started to work at the Department of Experimental Zoology this year: Dr. István Benedeczky, biologist, senior scientific worker on the 16th of July 1975, while László Hernádi, biologist, assistant scientific worker on the 1st of September 1975 joined in the work of morphological laboratory. Katalin H.-Dobó was appointed to be central practicant to the electrophysiological laboratory.

Inland scientific connections

Similarly to previous years, the Institute had inland connections with several scientific Institutes of the Hungarian Academy of Sciences and Departments of Universities, realized by co-operations, consultations and teaching.

1. With the Institute of Biochemistry of the Biological Research Center (Szeged) of the Hungarian Academy of Sciences the investigations were carried out in order to study the kinetic characteristics of the accumulation of ^{14}C, ^{3}H 5-hydroxytryptamine in the ganglia of *Anodonta cygnea* L.
2. Our Institute supplied from its own locust breeding insects for research work performed by NEVIKI (Veszprém).
3. Investigations of the pesticide remainders in the organisms of Lake Balaton were carried out with Department of DDD of OKI (Budapest).
4. With the Bacteriological and chemical Laboratory of KÖJÁL of towns Veszprém and Siófok investigations on water-chemistry were carried out.
5. Using computer analysis common research was done for clearing up the connections between planktonic organisms of Lake Balaton with the Department of Zoology and Department for the Development of Productivity of the University of Agricultural Sciences (Keszthely).

Participations in university education

Dr. JENŐ PONYI, Deputy Director of the Institute, held lectures at a summer course on the "*Basic problems of hydrobiology*" for students of the Agricultural High School (Kaposvár). Dr. BÉLA ENTZ, senior scientific research worker held lectures for students of the Department of Tropical Biology at the University of Agricultural Sciences (Gödöllő) at the topic "*Tropical Hydrobiology and Fishering*".

GYÖRGY FŰRÉSZ, student of the University of Agricultural Sciences (Gödöllő), prepared his thesis to be submitted for certification at the Hydrobiological Department of the Institute entitled: "Investigations of the growth and conditions of the life of *Aspius aspius* L., and considerations regarding its utilization for fishing."

In the summer months 8 university students joined in the experimental work of the two Departments, and 5 students from the Agricultural High School (Kaposvár) took part in the summer course organized by the Hydrobiological Department. The students of the third course of the University of Agricultural Sciences (Keszthely) visited our Institute. In the frame-work of a movement "One School — One Factory" some held was extended to the Primary School in Tihany.

About 50 Hungarian scientific workers visited our Institute in 1975 for 1—3 days to carry out methodical studies or to use our library. Several workers spent a longer period of time at our Institute: I. HORVÁTH from the Research Station of Fish-production, Szarvas; Dr. P. V.-MÁNYI from the Department of Biophysics of the Medical University of Pécs; Dr. B. MEZEI and Dr. T. SIMON from the Department of Intensive Therapy of the Medical University of Pécs; Dr. L. SIMON Pharmacological Department of Medical University of Szeged; Dr. P. SZABÓ from the Department of Zoology of the Kossuth Lajos University, Debrecen; Dr. G. UHERKOVICH from the PAK Laboratory of Hydrobiology, Pécs.

The Institute attended the Exhibition organized at the National Museum to the 150th anniversary of the foundation of the Hungarian Academy of Sciences.

In 1975 the following external themes were investigated at our Institute:

1. For the Balaton Fishery Company (Siófok) the investigations on the theme "Relations of the growth and nourishment of plant-feeding fishes in Lake Balaton" were carried out.
2. On the assignment of the United Chemical Companies (Budapest) the effect of Substance EVAGRO-C, -E and -K improving soils was observed on water organisms.
3. According to the assignment of the Water Management in West-Transdanubian Region (Szombathely) the toxicity of the substance MH30 causing inhibition in the growth of plants was observed in water organisms.
4. On the assignment of the Water Management in South-Transdanubian Region (Pécs) the investigations were carried out in the theme "Placing polluted water in fish ponds".

Scientific connections with foreign institutes and research workers

A. In 1975 collaborative work was done in the following themes:

1. According to bilateral agreement the mutual work has been continued on the theme "Neurobiology of Invertebrates" between our Institute and the Brain Research Laboratory of the Institute of Biology and Medicine of Montenegro of the Serbian Academy of Sciences. Within the frame-work of this agreement István Vadász scientific research worker was working for two months in Kotor between the 20th of June and 20th of August.
2. Within the frame-work of bilateral agreement the collaboration has been continued with the Institute of Developmental Biology of the Academy of Sciences of the USSR (Moscow) and in the theme "Central localization of the foot receptors of *Helix pomatia* L. and the nature of the slow inhibitory postsynaptic potentials" Dr. D. A. Sakharov worked for three months in our Institute.
3. Common researches were done also within the frame-work of multilateral agreement between the Academies with the Bogomoletz Physiological Institute of the Ukrainian Academy of Sciences (Kiev). As a result of INTERMOZG co-operation several study trips were realized between the staff of the two Institutes and now two papers are to be published on the ion currents of the bimodal cell of the *Helix* and on the role of Ca^{2+} and Ba^{2+} ions on different *Helix* neurons. The above theme formed also a part of the co-operation in Biophysical Researches of the Council of Mutual Economic Aid. In the mutual work Dr. I. S. Magura, István Vadász and Dr. István Kiss scientific research fellows took parts.
4. The mutual work has been continued also according to bilateral agreement with the Institute of Ecology of the Polish Academy of Sciences (Warszawa) on the topic "Studying the productivity of the Lakes Balaton and Mazur" and within this agreement Dr. Jenő Ponyi, Deputy Director of the Institute, and Dr. Péter Bíró, scientific research fellows spent one week at the companion Institute. Within the frame-work of the same agreement Dr. I. Turczynska and Dr. K. Dusoge have been working for three weeks at our Institute from the companion Institute. In our Institute a Working Meeting was organized, between the 1st and 5th of December 1975, attended by Dr. Z. Kajak, Dr. I. Spodniewska, Dr. A. Stanczykowska, Dr. T. Weglenska and Dr. K. Lewandowsky from the above Institute.

B. Travels abroad from our Institute besides the above-mentioned trips in 1975:

1. Dr. Károly Elekes, scientific research worker, has been working for four months, between the 27th of January and 2nd of June 1975, in the Zoological Station in Naples (Italy).
2. Dr. László Hiripi, scientific research worker, spent three months between the 10th of April and 31st of August at St. Andrews in the Gatty Marine Laboratory, then spent two months at the Department of Zoology of the University of Cambridge (Great Britain).
3. Dr. István Kiss, scientific research worker, attended the course on "Second Winter School on Biophysics of Membrane Transport" organized in Poland by the Agricultural University of Wrocław.
4. Dr. Jenő Ponyi, Scientific Deputy Director, visited the Research Institute for Biology, Geography and Geology in Pingarati (Roumania) between the 14th and 27th of September.
5. Dr. Katalin S.-Rózsa, senior scientific research worker, attended the "Symposium on Comparative Pharmacology of Synaptic Receptors" held in Leningrad (USSR) between the 12th and 14th of May, 1975. Then between the 25th and 31st of August attended the Symposium on the "New First and Second Messenger" held in Brescia (Italy).
6. Dr. János Salánki, Director of the Institute, in the frame-work of agreement between the Hungarian Academy of Sciences and NAS took a study trip to the USA between the 10th of March and 24th of May 1975. He has been working for six weeks at the Neurobiological Laboratory of Friday Harbor of the Washington University, then visited the following Institutes and Universities: Department of Zoology, University

of Washington, Seattle; Department of Entomology, University of California, Riverside; Department of Neurosciences, University of California, San Diego; Department of Physiology and Biophysics, University of Illinois, Urbana; Department of Biology, Tuft's University, Medford; Worcester Foundation for Experimental Biology, Shrewsbury; Department of Biobehavioral Sciences, University of Connecticut, Storrs; Department of Biology, Yale University, New Haven; Neurobiology Department, Armed Forces Radiobiology Research Institute, Bethesda; Department of Physiology, Columbia University, New York. Between the 22nd and 27th of September, 1975 he attended the meeting of the Executive Committee of IUBS at Paris (France) then between the 17th and 21st of November attended the meeting of experts of the Agreements in Biophysics organized in the frame-work of the Council of Mutual Economic Aid in Kiev (USSR).

7. István Vadász, scientific research worker, attended the training course on "Ion transport in neurons" organized by IBRO in Kiev between the 2nd and 12th of June, 1975.
8. Dr. Imre Zsolnai-Nagy, senior scientific research worker, has continued his working-study trip at the Center of Experimental Gerontology of I. N. R. C. A. at Ancona (Italy).

C. Visiting scientists from abroad to our Institute during 1975:

In this year approximately 150 visiting scientists spent here shorter or longer periods. Among them were two groups of students, each of 10 persons, from the Georgian State University and the Novosibirsk State University (USSR). The 25 students of the international training course organized by UNESCO for Engineer in Geology were also received here.

In addition to the work carried out according to mutual agreements for a longer period were working in our Institute Dr. B. Shisov from the Laboratory of Helmints of the Morphological Institute of the Academy of Sciences of USSR (Moscow), and that of the Dr. K. Bykov from the Department of Physiology of Leningrad State University.

Meetings

In 1975 the following meetings were held at our Institute:

1. Meeting of the headquarters of the Physiological Societies of the socialist countries was organized by the Secretary General of the Hungarian Physiological Society, by Dr. László Hársing, between the 9th and 11th of May with 15 participants.
2. Conference on membrane was organized by the Hungarian Biochemical Society and our Institute between the 14th and 17th of May with 50 participants.
3. Meeting of Protozoological Section of the Hungarian Biological Society held on the 22nd and 23rd of May with 25 participants organized by the Department of Biology of the Budapest Medical University (SOTE).
4. "Spring School" was organized in the field of nuclear physics by the Central Research Institute of Physics of the Hungarian Academy of Sciences between the 18th and 20th of May and the 25th and 31st of May each with 25 participants.
5. Meeting on Discrete Geometry was organized between the 2nd and 7th of June by the Bolyai János Mathematical Society with 40 participants.
6. Symposium on Blood Coagulation supported by VEAB was organized by the Markusovszky Hospital (Szombathely) on the 19th and 20th of June with 15 participants.
7. International Postgraduate Course in Hydrobiology was organized by VITUKI between the 24th and 30th of June with 25 participants.
8. Postgraduate course on the Mechanisms of cell proliferation organized by Cytological Society and the Institute of Experimental Medicine of the Hungarian Academy of Sciences between the 1st and 5th of September with 60 participants.
9. The Third International Symposium on Neurobiology of Invertebrates on the topic of "Gastropoda Brain" was organized by our Institute and supported by the Biological Section of the Hungarian Academy of Sciences between the 8th and 12th of September with 70 participants.
10. Symposium on the Biology of Movements was organized by the sport section of the Hungarian Biological Society and the Biomechanical Committee of the Society for

Physical Training and Sport-researches, between the 24th and 26th of September with 30 participants.

11. The XVIIth Hydrobiological Days was organized between the 2nd and 4th of October with 64 participants by contributions of the Hydrobiological Department of our Institute, the Hungarian Hydrological Society and VEAB.
12. Meeting on the "Net project in Higher Education" was organized by the Center of Higher Education and Pedagogy, between the 13th and 17th of October with 25 participants.

Improvements of research facilities in 1975

The equipment park was completed among others with a Dual-beam oscilloscope, R5103N/D12 (Tektronix); Konductometer, OK-102 (Radelkisz); microbus with trailer (Zuk, Poland); Zeiss micromanipulator (DDR); Automatic titrimeter OP-506 (Radelkisz).

In 1975 the following equipment were made in our workshop: one puller for microelectrodes, one movement indicator with light-transducer, one FET input operation amplifier with LP and HP filters.

Library

At the end of the year the Institute's Library comprised 13,921 volumes. Books: 5054 units, journals: 8867 units.

The Institute's Year Book — *Annal. Biol. Tihany* (1975) Vol. *42* was sent to 682 Institute and private persons all over the world. In exchange the Library received 191 different journals (Volumes) and publications.

KRÓNIKA

Az MTA Biológiai Kutatóintézetében 1975-ben a kutatás az 1972—1975. évekre elfogadott középtávú kutatási tervnek megfelelően folyt, mely országos ill. MTA kutatási főirányokhoz csatlakozott. A *Kísérletes Állattani Osztály* munkája az „*Életfolyamatok szabályozási mechanizmusa*" c. országos főfeladaton belül a neurohumorális szabályozás törvényszerűségeinek feltárására irányult gerinctelen állatokon, a *Hidrobiológiai Osztály* pedig folytatta a Balaton hidrobiológiai kutatását „*A Balaton és vízgyűjtőterületének kutatása*" c. témában, mely az „*Ember és természeti környezetének védelme*" c. tárcaszintű főirányhoz kapcsolódik.

A két osztály tudományos tevékenységét tükröző tanulmányok részben az *Annal. Biol. Tihany 42.* kötetében, részben más hazai és külföldi folyóiratokban (lásd: *Annal. Biol. Tihany*, 1976, *43*, 129 oldal) kerültek közlésre. Az 1975-ben tartott tudományos előadások jegyzéke az *Annal. Biol. Tihany 43.* kötetének 130—131. oldalán található.

1975-ben „A távlati tudományos kutatási terv kutatásaiban elért jelentős eredmények" elnevezésű, a Magyar Tudományos Akadémia által meghirdetett pályázaton az alábbi munka nyert pályadíjat: Biró Péter és Garádi Péter: Investigations on the growth and population-structure of bream (*Abramis brama* L.) at different areas of Lake Balaton, the assessment of mortality and production. — *Annal. Biol. Tihany*, 1974, *41*, 153—179.

Nemcsók János tudományos segédmunkatárs „A monoaminok szerepe a tavikagyló (*Anodonta cygnea* L.) periodikus aktivitásának szabályozásában" c. egyetemi doktori értekezésének megvédésével 1975. december 16-án egyetemi doktori címet szerzett a József Attila Tudományegyetemen, Szegeden.

Az év folyamán Komáromi Sándorné adminisztratív ügyintéző „Kiváló Dolgozó" kitüntetésben részesült jó munkája elismeréseként.

Az Intézet személyi állománya 56 fő, mely a következőképpen oszlott meg: kutató 21, műszaki tanácsadó 1, kutatási segéderő 14, adminisztratív dolgozó 6, egyéb beosztású 14.

Az Intézet kutató állományában az alábbi változások történtek: Frankó András, a Hidrobiológiai Osztály tudományos segédmunkatársa Szegedre, a József Attila Tudományegyetem Mikrobiológiai Intézetébe távozott 1975. március 31-el. V.-Szőke Ida, a Kísérletes Állattani Osztály tudományos segédmunkatársa a Zánkai Úttörővárosba távozott 1975. május 1-el. B.-Muskó Ilona munkaviszonya a Kísérletes Állattani Osztályon 1975. június 30-án a kinevezési határidő lejártával megszűnt. Dr. Tamás Gizella, mint arról az *Annal. Biol. Tihany 42.* kötetében megemlékeztünk, 1975. augusztus 19-én váratlanul elhunyt. A Kísérletes Állattani Osztályon három új kutató kezdte meg működését az év folyamán. Dr. Benedeczky István biológus, tudományos főmunkatársként 1975. július 16-án, Hernádi László biológus, tudományos segédmunkatársként, 1975. szeptember 1-én kapcsolódott be a morfológiai laboratórium munkájába. H.-Dobó Katalin biológus 1975. szeptember 1-én központi gyakornokként az elektrofiziológiai laboratóriumban kezdett dolgozni a kutatói pályán.

Belföldi tudományos kapcsolatok

A korábbi évekhez hasonlóan számos Intézettel és Egyetemmel állt kapcsolatban Intézetünk. Együttműködés folyt az alábbi Intézetekkel:

1. Az MTA Biológiai Központ Biokémiai Intézetével (Szeged) közös vizsgálatok folytak 5HT beépülés kinetikai sajátosságainak vizsgálatára *Anodonta cygnea* L. ganglionjaiban.
2. A Veszprémi NEVIKI rovarkutatásaihoz Intézetünk sajátáskatenyészetéből állatok biztosításával járultunk hozzá.
3. Az Országos Közegészségügyi Intézet DDD Osztályával peszticid kutatás folyt balatoni szervezeteken.
4. A Veszprém megyei, valamint a Somogy megyei KÖJÁL Bakteriológiai és Vízkémiai Laboratóriumával közös vízkémia kutatások folytak.
5. A Keszthelyi Agrártudományi Egyetem Állattani és Termelésfejlesztési Intézetével közös kutatás folyt a Balaton planktonját alkotó szervezetek egymásközti kapcsolatának számítógépes vizsgálatára.

Oktató munkában való részvétel

Dr. Ponyi Jenő, tudományos igazgatóhelyettes „*A hidrobiológia alapjai*" címmel a Kaposvári Mezőgazdasági Főiskola hallgatóinak tartott előadássorozatot az Intézetben szervezett nyári kurzus keretein belül. Dr. Entz Béla tudományos főmunkatárs „*Trópusi hidrobiológia és halászat*" címmel előadásokat tartott a Gödöllői Agrártudományi Egyetem Mezőgazdasági Kara Melegégövi Tagozata hallgatói számára.

Az Intézet Hidrobiológiai Osztályán készítette Fűrész György a Gödöllői Agrártudományi Egyetem Gazdaságtudományi Karának V. éves hallgatója diplomamunkáját „A balatoni ragadozó őn (*Aspius aspius* L.) növekedésének, életkörülményeinek vizsgálata és halászati hasznosításának értékelése" címmel.

A nyári hónapokban 8 biológia szakos hallgató dolgozott Intézetünk laboratóriumaiban, emellett a Kaposvári Mezőgazdasági Főiskola 5 hallgatója részt vett a Hidrobiológiai Osztály által szervezett nyári gyakorlaton. Az Intézet kutatómunkájával megismerkedtek a Keszthelyi Agrártudományi Egyetem III. éves hallgatói. Az „Egy üzem, egy iskola" mozgalom keretében patronáltuk a Tihanyi Állami Általános Iskolát.

Az Intézetet mintegy 50 hazai kutató kereste fel 1—3 napra főként metodikai tanulmányok, vagy könyvtárhasználat céljából. Az Intézetet felkereső kutatók közül az alábbiak dolgoztak hosszabb ideig az Intézetben:

Horváth Ilona, Haltenyésztési Kutató Intézet, Szarvas; Dr. V. Mányi Piroska, POTE Biofizikai Intézete, Pécs; Dr. Mezei Béla és Dr. Simor Tamás, POTE Intenzív Terápiás Osztálya, Pécs; Dr. Simon Lajos, SZOTE Gyógyszerészeti Vegytani Intézete, Szeged; Dr. Szabó Péter, KLTE Állattani Intézete, Debrecen; Dr. Uherkovich Gábor, PAK Hidrobiológiai Laboratóriuma, Pécs.

Az Intézet képviseltette magát az MTA fennállásának 150. évfordulója alkalmából a Nemzeti Múzeumban rendezett kiállításon.

Az Intézet 1975-ben az alábbi külső megbízáson alapuló kutatásokat végezte:

1. A Balatoni Halászati Vállalat (Siófok) részére folytatódott „A fehér busa növekedési és táplálkozási viszonyai a Balatonban" megnevezésű kutatási téma kidolgozása.
2. Az Egyesült Vegyiművek (Budapest) megbízásából az EVAGRO-C, -E és -K talajjavító anyagok toxicitását vizsgálták vízi szervezeteken.
3. A Nyugatdunántúli Vízügyi Igazgatóság megbízásából (Szombathely) vizsgálták az MH30 jelzésű növénynövekedésgátló szer toxicitását vízi szervezetekre.
4. A Pécsi VIZIG (Déldunántúli Vízügyi Igazgatóság) megbízásából „Szennyvizek halastavi elhelyezése" c. témában végeztek kutatásokat.

Külföldi tudományos kapcsolatok

A. 1975-ben az alábbi témákban folyt együttműködés:

1. Folytatódott a kétoldalú együttműködés a Szerb Tudományos Akadémia Montenegrói Biológiai és Orvosi Kutatóintézet Agykutató Laboratóriumával a „Gerinctelen neurobiológiai kutatások" c. témában. Ennek keretében Vadász István tudományos munkatárs 1975. június 20. és augusztus 20. között 2 hónapot töltött Kotorban.

2. Akadémiák közötti kétoldalú együttműködés keretében folytatódott a közös kutatás a SzUTA Fejlődésbiológiai Intézetével (Moszkva). „A *Helix pomatia* L. talpreceptorainak központi lokalizációja és a lassú gátló posztszinaptikus potenciál természete" megnevezésű témában Dr. D. A. Sakharov 3 hónapot dolgozott Intézetünkben.
3. Akadémiák közötti többoldalú együttműködés keretein belül a Bogomoletz-ról elnevezett Élettani Intézettel (Kiev, SzU) folyt közös kutatás. INTERMOZG együttműködés eredményeként kölcsönös tanulmányutak megvalósulása után két dolgozat van megjelenés alatt, egyik a *Helix pomatia* bimodális sejtje ionáramaival, másik a *Helix pomatia* különböző neuronjain a Ca^{2+} és Ba^{2+} szerepével foglalkozik. Ez a téma a KGST biofizikai együttműködésének is részét képezi. A téma kidolgozásában Dr. I. S. Magura, Vadász István és Dr. Kiss István tudományos munkatársak vettek részt.
4. A Lengyel Tudományos Akadémia Ecológiai Intézetével (Varsó) „A Balaton és a Mazuri tavak produktivitásának kutatása" címmel folytatódott a korábbi együttműködés, melynek keretében Dr. Ponyi Jenő tudományos igazgatóhelyettes és Dr. Bíró Péter tudományos munkatárs 1—1 hetet töltött a partnerintézetben. Ugyanezen együttműködés keretein belül J. Turczynska és K. Dusoge 3 hétig dolgoztak Intézetünkben. A partnerintézetből 1975. december 1—5. között Dr. Z. Kajak, Dr. I. Spodniewska, Dr. A. Stanczykowska, Dr. T. Weglenska és Dr. K. Lewandowsky munkaértekezleten vettek részt Intézetünkben.

B. Az egyezményes kutatások keretein belül megvalósuló kiutazásokon túl az alábbi tanulmányutak valósultak meg 1975-ben:

1. Dr. Elekes Károly tudományos munkatárs 1975. jan. 27—jún. 2. között 4 hónapot dolgozott a nápolyi Stazione Zoologica Intézetben.
2. Dr. Hiripi László tudományos munkatárs április 10. és aug. 31. között 3 hónapot dolgozott St. Andrews-ben, a Gatty Marine Laboratory-ban. 2 hónapig volt a Department of Zoology, University of Cambridge-ben.
3. Dr. Kiss István tudományos munkatárs 1975. február 5—14. között részt vett a Lengyelországban szervezett „Second Winter School on Biophysics of Membrane Transport" rendezvényen.
4. Dr. Ponyi Jenő tudományos igazgatóhelyettes szeptember 14. és szeptember 27. között Romániában, a Pingarati „Stejarul" Biológiai, Földrajzi és Geológiai Kutatóintézetben volt 2 hétig.
5. Dr. S.-Rózsa Katalin tudományos főmunkatárs 1975. május 12—14. között Leningrádban részt vett a „Symposium on Comparative Pharmacology of Synaptic Receptors" c. rendezvényen. Augusztus 25—31. között részt vett a „New First and Second Messenger" c. szimpoziumon Bresciában (Olaszország).
6. Dr. Salánki János intézeti igazgató az MTA és NAS közötti megállapodás keretében 1975. március 10—május 24. között 6 hétig dolgozott a Washingtoni Egyetem Friday Harbor-i Neurobiológiai Laboratóriumában, majd látogatást tett az alábbi intézetekben: Department of Zoology, University of Washington, Seattle; Department of Entomology, University of California, Riverside; Department of Neurosciences, University of California, San Diego; Department of Physiology and Biophysics, University of Illinois, Urbana; Department of Biology, Tuft's University, Medford; Worchester Foundation for Experimental Biology, Shrewsbury; Department of Biobehavioral Sciences, University of Connecticut, Storrs; Department of Biology, Yale University, New Haven; Neurobiology Department, Armed Forces Radiobiology Research Institute, Bethesda; Department of Physiology, Columbia University, New York. 1975. szeptember 22—27. között a IUBS Végrehajtó Bizottsága ülésén vett részt Párizsban, majd november 17—21. között Kievben (Szovjetunió) részt vett a KGST Biofizikai Együttműködés szakértői értekezletén.
7. Vadász István tudományos munkatárs 1975. június 2—12. között IBRO tanfolyamon vett részt Kievben.
8. Dr. Zsolnai-Nagy Imre tudományos főmunkatárs folytatta munkatanulmányútját az I. N. R. C. A. Anconai Kísérletes Gerontológiai Központjában, Olaszországban.

C. Az Intézet külföldi látogatói 1975-ben:

Az Intézetet az év folyamán mintegy 150 látogató kereste fel, hosszabb-rövidebb időre. Ezek között a Tbiliszi Állami Egyetem, valamint a Novoszibirszki Állami Egyetem

10—10 hallgatójából álló csoport is szerepel. Fogadtuk az UNESCO által szervezett Nemzetközi Mérnökgeológiai tanfolyam 25 hallgatóját is.

Az egyezményes témák keretein túlmenően hosszabb időt dolgozott Intézetünkben Dr. B. SHISOV a SzUTA Összehasonlító Morfológiai Intézetének Helminthológiai Laboratóriumából (Moszkva), valamint D. K. BYKOV a Leningrádi Állami Egyetem Élettani Intézetéből.

Rendezvények

Az 1975. év folyamán az Intézetben az alábbi összejövetelek megrendezésére került sor:

1. Szocialista Országok Élettani Társaságai Vezetőségének ülése Dr. HÁRSING LÁSZLÓ a MÉT főtitkárának rendezésében, május 9—11. között 15 fő részvételével.
2. Membrán konferencia május 14—17. között 50 résztvevővel a Magyar Biokémiai Társaság és az Intézet rendezésében.
3. A Magyar Biológiai Társaság Protozoológiai Szekciójának ülése május 22—23-án 25 résztvevővel, a SOTE Biológiai Intézetének szervezésében.
4. Az MTA Központi Fizikai Kutatóintézetének rendezésében „Tavaszi Továbbképző Iskola" május 18—20., valamint május 26—31. között, 25—25 résztvevővel.
5. A Bolyai János Matematikai Társulat rendezésében június 2—7., 40 résztvevővel „Diszkrét Geometriai Kollokvium" c. összejövetel.
6. „Véralvadás" szimpozium, június 19—20-án a VEAB támogatásával, a Szombathelyi Markusovszky Kórház rendezésében, 15 résztvevővel.
7. Továbbképző tanfolyam hidrológusok számára a VITUKI rendezésében június 24—30. között, 25 résztvevővel.
8. A Citológiai Társaság „Sejt-proliferizációs mechanizmusok" címmel tartott Továbbképző kurzust szeptember 1—5. között, 60 résztvevővel az MTA Kísérletes Orvostudományi Intézetének közreműködésével.
9. Intézetünk az MTA Biológiai Osztályának támogatásával megrendezte a Gerinctelen Állatok Harmadik Nemzetközi Neurobiológiai szimpoziumát „Gastropoda Agy" tárgykörből, szeptember 8—12. között, 70 résztvevővel.
10. A Magyar Biológiai Társaság Mozgásbiológiai Szekciója és a Testnevelési és Sporttudományos Tanács Biomechanikai Bizottsága „Mozgásbiológiai szimpozium"-ot rendezett szeptember 24—26. között, 30 résztvevővel.
11. A XVII. Hidrobiológus Napok megrendezésére október 2—4. között került sor 64 fő részvételével a Magyar Hidrológiai Társaság és a VEAB, valamint az Intézet Hidrobiológiai Osztálya közreműködésével.
12. A Felsőoktatási Pedagógiai Kutatóközpont „Hálós tervezés a felsőoktatásban" címmel konferenciát szervezett október 13—17. között, 25 résztvevővel.

Kutatási feltételek fejlődése 1975-ben

Az 1975-ben vásárolt jelentősebb műszerek, kutatási eszközök:

Dual-beam oscilloscope, R5103N/D12 (Tektronix); Konduktometer, OK-102 (Radelkisz); ZUK mikrobusz (lengyel) utánfutóval; Zeiss mikromanipultár (NDK); Automata titriméter, OP-506 (Radelkisz).

1975-ben az Intézetben készült kutatási eszközök:

Üvegkapilláris húzó berendezés; Reflexiós mozgásindikátor; FET bemenetű Differenciált erősítő, LP és HP szűrőkkel.

Könyvtár

Az Intézet leltározott állománya az évvégi összesítés alapján 1975-ben: 13 921 egység, ebből könyv 5054 db, folyóirat: 8867 db.

Az intézeti Évkönyv 42. kötetét 682 címre küldtük meg, melyért cserébe 191 kiadvány érkezett.

LIST OF PAPERS PUBLISHED ELSEWHERE AS IN VOL. 42 OF OUR ANNALES

Bíró P. (1975): A küsz (*Alburnus alburnus* L.) növekedése a Balatonban, mortalitásának és produkciójának becslése. — *Halászat, Tudományos melléklet* **1**, 5—10.

Bíró P. (1975): Observations on the fish production of Lake Balaton. — In: *Lymnology of Shallow Waters*. Eds: J. Salánki and J. Ponyi. — *Symp. Biol. Hung.* **15**, *pp.* 273—279. *Akadémiai Kiadó, Budapest.*

Herodek S., G. Tamás (1975): Phytoplankton production in Lake Balaton. — In: *Lymnology of Shallow Waters*. Eds: J. Salánki and J. Ponyi. — *Symp. Biol. Hung.* **15**, *pp* 29—34. *Akadémiai Kiadó, Budapest.*

Osborne N. N., L. Hiripi, N. Neuhoff (1975): The in vitro uptake of biogenic amines by snail *(Helix pomatia)* nervous tissue. — *Biochem. Pharmacol.* **24**, 2141—2148.

Ponyi J. (1975): The biomass of zooplankton in Lake Balaton. — In: *Lymnology of Shallow Saters*. Eds: J. Salánki and J. Ponyi. — *Symp. Biol. Hung.* **15**, *pp.* 215—224. *Akadémiai Kiadó, Budapest.*

Ponyi J., P. Bíró (1975): Szennyvizes halastavi kutatások Fonyódon I—III. — *Halászat* XXI, 11—13, 36—37, 74—77.

Puppi A., I. Kiss (1975): Ionic mechanisms in the correlation between the redox state of the biophase and the type of effects of acetylcholine of the giant neurones of *Lymnaea stagnalis*. — *Comp. Biochem. Physiol.* **51**C, 161—164.

S.-Rózsa K. (1975): Ciklikus nukleotidok részvétele ingerületi folyamatok szabályozásában. — *MTA Biol. Oszt. Közl.* **18**, 277—291.

Salánki J., J. Ponyi (1975) (Eds): *Lymnology of Shallow Waters*. — *Symp. Biol. Hung.* pp. **15**, 1—304. *Akadémiai Kiadó, Budapest.*

Salánki J., I. Vadász, M. Véró (1975): *Helix pomatia* L. Br-típusú sejtreaktivitás-mintázatának hőmérsékletfüggése. — *Biológia* **22**, 145—159.

P.-Zánkai N. (1975): Quantitative Untersuchungen zur Nahrungsausnutzung durch *Eudiaptomus gracilis*. — In: *Lymnology of Shallow Waters*. Eds: J. Salánki and J. Ponyi. — *Symp. Biol. Hung.* **15**, pp 225—231. *Akadémiai Kiadó, Budapest.*

Wollemann M., K. S.-Rózsa (1975): Effects of serotonin and catecholamines on the adenylate cyclase of molluscan heart. — *Comp. Biochem. Physiol.* **51**C, 63—66.

LIST OF SCIENTIFIC LECTURES IN 1975 YEAR

Bíró P.: A fogassüllő táplálékfogyasztása és energiatranszformálása a Balatonban. — *1975. május 27., Limnológiai Szakosztály előadói ülése.*

Bíró P., Garádi P.: A ligulózis hatása balatoni dévérkeszeg (*Abramis brama* L.) növekedésére. — *XVII. Hidrobiológus Napok, Tihany, 1975. október 2—4.*

Dési I., Pásztor Zs., Ponyi J., Holló A.: A balatoni élővilág peszticid kontaminációjának vizsgálata. — *XVIII. Balatoni Közegészségügyi Napok, 1975. május 7.*

Elekes K., Hiripi L., S.-Rózsa K., Nemcsók J.: Subcellular localization of biogenic monoamines in the central nervous system and heart of the snail *Helix pomatia* L., as revealed by density gradient centrifugation. — *Symposium on Snail Brain, Tihany, 1975. szeptember 8—12.*

Entz B.: A nílusi árvíz hatása a Nasser-Nubia tó limnológiai viszonyaira. — *XVII. Hidrobiológus Napok, Tihany, 1975. október 2—4.*

Herodek S.: Algák szervesanyag termelése a Balatonban. — *Magyar Hidrológiai Társaság Limnológiai Szakosztálya, Budapest, 1975. szeptember 9.*

Hiripi L., Osborne N. N.: Serotonin and dopamine uptake by the snail *(Helix pomatia)* auricle and CNS. — *Symposium on Snail Brain, Tihany, 1975. szeptember 8—12.*

Holló A., Ponyi J., Gönczi L., Pásztor Zs.: A Balatonnak és élővilágának klórozott szénhidrogén szennyezettsége. — *XII. Hidrobiológus Napok, Tihany, 1975. október 2—4.*

Kiss I., Salánki J.: *Lymnaea stagnalis* központi idegrendszerében $CoCl_2$ festéssel identifikált neuronok morfológiai és funkcionális jellemzői. — *MÉT XLI. Vándorgyűlése, Szeged, 1975. június 7—10.*

Kiss I., Salánki J.: Functional and branching in the central nervous system of *Lymnaea stagnalis L.* — *Symposium on Snail Brain, Tihany, 1975. szeptember 8—12.*

Kiss T., S.-Rózsa K.: A szerotonin hatóhelyének vizsgálata *Helix pomatia* L. szívizomsejtjeinek membránján. — *MÉT XLI. Vándorgyűlése, Szeged, 1975. július 7—10.*

Kiss I.: Az éti csiga szívizomsejtjeinek passzív elektromos tulajdonságai. — *Biofizikai Társaság Vándorgyűlése, Debrecen, 1975. augusztus 28.*

Pásztor Zs., Ponyi J., Holló A., Gönczi L.: A lindán és a DDT koncentráció gázkromatográfiás vizsgálata a Balaton különböző vízterületein. — *OKI tudományos ülése, 1975. április 29-én.*

Ponyi J.: A Limnológiai Szakosztály tevékenysége és a Balaton kutatás. — *A Limnológiai Szakosztály 25 éves fennállása alkalmából rendezett ünnepi ülésen elhangzott előadás 1975. március 25-én.*

Ponyi J., P.-Zánkai N.: Az *E. gracilis* produkciójának kérdése a Balatonban. — *Limnológiai Szakosztály, 1975. május 27.*

Ponyi J., Tusnádi Gy., Vanger É.: Kísérlet a balatoni planktonszervezetek táplálkozási kapcsolatainak megállapítására CDC 3300 típusú számítógép segítségével. — *XVII. Hidrobiológus Napok, Tihany, 1975. október 2—4.*

S.-Rózsa K., Kiss T.: Role of cyclic nucleotides in the effect of transmitters on invertebrate hearts. — *Symposium on Comparative Pharmacology of Synaptic Receptors, Leningrád, 1975. május 12—14.*

S.-Rózsa K.: A szívműködés szabályozását ellátó neuronhálózat szerveződése éti csigán (*Helix pomatia* L.). — *MÉT XLI. Vándorgyűlése, Szeged, 1975. július 7—10.*

S.-Rózsa K.: Neuronal network underlying the regulation of heart beat in *Helix pomatia* L. — *Symposium on Snail Brain, Tihany, 1975. szeptember 8—12.*

Salánki J.: Physiological basis of molluscan rhythms. — *Friday Harbor Laboratory (USA), 1975. április 17.*

Salánki J.: Rhythm regulation in molluscs. — *University of California, San Diego (USA), 1975. április 29.*

Salánki J.: Neurophysiological basis of molluscan rhythms. — *University of Illinois, Urbana (USA), 1975. május 2.*

Salánki J.: Neurophysiological basis of molluscan rhythms. — *University of Connecticut, Storrs (USA), 1975. május 8.*

Salánki J.: Neurophysiological basis of rhythmic activity in molluscs. — *Yale University, New Haven (USA), 1975. május 12.*

Salánki J.: Physiological basis of molluscan rhythms. — *AFRI Bethesda (USA), 1975. május 19.*

Salánki J., Truong Van Bay: Szenzoros bemenet elektrofiziológiai vizsgálata a száj körüli receptorok kémiai ingerlése esetén *Helix pomatia*-n. — *MÉT XLI. Vándorgyűlése, Szeged, 1975. július 7—10.*

Salánki J., Truong Van Bay: Peripheral and central discrimination at chemoreceptor stimulation in the snail, *Helix pomatia* L. — *Symposium on Snail Brain, Tihany, 1975. szeptember 8—12.*

Salánki J.: Biológiai kutatások feladatai a Balaton térségében. — *Veszprémi Akadémiai Bizottság Közgyűlése, Veszprém, 1975. december 13.*

Truong Van Bay, Salánki J.: Száj körüli receptorok kémiai érzékenységének elektrofiziológiai vizsgálata éti csigán (*Helix pomatia* L.). — *MÉT XLI. Vándorgyűlése, Szeged, 1975. július 7—10.*

Vadász I.: Ioncsatornagátlók hatása *Helix pomatia* Br-típusú sejtjének ionáramaira. — *Biofizikai Vándorgyűlés, Debrecen, 1975. augusztus 28.*

Vadász I., Salánki J.: On the mechanisms of spike and burst generation in the bimodal pacemaker RPal neuron of *Helix pomatia* L. — *Symposium on Snail Brain, Tihany, 1975. szeptember 8—12.*

Varanka I., Salánki J.: Nehézfémsók és oxigénhiány hatása kagylók aktivitására. Biológiai módszer a vizek szennyeződésének vizsgálatára. — *XVII. Hidrobiológus Napok, Tihany, 1975. október 2—4.*

P.-Zánkai N., Tamás G.: Az *Eudiaptomus gracilis* táplálkozása a Balatonban. — *XVII. Hidrobiológus Napok, Tihany, 1975. október 2—4.*

P.-Zánkai N.: A balatoni *Eudiaptomus gracilis* egyedfejlődése a hőmérséklet és a táplálékkoncentráció függvényében. — *XVII. Hidrobiológus Napok, Tihany, 1975. október 2—4.*

ANNALES INSTITUTI BIOLOGICI (TIHANY)
HUNGARICAE ACADEMIAE SCIENTIARUM

INDEX GENERALIS II.

Vol. 27 (1960) — 42 (1975)

Classification — Osztályozás — Классификация

1 Physiology, Pharmacology — Fiziológia, Farmakologia — Физиология, фармаколотия
2 Biochemistry — Biokémia — Биохимия
3 Morphology — Morfológia — Морфология
4 Chemistry — Kémia — Химия
5 Bacteriology — Bakteriológia — Бактериология
6 Botany — Botanika — Ботаника
7 Zoology — Zoológia — Зоология
8 Limnology — Limnológia — Лимнология
9. Methods — Módszerek — Методика
10 Miscellanies — Varia — Разное

A

B

14 7 8 Bíró, P. (1972)
First summer growth of pike-perch (*Lucioperca lucioperca* L.) in Lake Balaton. — Az elsőnyaras fogassüllő-ivadék (*Lucioperca lucioperca* L.) növekedése a Balatonban.
39, 101–113.

15 7 8 Bíró, P. (1973)
The food of pike-perch (*Lucioperca lucioperca* L.) in Lake Balaton. — A fogassüllő (*Lucioperca lucioperca* L.) tápláléka a Balatonban.
40, 159–183.

16 7 8 Bíró, P. (1974)
Observations on the food of eel (*Anguilla anguilla* L.) in Lake Balaton. — Az angolna (*Anguilla anguilla* L.) táplálékának vizsgálata a Balatonban.
41, 133–151.

17 7 8 Bíró, P. (1975)
The growth of bleak (*Alburnus alburnus* L.) (Pisces, Cyprinidae) in Lake Balaton and the assessment of mortality and production rate. — A küsz (*Alburnus alburnus* L.) növekedése a Balatonban, mortalitásának és produkciójának becslése.
42, 139–156.

18 7 8 Bíró, P.—Elek, L. (1969)
The spring and summer nutrition of the 300–500 g pike-perch (*Lucioperca lucioperca* L.) in Lake Balaton in 1968. I. Data bearing relation to the nutritional conditions proceeding the destruction of fish in 1965. — A 300–500 g súlyú (IV. osztályú) balatoni süllő (*Lucioperca lucioperca* L.) tavaszinyári táplálkozása 1968-ban. I. Adatok az 1965. évi halpusztulást követő időszak táplálkozási viszonyaihoz. — Биро, П.—Элек, Л.: Питание Балатонского судака IV.-ого размера (вес 300–500 г) весной и летом 1968 года. I. Данные к условиям питания в период после массовой гыбели рыб в 1965 году.
36, 135–149.

19 7 8 Bíró, P.—Garádi, P. (1974)
Investigations on the growth and population-structure of bream (*Abramis brama* L.) at different areas of Lake Balaton, the assessment of mortality and production. — A dévérkeszeg (*Abramis brama* L.) növekedésének és populációstruktúrájának vizsgálata a Balaton különböző vízterületein, a mortalitás és produkció becslése.
41, 153–179.

Bíró, P. see: 58, 193, 195, 198

20 7 8 Bothár, A.—Ponyi, J. (1968)
Informatory investigations about qualitative and quantitative conditions of the Crustacean plankton of the Danube section near Alsógöd (Hungary). (Danubialia Hungarica, XLVII.) — Tájékozódó vizsgálatok a magyar Duna alsógödi szakasza planktonrákjainak minőségi és mennyiségi viszonyairól. (Danubialia Hungarica, XLVII.) — Ботхар, А.—Поньи, Й.: Ориентировочные количественные и качественные исследования планктонных раков на участке Дуная у Алшогед.
35, 117–126.

21 6 8 Böszörményi, Z.—Cseh, E.—Felföldy, L.—Szabó, E. (1962)
9 A Balatonban C^{14}-módszerrel végzett fotoszintézis mérés módszertani kérdéseiről. — Some methodical questions on photosynthetic measurements with radioactive tracer C^{14}-technique in Lake Balaton.
29, 39–63.

C

22 2 6 Cseh, E.—Szabó, E. (1965)
8 The glycine uptake of *Scenedesmus obtusiusculus*. — A *Scenedesmus obtusiusculus* glicin felvétele. — Чех, Э.—Сабо, Э.: Усвоение глицина у *Scenedesmus obtusiusculus*.
32, 247–253.

D

E

30 *8* ENTZ, B.—E. FILLINGER, M. (1961)
Adatok a Balaton fényklímájának ismeretéhez. (A víz zavarosságának okairól és kihatásairól.) — Angaben zur Kenntnis des Lichtklimas des Balaton. (Über die Ursache der Wassertrüben und deren Auswirkungen.)
28, 49—89.

31 *8* ENTZ, B.—E. FILLINGER, M. (1962)
Adatok a Balaton fényklímájának ismeretéhez II. (Fényviszonyok a hóborította befagyott Balaton-vízben.) — Angaben zur Kenntnis des Lichtklimas des Balaton II. (Über die Lichtverhältnisse im Wasser des zugefrorenen und schneebedeckten Sees.)
29, 65—74.

32 *8* *9* ENTZ, B.—NÉMETH, L. (1962)
Módszer és mérőeszköz gyenge aktivitású radioaktív anyagok vizsgálatára, elsősorban édesvizekben. — Methode und Messgerät zur Untersuchung von schwach radioaktiven Stoffen, besonders in Süsswassern.
29, 75—78.

33 *4* ENTZ, B.—PONYI, J.—TAMÁS, G. (1963)
Sedimentuntersuchungen im südwestlichsten Teile des Balaton, in der Bucht von Keszthely in 1962. — Üledékvizsgálatok a Balaton legdélnyugatibb vízterületén, a Keszthelyi-öbölben 1962-ben.
30, 103—125.

F

F.-KALKÓ, ZS. see: 263, 296

34 *1* *2* FARKAS, T. (1966)
Effect of norepinephrine on adipose tissue lipase and phosphorylase activity of the frog *Rana esculenta* L. — Noradrenalin hatása kecskebéka (*Rana esculenta* L.) zsírszövetének lipase és foszforilase aktivitására. — Фаркаш, Т.: Влияние норадреналина на активность фосфорилазы и липазы жировой ткани *Rana esculenta* L.
33, 159—166.

35 *1* *2* FARKAS, T. (1967)
Examinations on the fat metabolism in freshwater fishes. The symphathetic nervous system and the mobilization of fatty acids. — Vizsgálatok édesvízi halak zsíranyag forgalmán. Szimpatikus idegrendszer és zsírmozgósítás. — Фаркаш, Т.: Исследование обмена жиров пресноводных рыб. Симпатическая нервная система и мобилизация жира.
34, 129—138.

36 *1* *2* FARKAS, T. (1968)
The effects of some adrenergic blocking agents on the mobilisation of fatty acids in lower vertebrates. — Néhány adrenerg gátlószer hatása a zsírmozgósításra alacsonyabbrendű gerincesekben. — Фаркаш, Т.: Влияние некотовых адренергических ингибиторов на мобилизацию жира у низших позвоночных.
35, 127—133.

37 *1* *2* FARKAS, T. (1969)
Effect of agents modifying the level of cyclic 3',5'-adenosine monophosphate in adipose tissue on mobilisation of fats in fish and frogs. — A zsírszövet cAMP szintjét befolyásoló ágensek hatása zsírmozgósításra halakban és kétéltűekben. — Фаркаш, Т.: Воздействие веществ, изменяющих уровень циклической АМФ жировой ткани, на мобилизацию жира рыб и амфибий.
36, 163—171.

38 *2* *8* FARKAS, T. (1970)
The dynamics of fatty acids in the aquatic food chain, phytoplankton, zooplankton, fish. — Zsírsavak dinamikája a phytoplankton—crustacea plankton—hal táplálkozási láncolatban. — Фаркаш, Т.: Динамика жир-

ных кислот в питательной цепи: фитопланктон Crustacea планктон—рыба.
37, 165—176.

39 *2* *8* Farkas, T. (1971)
A possible explanation for the differences in the fatty acid composition of fresh-water and marine fishes. — Kísérlet az édes- és tengervízi halak zsírsavösszetételében kimutatott különbségek értelmezésére.
38, 143—152.

40 *2* *8* Farkas, T.—Herodek, S. (1960)
Seasonal changes in the fat contents of the Crustacea plankton in Lake Balaton. — A balatoni crustacea-plankton zsírtartalmának évszakos változása. — Фаркаш, Т.—Херодек, Ш.: Изменение содержания жира в Crustacea-plankton озера Балатона в течение года.
27, 3—7.

41 *2* *8* Farkas, T.—Herodek, S. (1961)
Seasonal changes in the fatty acid compositions of fresh water Crustaceans. — Évszakos változások az édesvízi rákok zsírsavösszetételében. — Фаркаш, Т.—Херодек, Ш.: Сезонные изменения состава жирных кислот у пресноводных раков.
28, 91—94.

42 *2* *8* Farkas, T.—Herodek, S. (1962)
On the origin of the characteristic fatty acid composition of water organisms. — A vízi szervezetekre jellemző zsír eredetéről.
29, 79—83.

43 *2* *8* Farkas, T.—Herodek, S. (1963)
A hőmérséklet hatása a crustacea plankton zsírsavösszetételére. — Temperatureinfluss auf die Fettsäurezusammensotzung des Crustaceenplanktons. — Фаркаш, Т.—Херодек, Ш.: Влияние температуры на состав жирных кислот планктона Crustaceae.
30, 127—136.

44 *2* *8* Farkas, T.—Herodek, S. (1967)
Investigations of the fatty acid composition of fishes from Lake Balaton. — Vizsgálatok balatoni halak zsírsav-összetételén. — Фаркаш, Т.—Херодек, Ш.: Изучение состава жирных кислот Балатонских рыб.
34, 139—146.

Farkas, T. see: 82, 83

45 *6* *8* Felföldy, L. (1960)
Apparent photosynthesis of *Potamogeton perfoliatus* L. in different depths of Lake Balaton. — Fotoszintézis-mérés *Potamogeton perfoliatus* L. hínárral a Balaton különböző mélységeiben. — Фельфёлди, Л.: Измерение фотосинтеза на тине *Potamogeton perfoliatus* L. в различных глубинах озера Балатона.
27, 201—208.

46 *6* *8* Felföldy, L. (1960)
Photosynthetic experiments with unicellular algae of different photosynthetic type. — Egysejtű algák különféle fotoszintézis-típusáról.
27, 193—200.

47 *6* *8* Felföldy, L. (1961)
Effect of temperature on the photosynthesis of natural diatom population. — A hőmérséklet hatása a Balaton-part kövein élő természetes kovamoszat-populáció fotoszintézisére.
28, 95—98.

48 *6* *8* Felföldy, L. (1961)
On the chlorophyll content and biological productivity of periphytic diatom communities on the stony shores of Lake Balaton. — A Balaton köves partjain élő kovamoszat bevonat klorofilltartalmáról és biológiai produkciójáról.
28, 99—104.

G

вич, Ф.: Изучение биологических и хозяйственных показателей происходящих из УССР рас *Bombyx mori* L.
28, 11—15.

68 *7* Gubicza, A.—Lukacsovics, F. (1962)
Bombyx mori L. Szaniis rasszainak vizsgálata. — Untersuchung der Szaniis-Rassen von *Bombyx mori* L. — Губица, А.—Лукачович, Ф.: Исследование рас *Bombyx mori* L. Szaniis.
29, 17—25.

69 *7* Gubicza, A.—Molnár, I. (1964)
The effect of gamma irradiation on the Varo race of *Bombyx mori* L. II. Irradiation of eggs in the early and late embryonic stages. — Gammasugárzás hatása a *Bombyx mori* L. Varo rasszára. II. Peték besugárzása a csírafejlődés és embrionálódás szakaszában. — Губица, А.—Молнар, И.: Влияние гамма-лучей на расу Varo тутового шелкопряда. I. Облучение яиц.
31, 3—13.

70 *3* Gubicza, A.—S.-Rózsa, K. (1969)
Identification of central neurons innervating the heart of *Lymnaea stagnalis* L. (Gastropoda). — Gastropodák szívét beidegző központi neuronok azonosítása. — Губица, А.—Ш.-Рожа, К.: Локализация центральных нейронов иннервирующих сердце большого прудовика (брюхоногий).
36, 3—9.

71 *3* Gubicza, A.—S.-Rózsa, K. (1970)
Investigations on the interganglionic and peripheral neuronal pathways on the central nervous system of *Lymnaea stagnalis* L. — Ganglionközti és perifériás neuronpályák vizsgálata *Lymnaea stagnalis* L. központi idegrendszerében. — Губица, А.—Ш.-Рожа, К.: Исследование межганглиозных и периферических путей в центральной нервной системе большого прудовика.
37, 17—31.

72 *3* Gubicza, A.—Salánki, J. (1969)
Comparative study on the Nissl substance and RNA content in the central nervous system of *Anodonta cygnea* L. — Nissl-anyag és RNS összehasonlító vizsgálata *Anodonta cygnea* L. központi idegrendszerében. — Губица, А.—Шаланки, Я.: Сравнительное исследование материала Ниссла и РНК в центральной нервной системе беззубки.
36, 11—17.

73 *3* *9* Gubicza, A.—Zs.-Nagy, I. (1964)
Comparative study of recognized (classic) and modified impregnation methods on the ganglions of *Anodonta cygnea* L. — Klasszikus és módosított impregnációs módszerek összehasonlító vizsgálata *Anodonta cygnea* L. ganglionján. — Губица, А.—Ж.-Надь, К.: Сравнительное исследование методов импрегнации на ганглиях беззубки (*Anodonta cygnea* L.)
31, 15—21.

74 *3* *9* Gubicza, A.—Zs.-Nagy, I. (1965)
Histological examination of the ganglions in the fresh water mussel with impregnation methods *Anodonta cygnea* L. — Az édesvízi kagyló (*Anodonta cygnea* L.) ganglionjainak szövettani vizsgálata impregnációs módszerek alapján. — Губица, А.—Ж.-Надь, И.: Гистологическое исследование ганглиев беззубки *Anodonta cygnea* L. при помощи импрегнации.
32, 11—15.

75 *3* Gubicza, A.—Zs.-Nagy, I. (1966)
A cyto-topographic study in the ganglia of *Anodonta cygnea* L. — Cytotopográfiai vizsgálatok az *Anodonta cygnea* L. ganglionjaiban. — Губица, А.—Ж.-Надь, И.: Цитотопографическое исследование ганглиев *Anodonta cygnea* L.
33, 3—11.

Gubicza, A. see: 4, 137, 138, 139, 230
Gulyás, P. see: 10

H

76 *6* H.-Bartha, Zs. (1974)
The occurrence of *Aphanizomenon issatschenkoi* (Ussaczew) Proschkina—Lavrenko in Lake Balaton. — *Aphanizomenon issatschenkoi* (Ussaczew) Proschkina—Lavrenko előfordulása a Balatonban.
41, 127—131.

H.-Vas, É. see: 245
Hajdu, L. see: 163
Hámori, Gy. see: 150

77 *2* Herodek, S. (1966)
Comparison of the triglyceride synthesis of carp and rat in adipose tissue and liver slices incubated with 1-^{14}C palmitic acid. — A ponty (*Cyprinus carpio* L.) és a patkány triglicerid szintézisének összehasonlítása 1-^{14}C palmitinsavval inkubált zsírszövet és máj metszetekben. — Херодек, Ш.: Сравнительное исследование синтеза триглицеридов в жировой и печеночной тканях, инкубированных с 1-^{14}C-пальмитиновой кислотой, у карпа и крысы.
33, 167—172.

78 *2* *8* Herodek, S. (1969)
Gas chromatographic studies on the seasonal changes in the fatty acid composition of the copepod (Crustacea) plankton. — A copepoda (Crustacea) plankton zsírjában mutatkozó évszakos változások gázkromatográfiás vizsgálata. — Херодек, Ш.: Исследование сезонных изменений жиров ракообразного планктона при помощи газовой хроматографии.
36, 173—177.

79 *2* Herodek, S. (1969)
The metabolism on the intracardially injected 1-^{14}C palmitic acid in the carp (*Cyprinus carpio* L.). — A pontyba intracardialisan injektált 1-^{14}C palmitinsav anyagcseréje. — Херодек, Ш.: Обмен веществ 1-^{14}C пальмитиновой кислоты в веденной внутрисердечно карпу.
36, 179—184.

80 *2* Herodek, S. (1970)
Desaturation of palmitic acid-1-^{14}C and stearic acid-1-^{14}C in *Gammarus (Rivulogammarus)* Roeseli Gervais (Crustacea, Amphipoda). — A palmitinsav-1-^{14}C és sztearinsav-1-^{14}C átalakulása a *Gammarus (Rivulogammarus)* Roeseli Gervais amphipoda rákban. — Херодек, Ш.: Преобразование 1-^{14}C-палмитиновой и 1-^{14}C-стеариновой кислоты у рака *Gammarus (Rivulogammarus)* Roeseli Gervais Amphipoda.
37, 177—182.

81 *2* Herodek, S. (1973)
Incorporation of 1-^{14}C stearic acid and 1-^{14}C linolenic acid into the liver lipids of the carp (*Cyprinus carpio* L.). — Az 1-^{14}C sztearinsav és 1-^{14}C linolénsav beépülése a ponty (*Cyprinus carpio* L.) májának lipidjeibe.
40, 191—195.

82 *2* Herodek, S.—Farkas, T. (1960)
Changes in the composition of fatty acids in *Bombyx mori* L. in the course of ontogeny. — A *Bombyx mori* L. zsírsavösszetételének változása az egyedfejlődés folyamán.
27, 9—13.

83 *2* *8* Herodek, S.—Farkas, T. (1967)
Gas chromatographic studies on the fatty acid composition of some freshwater crustaceans. — Néhány édesvízi rák zsírsavösszetételének gázkromatográfiás elemzése. — Херодек, Ш.—Фаркаш, Т.: Анализ состава жирных кислот некоторых пресноводных раков посредством газовой хроматографии.
34, 147—152.

84 *6* *8* HERODEK, S.—OLÁH, J. (1973)
Primary production in the frozen Lake Balaton. — Elsődleges termelés a Balaton jege alatt.
40, 197—206.

85 *6* *8* HERODEK, S.—TAMÁS, G. (1973)
The primary production of phytoplankton in Lake Balaton April—September 1972. — A Balaton fitoplanktonjának elsődleges termelése 1972 április—szeptemberben.
40, 207—218.

86 *6* *8* HERODEK, S.—TAMÁS, G. (1974)
The primary production of phytoplankton in Lake Balaton October 1972—March 1973. — A fitoplankton termelése a Balatonban 1972 október—1973 március között.
41, 205—216.

87 *6* *8* HERODEK, S.—TAMÁS, G. (1975)
The primary production of phytoplankton in the Keszthely-basin of Lake Balaton in 1973—1974. — A fitoplankton elsődleges termelése a Balaton Keszthelyi-medencéjében.
42, 175—190.

HERODEK, S. see: 1, 40, 41, 42, 43, 44

88 *2* *9* HIRIPI, L. (1968)
Paper chromatographic and fluorometric examination of the serotonin content in the nervous system and other tissues of three freshwater molluscs *(Anodonta, Unio, Lymnaea)*. — Szerotonin papírkromatográfiás és fluorimetriás vizsgálata három édesvízi mollusca *(Anodonta, Unio, Lymnaea)* idegrendszerében és más szöveteiben. — Хирипи, Л.: Исследование серотонина при помощи бумажной хроматографии и флуориметрии в нервной системе и других тканях трех видов пресноводных моллюсков *(Anodonta, Unio, Lymnaea)*
35, 3—11.

89 *2* HIRIPI, L. (1970)
Examination of monoamine synthesis and break down in the nervous system and other tissues of *Lymnaea stagnalis* L. — Monoamin szintézis és lebontás vizsgálata *Lymnaea stagnalis* L. idegrendszerében és egyéb szöveteiben. — Хирипи, Л.: Исследование синтеза и разложения моноаминов в нервной системе и в других тканях *Lymnaea stagnalis* L.
37, 33—41.

90 *2* *9* HIRIPI, L. (1972)
Catecholamines in the different tissues of fresh water mussel (*Anodonta cygnea* L., Pelecypoda) analysed by thin-layer chromatographic and fluorimetric methods. — Katecholaminok vékonyrétegkromatográfiás és fluorimetriás vizsgálata *Anodonta cygnea* L. (Pelecypoda) különböző szöveteiben.
39, 13—20.

91 *1* *7* HIRIPI, L. (1973)
Pharmacological investigations on the regulation mechanisms of the periodic activity of the fresh water mussel (*Anodonta cygnea* L.). — A periodikus aktivitás szabályozási mechanizmusának farmakológiai vizsgálata tavi kagylón (*Anodonta cygnea* L.).
40, 27—53.

92 *2* *3* HIRIPI, L.—ELEKES, K.—S.-RÓZSA, K. (1975)
Intracellular distribution of serotonin in the central nervous system and in the heart of *Helix pomatia* L. — Szerotonin intracelluláris megoszlása *Helix pomatia* L. központi idegrendszerében és szívében. —
42, 3—20.

93 *1* *2* *7* HIRIPI, L.—NEMCSÓK, J.—SALÁNKI, J. (1974)
The effect of monoamine oxidase inhibitors on the ganglionic serotonin and catecholamine levels and on the activity in the fresh water mussel (*Anodonta cygnea* L., Pelecypoda). — Monoaminoxidáz gátlószerek hatása

J

K

100 *1 7 9* KISS, I.—SALÁNKI, J. (1971)
The heterogenic chemical sensitivity of the central neurones of *Lymnaea stagnalis* L. — *Lymnaea stagnalis* L. központi neuronjainak heterogén kémiai érzékenysége.
38, 39—52.

101 *1 7* KISS, I.—SALÁNKI, J. (1973)
The role of ionic environment in the potential generation of the giant neurones of *Lymnaea stagnalis* L. — Az ionmilió szerepe *Lymnaea stagnalis* L. óriás neuronjainak potenciál generálásában.
40, 55—71.

102 *1 9* KISS, I.—SALÁNKI, J. (1974)
The Na-dependence of the resting and action potential in the giant neurones of *Lymnaea stagnalis* L. — A nyugalmi és akciós potenciálok Na-függése *Lymnaea stagnalis* L. óriás neuronjaiban.
41, 35—43.

103 *1 9* KISS, I.—SALÁNKI, J.—VÉRÓ, M. (1972)
Dependence of reaction to ACh on the membrane potential of neurones of *Lymnaea stagnalis*. — Az ACh-ra adott válasz függése a membránpotenciáltól *Lymnaea stagnalis* neuronjain.
39, 21—27.

104 *1 9* KISS, I.—VADÁSZ, I. (1973)
The effects of local anaesthetics on the activity generation and chemical sensitivity of giant neurones. — Helyi érzéstelenítők hatása az óriás neuronok aktivitásgenerálására és kémiai érzékenységére.
40, 73—84.

KISS, I. see: 232

105 *1 9* KISS, T.—S.-RÓZSA, K. (1972)
Effect of biologically active substances on the spontaneous electrical activity of the heart muscle cells of *Helix pomatia* L. — Biológiailag aktív anyagok hatása *Helix pomatia* L. szívizomsejtjeinek spontán elektromos aktivitására.
39, 29—38.

106 *1 9* KISS, T.—S.-RÓZSA, K. (1975)
Membrane effects of cyclic nucleotides and their role in the realization of transmitter actions on the heart muscle cells of *Helix pomatia* L. — Ciklikus nukleotidok membránhatása, valamint szerepük transzmitterek hatásának realizálásában *Helix pomatia* L. szívizomsejtjein.
42, 43—60.

107 *1 9* KISS, T.—S.-RÓZSA, K. (1975)
Site of action of 5-hydroxytryptamine on the membrane of heart muscle cells in *Helix pomatia* L. — 5-hydroxytryptamine hatóhelyének vizsgálata *Helix pomatia* L. szívizomsejtjeinek membránján.
42, 61—72.

KISS T. see: 261

108 *3* KONOK, I. (1960)
Studies on the neurosecretory activity of the brain in the fresh water Crustacean, *Astacus leptodactylus* ESCHSCHOLZ (Decapoda). — Vizsgálatok a kecskerák, *Astacus leptodactylus* ESCHSCHOLZ (Decapoda) agyának neuroszekretorikus tevékenységével kapcsolatban.
27, 15—28.

109 *1 3* KONOK, I. (1961)
Studies on the light- and dark-adaptation of the colour of the crayfish, *Astacus leptodactylus* ESCHSCHOLZ (Decapoda) controlled by the secretory activity of the central nervous system. — Vizsgálatok a kecskerákon, *Astacus leptodactylus* ESCHSCHOLZ (Decapoda), a központi idegrendszer szekréciós tevékenysége által szabályozott fény- és sötétség-adaptációval kapcsolatban.
28, 29—47.

L

117 *1* *9* LÁBOS, E. (1964)
Studies on the electric excitability of the adductor muscle of glochidia. — Elektromos ingerlékenység vizsgálata *Anodonta*-lárvák (glochidiumok) záróizmán. — Лабош, Э.: Исследование электрической возбудимости на запирательной мышце личинок (глохидиев) беззубки.
31, 27—37.

118 *1* *9* LÁBOS, E. (1965)
The effect of the change of electrode dimensions and distance on the action potential induced by electric excitation of the unmyelinated nerve *Anodonta cygnea* L. — Elektródaméret és távolság változtatásának hatása velőhüvelymentes ideg elektromos ingerekkel kiváltott akciós potenciáljára. — Лабош, Э.: Влияние изменения расстояния и размера электродов на потенциал действия безмиелинового нерва, вызванный электрическим раздражением.
32, 17—27.

119 *1* *9* LÁBOS, E. (1965)
Influence of metabolic inhibitors on light sensitized contractions by erythrosin in mussel's larvae (*Anodonta cygnea* L.). — Anyagcseregátló szerek hatása erythrosinnal fényérzékenyített kontrakcióra kagylólárvákon. — Лабош, Э.: Влияние ингибиторов обмена веществ на фотосенсибилизированное эритрозином сокращение глохидиев беззубки.
32, 29—36.

120 *1* *9* LÁBOS, E. (1966)
Contributions to the mechanism of tryptamine effect on the adductor activity of fresh-water mussel larvae. — Adatok a triptaminhatás mechanizmusához édesvízi kagylólárvák záróizomtevékenységén. — Лабош, Э.: К вопросу о механизме действия триптамина на запирательную мышцу глохидиев беззубки.
33, 13—35.

121 *1* *9* LÁBOS, E. (1967)
Contributions to the mechanism of activating light cation effect on glochidia. — Adatok alkáli fém és földfém ionok aktiváló hatásának mechanizmusához *Anodonta* lárván. — Лабош, Э.: Данные к механизму активирующего эффекта ионов щелочного и щелочно-земельного металлов на глохидиях беззубки.
34, 3—24.

122 *1* LÁBOS, E. (1969)
Make and break responses of *Anodonta* nerve evoked by direct current stimulation. — *Anodonta* ideg zárási és nyitási ingerülete egyenáramú ingerlés hatására. — Лабош, Э.: Возбуждения замыкания и размыкания нерва беззубки под влиянием постоянного тока.
36, 25—39.

123 *1* LÁBOS, E. (1970)
Activation of the adductor in *Anodonta*-glochidia by N, N-dialkyl-tryptamines, 5-methoxy-tryptamine, β-adrenerg-antagonists, cocaine, scopolamine and other pharmacons. — N, N-dialkil triptaminok, 5-metoxi-triptamin, β-adrenerg-antagonisták, kokain, szkopolamin és egyéb farmakonok aktiváló hatása *Anodonta*-glochidiumok záróizom-tevékenységére. — Лабош, Э.: Возбуждающее воздействие N, N-диалкил триптаминов, 5-метокситриптамина, β-адренергических антагонистов, кокаина, скополамина и других фармакологических веществ на активность запирательной мышцы глохидиев беззубки.
37, 55—71.

124 *1* LÁBOS, E. (1970)
Photodynamic effects and irreversible damage in autoactive neurons of *Helix pomatia* evoked by rose bengal and methylene blue exposed to visible light. — Autoaktív *Helix pomatia* neuronok fotodinámiás befolyásolása és irreverzibilis károsítása bengálvörössel és metilénkékkel. — Лабош, Э.: Фотодинамическое влияние на нейроны *Helix pomatia* со

спонтанной активностью и их необратимое повреждение бенгальским красным и метиленовым синим.
37, 43—53.

125 *1* LÁBOS, E. (1971)
On the mechanical properties of the hinge ligament of *Anodonta cygnea* L. (Pelecypoda) in situ. — *Anodonta cygnea* L. (Pelecypoda) sarokpántszalagjának néhány mechanikai jellemzője in situ.
38, 53—63.

126 *1* LÁBOS, E.—GLAIZNER, B.—SALÁNKI, J. (1970)
Initial value laws applied to spontaneous rhythm, evoked oscillations and aperiodic responses of *Anodonta* adductor muscles. — Kezdeti értéktörvények alkalmazása *Anodonta* záróizom spontán és kiváltott oszcillációira, valamint aperiodikus válaszaira. — Лабош, Э.—Глезнер, Б.—Шаланки, Я.: Применение начальных количественных законов для спонтанной и вызванной осциляции апериодических ответов аддуктора *Анодонты*.
37, 73—83.

127 *1* LÁBOS, E.—LUKACSOVICS, F. (1968)
The role of environmental temperature and pH on the variations in K^+- and tryptamine-sensitivity of glochidia of *Anodonta cygnea* L. — A közeg hőmérsékletének és pH-jának szerepe az *Anodonta cygnea* L. glochidiumok K^+- és triptamin-érzékenységének eltéréseiben. — Лабош, Э.—Лукачевич, Ф.: Роль температуры и pH среды в различной чувствительности глохидиев беззубки к триптамину и ионам калия.
35, 13—24.

128 *1* LÁBOS, E.—S.-RÓZSA, K.—SALÁNKI, J. (1964)
On the role of SH-groups in the rhythmic activity of adductor muscle of glochidia. — SH-csoportok jelentősége glochidiumok ritmikus záróizomtevékenységében. — Лабош, Э.—Ш.-Рожа, К.—Шаланки, Я.: Значение SH-групп в ритмической деятельности запирательной мышцы глохидиев.
31, 39—54.

129 *1* LÁBOS, E.—SALÁNKI, J. (1963)
The effect of alkali metal ions and alkaline earth metal ions on the rhythmic activity of glochidia of the freshwater mussel *Anodonta cygnea* L. — Alkáli fém és alkáli földfém ionok hatása az édesvízi kagyló (*Anodonta cygnea* L.) glochidiumainak ritmikus aktivitására. — Лабош, Э.—Шаланки, Я.: В лияние ионов щелочных и щелочно-земных металлов на ритмическую активность глохидий беззубки (*Anodonta Cygnea* L.)
30, 45—57.

130 *1* LÁBOS, E.—SALÁNKI, J.—VARANKA, I. (1969)
Frequency-dependence of action potential on non-myelinated nerve of *Anodonta cygnea* L. (Pelecypoda). — Akciós potenciál frekvenciafüggése *Anodonta cygnea* L. (Pelecypoda) nem myelinizált idegén. — Лабош, Э.—Шаланки, Я.—Варанка, И.: Частотная зависимость потенциала действия в безмякотном нерве беззубки.
36, 41—56.

131 *1* LÁBOS, E.—TURCSÁNYI, B. (1966)
On primary and secondary processes of photoinduced muscle response in *Anodonta*-larvae.—A fotoindukált izomkontrakció elsődleges és másodlagos folyamatairól. — Лабош, Э.—Турчани, Б.: Первычные и вторичные процессы фотоиндукционной мышечной контракции.
33, 45—60.

132 *1* LÁBOS, E.—VARANKA, I. (1966)
On the nature of the components of the potential complex induced by electric stimulation on *Anodonta* nerve. — Az elektromos ingerrel kiváltott potenciálkomplexum komponenseinek természetéről, *Anodonta* idegen. — Лабош, Э.—Варанка, И.: О характере компонентов нервного импульса, вызванного электрическим раздражением в нерве беззубки.
33, 61—78.

133 *1* *3* LÁBOS, E.—Zs.-NAGY, I.—BENKŐ, K.—SALÁNKI, J. (1963)
Electrophysiological and electron microscopic studies on the fibre composition of the cerebrovisceral connective of *Anodonta cygnea* L. — Elektrofiziológiai és elektronmikroszkópos adatok az *Anodonta cygnea* L. cerebrovisceralis connektívumának rostösszetételéhez. — Лабош, Э.—Ж.-Надь, И.—Бенкё, К.—Шаланки, Я.: Электрофизиологические и электронно-микроскопические данные к составу волокон церебро-висцерального коннектива беззубки (*Anodonta cygnea* L.)
30, 59—65.

134 *2* *3* LÁBOS, E.—Zs.-NAGY, I.—HIRIPI, L. (1966)
Histological and chemical studies on the yellow pigment present in the nerve- and other tissues of *Anodonta cygnea* L. — Hisztológiai és kémiai vizsgálatok az *Anodonta cygnea* L. ideg- és egyéb szöveteinek sárga pigmentjén. — Лабош, Э.—Ж.-Надь И.—Хирипи, Л.: Гистологическое и химическое исследование желтого пигмента нервной и других тканей беззубки.
33, 37—44.

LÁBOS, E. see: 140, 210, 231, 233, 234, 235, 236, 303, 327

135 *1* *7* *9* LUKACSOVICS, F. (1966)
Ciliary activity examinations after anoxybiosis on the isolated gills of *Anodonta cygnea* L. — Csillóaktivitás vizsgálatok anoxybiozis után az *Anodonta cygnea* L. izolált kopoltyúján. — Лукачович, Ф.: Изучение активности ресничек изолированных жабер *Anodonta cygnea* L. после анаксибиоза.
33, 95—102.

136 *1* *7* *9* LUKACSOVICS, F. (1966)
Hypoxial examination of *Anodonta cygnea* L. on the O_2-consumption of gill-tissues and the relation between body dimensions and the respiration of the gill-tissue. — *Anodonta cygnea L.* hypoxiás vizsgálata a kopoltyúszövetek O_2-fogyasztásán, valamint testméret és a kopoltyúszövet légzésének relációja. — Лукачович, Ф.: Исследование потребления кислорода жаберными лепестками *Anodonta cygnea* L. в гипоксических условиях и наблюдения над взаимоотношением между размером тела и жаберным дыханием.
33, 79—94.

137 *1* *7* *9* LUKACSOVICS, F.—GUBICZA, A. (1960)
Über die Atmung der verschiedenen Rassen des Seidenspinners *Bombyx mori* L. I. Untersuchung der Atmung von Eiern. — *Bombyx mori* L. különböző rasszainak légzése. I. Peték légzésének vizsgálata. — Лукачович, Ф.—Губица, А.: Дыхание различных рас *Bombyx mori* L. I. Исследование дыхания яиц.
27, 29—39.

138 *1* *7* *9* LUKACSOVICS, F.—GUBICZA, A. (1961)
Die Atmung der verschiedenen Rassen von *Bombyx mori* L. II. Untersuchung der Atmung der Larven. — A *Bombyx mori* L. különböző raszszainak lélegzése. II. Lárvák lélegzésének vizsgálata. — Лукачович, Ф.—Губица, А.: Дыхание разных рас *Bombyx mori* L. II. Изучение дыхания червей.
28, 17—27.

139 *7* *9* LUKACSOVICS, F.—GUBICZA, A. (1963)
Gamma sugárzás hatása a *Bombyx mori* L. (Lepidoptera) Varo rasszára. I. Diapulzáló peték vizsgálata. — Untersuchung der Einwirkung der Gammastrahlung an diapausierenden Eiern von *Bombyx mori* L. (Lepidoptera).
30, 67—72.

140 *7* *8* *9* LUKACSOVICS, F.—LÁBOS, E. (1965)
Chemo-ecological relationship between some fish species in Lake Balaton and the glochidia of *Anodonta cygnea* L. — Kemo-ökológiai kapcsolatok vizsgálata néhány balatoni halfaj és az *Anodonta cygnea* L. glochidiuma

között. — Лукачович, Ф.—Лабош, Э.: Исследование хемо-экологических связей между глохидиями *Anodonta cygnea* L. и несколькими видами Балатонских рыб.
32, 37—54.

141 *1* *7* *9* LUKACSOVICS, F.—SALÁNKI, J. (1964)
Effect of substances influencing tissue respiration and of the temperature on the O_2 consumption of the gill tissue in *Unio tumidus*. — Szövetlégzést befolyásoló anyagok, valamint hőmérséklet hatása az *Unio tumidus* kopoltyúszövetének O_2 fogyasztására. — Лукачович, Ф.—Шаланки, Я.: Влияние веществ, изменяющих тканевое дыхание, и температуры на потребление кислорода жабрами перловицы *(Unio tumidus)*
31, 55—63.

142 *1* *7* *9* LUKACSOVICS, F.—SALÁNKI, J. (1968)
Data to the chemical sensitivity of freshwater mussel (*Anodonta cygnea* L.). — Adatok a tavi kagyló (*Anodonta cygnea* L.) kémiai érzékenységéhez. — Лукачович, Ф.—Шаланки, Я.: К вопросу о химической чувствительности беззубки.
35, 25—34

LUKACSOVICS, F. see: 4, 67, 68, 127, 235, 238, 239

M

MARKOVA, L. N. see: 151

143 *7* MATSKÁSI, I. (1967)
Helminthological investigations of fish in Lake Balaton I. (Preliminary report). Trematodes. — A balatoni halak helmintológiai vizsgálata. I. (Előzetes közlemény). Trematodák. — Мачкаши, И.: Гельминтологическое исследование Балатонских рыб. I. (Предварительное сообщение.)
34, 153—156.

144 *7* *8* MATSKÁSI, I. (1968)
Helminthological investigations of fish in Lake Balaton II. (Monogenoidea). — A balatoni halak helmintofaunájának vizsgálata II. (Monogenoidea). — Мачкаши, И.: Изучение гельминтофауны рыб озера Балатон.
35, 135—139.

145 *7* *8* MÉSZÁROS, F. (1967)
Helminthological investigations of fish in Lake Balaton I. (Preliminary report). Nematodes. — A balatoni halak helmintológiai vizsgálata I. (Előzetes közlemény). Nematodák. — месарош, Ф.: Гельминтологическое исследование Балатонских рыб I. (Предварительное сообщение).
34, 157—161.

146 *7* *8* MÉSZÁROS, F. (1968)
Helminthological investigations of fish in Lake Balaton II. Parasitic nematodes from fish in the lake. – A balatoni halak helmintológiai vizsgálata II. Parazita nematodák a balatoni halakból. — Месарош, Ф.: Гельминтологическое исследование Балатонских рыб. II. Паразитические нематоды рыб озера Балатон.
35, 141—144.

MÉSZÁROS, J. see: 211
MOLNÁR, F. see: 60

147 *7* *8* MOLNÁR, GY.—TÖLG, I. (1961)
Adatok a fogassüllő (*Lucioperca lucioperca* L.) gyomoremésztés időtartamának hőmérséklet okozta változásáról. — Angaben zum durch verschiedene Temperaturgrade verursachten Wechsel in der Dauer der Magenverdauung des Zanders (*Lucioperca lucioperca* L.)
28, 109—115.

148 *7* *8* MOLNÁR, GY. —TÖLG, I. (1962)
Experimente mit Welse (*Silurus glanis* L.) zur Feststellung des Zusammenhanges der Temperatur und der Zeitdauer der Magenverdauung. —

N

O

156 *8* *9* OLÁH, J. (1970)
Measurement of the reducing ability of natural waters and sediments: a simple limnological method. — Természetes vizek és üledékek redukáló képességének mérése: egy egyszerű limnológiai módszer. — Олах, Я.: Измерение редицирющтей способности природах вод и осадков: простой лимнологический метод.
37, 209—222.

157 *5* *8* OLÁH, J. (1970)
Short periodic changes in the microbial plancton quantity of Lake Balaton. — Rövidperiódusú változások a Balaton mikrobiális plankton menynyiségében. — Олах, Я.: Короткие периодические изменения в количестве микропланктона Балатона.
37, 199—207.

158 *5* *8* OLÁH, J. (1971)
Glass effect and the microbial plankton–seston relation in the water of Lakes Balaton and Belső. — Az üveghatás és a mikrobiális plankton–szeszton kapcsolat a Balatonban és a Belső-tóban.
38, 153—160.

159 *5* *8* OLÁH, J. (1971)
The influence of River Zala on the bacteriological condition in Keszthely-Bay (Lake Balaton). — A Zala hatása a Keszthelyi-öböl bakteriológiai viszonyaira.
38, 161—166.

160 *5* *6* *8* OLÁH, J. (1971)
Weekly changes in the bacterio- and phytoplankton standing stock in Lake Balaton and in the highly eutrophic Lake Belső. — A bakterio- és fitoplankton állomány hetenkénti változásai a Balatonban és az erősen eutróf Belső-tóban.
38, 167—175.

161 *6* *8* OLÁH J. (1972)
Studies on the photosynthetic pigments and their decomposition in the sediment of Lake Balaton and Lake Belső. — Adatok a Balaton és Belső-tó üledékének fotoszintetikus pigment tartalmához és lebomlásához.
39, 115—121.

162 *5* *8* OLÁH, J. (1973)
Bacterial gradients at the sediment—water interface of shallow lakes. — Baktérium gradiensek a sekély tavak víz—üledék határán.
40, 219—225.

163 *5* *8* OLÁH, J.—HAJDU, L.—ELEKES, K. (1972)
Electron microscopic investigation of natural bacterial populations in the water and sediment of Lake Balaton and Lake Belső. — A természetes baktérium populációk elektronmikroszkópos vizsgálata a Balaton és Belső-tó vizében és üledékében.
39, 123—129.

164 *5* *8* OLÁH, J.—VÁSÁRHELYI, R. (1970)
Comparative bacteriological investigation of three shallow Hungarian lakes with different trophic levels. — Három sekély, különböző trofitású magyarországi tó összehasonlító bakteriológiai vizsgálata. — Олах, Я.—Вашархейи, Р.: Сравнительно бактериологические исследования трёх мелких венгерских озер с различными трофическими условиями.
37, 223—234.

165 *5* *8* OLÁH, J.—VÁSÁRHELYI, R. (1970)
Comparative nutrient agar studies on the quantitative survey of saprophytic water microorganisms. — Összehasonlító táptalaj-tanulmányok a szaprofita vízi mikroorganizmusok mennyiségi felmérésére. — Олах, Я.—Вашархейи, Р.: Сравнительное изучение питательных сред для количественного изучения сапрофитных водных микроорганизмов.
37, 235—246.

Oláh, J. see: 84, 193, 195, 198, 199

166 *4* *8* Orsós, É. (1968)
Über die chemischen Verhältnisse des offenen Wassers des Balatonsees nach Untersuchungen im Jahre 1966 und 1967. — A Balaton nyíltvizének kémiai viszonyai az 1966. és 1967. évi vizsgálatok alapján. — Оршош, Е.: О химическом составе открытой воды озера Балатон по материалам исследований, проведенных и 1966–1967 годах.
35, 155–167.

P

167 *7* *8* P.-Zánkai, N. (Ponyi, L.) (1965)
Zoologische Untersuchung der Röhrichte des Balaton. II. Wassermilben (Hydracarina). — A Balaton nádasainak zoológiai vizsgálata II. Víziatkák (Hydracarina). — П.-Занкаи, Н.: Зоологическое исследование тростниковых зарослей Балатона. II. Водяные клещи (Hydracarina).
32, 175–186.

168 *1* *7* *8* P.-Zánkai, N. (1966)
On pH conditions of the alimentary canals of some Crustacenans. — Néhány rákfaj emésztőcsatornájának pH-viszonyairól. — П.-Занкаи, Н.: Об условиях pH в пищеварительном тракте некоторых видов рачков.
33, 217–231.

169 *7* *8* P.-Zánkai, N. (1968)
Über die Rädertieren- (Rotatoria-) Fauna des Plattensees nach Literaturangaben von 1897 bis 1960. — A Balaton kerekesféreg (Rotatoria) faunája az 1897–1960 év irodalmi adatai alapján. — П.-Занкаи, Н.: Фауна коловраток озера Балатон на основе литературных данных с 1897 годов по 1960 году.
35, 247–272.

170 *7* *8* P.-Zánkai, N.–Kertész, Gy. (1967)
Horizontal plankton investigations in Lake Balaton. VI. A study of the open water Rotatoria of Lake Balaton, based on collectings in 1965. — Horizontális planktonvizsgálatok a Balatonon. VI. A Balaton nyíltvízi rotatoriáinak vizsgálata az 1965. évi gyűjtések alapján. — П.-Занкаи, Н.–Кертес, Д.: Горизонтальное исследование планктонов Балатона VI. Изучение в открытой воде Балатона на основании анализа материала, осбранного в 1965 году.
34, 255–275.

171 *7* *8* P.-Zánkai, N.–Ponyi, J. (1970)
The quantitative proportions of rotifera plankton in Lake Balaton, in 1967. — A Balaton Rotatoria planktonjának mennyiségi viszonyai az 1967-es évben. — П.-Занкаи, Е.: Количественное исследование планктонных коловраток в озере Балатон в 1970 году.
37, 291–308.

172 *7* *8* P.-Zánkai, N.–Ponyi, J. (1971)
The horizontal distribution of Rotifera plankton in Lake Balaton. — A Balaton kerekesféreg planktonjának horizontális elterjedése.
38, 285–304.

173 *7* *8* P.-Zánkai, N.–Ponyi, J. (1972)
Quantitative relationships of the Rotatoria plankton in Lake Balaton during 1965–1966. — A Balaton Rotatoria planktonjának mennyiségi viszonyai 1965–1966-ban.
39, 189–204.

174 *7* *8* P.-Zánkai, N.–Ponyi, J. (1973)
The biomass of Rotatoria in Lake Balaton. — Kerekesférgek (Rotatoria)
40, 285–292.

175 7 8 P.-Zánkai, N.—Ponyi, J. (1974)
On the feeding of *Eudiaptomus gracilis* in Lake Balaton. — A balatoni *Eudiaptomus gracilis* táplálkozásáról.
41, 363—371.

176 7 8 P.-Zánkai, N.—Ponyi, J. (1974)
On the seasonal fluctuation in the food incorporation of *Eudiaptomus gracilis*. — Az *Eudiaptomus gracilis* táplálékértékesítésének évszakos változásairól.
41, 357—362.

P.-Zánkai, N. see: 178, 193, 194, 195, 197, 200

177 4 8 Pásztor, Zs.—Ponyi, J. —Holló, A.—Gönczy, L. (1975)
Investigations by gas chromarograph on the chlorinated hydrocarbon pollution in two areas of Lake Balaton. — A klórozott szénhidrogén szennyezettség gázkromatográfiás vizsgálata a Balaton két különböző vízterületén.
42, 191—202.

178 7 8 Paveljeva, E.—P.-Zánkai, N. (1971)
Quantitative nutritional characteristics of some water mite species. — Néhány vízi-atka faj táplálékfogyasztásának mennyiségi jellemzése.
38, 177—181.

179 1 9 Pécsi, T. (1965)
The effect of 5-hydroxytryptamine on the heart of fresh water mussel (*Anodonta cygnea* L.) in the case of different modes of application. — Az 5-hydroxytryptamin hatása a tavi kagyló (*Anodonta cygnea* L.) szívén különböző alkalmazási módok esetében. — Печи, Т.: Эффект серотонина на сердце беззубки (*Anodonta cygnea* L.) в зависимости от способа его применения.
32, 55—67.

180 1 Pécsi, T.—Kuziemski, H.—S.-Rózsa, K. (1967)
Pharmacological investigations on the isolated penial apparatus of freshwater snail *Lymnaea stagnalis* L. — Farmakológiai vizsgálatok egy édesvízi csiga, *Lymnaea stagnalis* L. izolált penis preparátumán. — Печи, Т.—Куземский, Г.—Ш.-Рожа, К.: Фармакологические исследования на изолированном половом аппарате болотного прудовика.
34, 31—49.

181 1 9 Pécsi, T.—Salánki, J. (1964)
The role of pressure in the periodical changes of cardiac action in the freshwater mussel. — Nyomásviszonyok szerepe a tavi kagyló (*Anodonta cygnea* L.) szívműködésének periodikus változásaiban. — Печи, Т.—Шаланки, Я.: Роль условий давления в периодическом изменении деятельности сердца беззубки (*Anodonta cygnea* L.)
31, 65—76.

Pécsi, T. see: 153, 212, 213, 221, 240
Penkov, I. see: 61, 62

182 7 8 Pénzes, B. (1966)
Adatok a balatoni dévérkeszeg (*Abramis brama* L.) növekedéséhez. — Beiträge zum Wachstum der Bleie (*Abramis brama* L.) im Balaton-See. — Пензэш, Б.: Данные о росте Балатонского леща (*Abramis brama* L.)
33, 173—176.

183 7 8 Ponyi, J. (1960)
Über im interestitialen Wasser der sandigen und steinigen Ufer des Balaton lebende Krebse (Crustacea). — A Balaton homokos és köves partjainak interstitiális vizében élő rákokról (Crustacea). — Поньи, Й.: О раках (Crustacea) живущих в межуточной интерстициальной воде песчанистых и каменистых берегов озера Балатона.
27, 85—92.

184 7 8 PONYI, J. (1961)
Über die Ernährung einiger Amphipoden (Crustacea) in Ungarn. — Néhány magyarországi amphipoda (Crustacea) táplálékáról. — Поньи, Й.: О питании некоторых встречаемых в Венгрии разновидностей Amphipoda (Crustacea).
28, 117—123

185 7 8 PONYI, J. (1962)
Zoologische Untersuchung der Röhrichte des Balaton I. Krebse (Crustacea). — A Balatoni nádasok állattani vizsgálata I. Rákok — Crustacea.
29, 129—163.

186 7 8 PONYI, J. (1965)
Crustaceen—Plankton-Studien im Balaton-see (I. Teil). Untersuchung der im Jahre 1925 vor Révfülöp gesammelten Netzfilter-Proben. — Crustacea-planktontanulmányok a Balatonon I. rész. Az 1925-ben Révfülöp előtt gyűjtött hálószüredék-minták vizsgálata. — Поньи, Й.: Изучение ракообразных планктонов в Балатоне I. Исследование образца фильтрата сачка, собранного перед Ревфюлэп в 1925 году.
32, 141—157.

187 7 8 PONYI, J. (1965)
Crustaceen-Planktonstudien am Balaton II. — Beiträge zur Kenntnis der Systematik und Cyclomorphose einiger Arten der Gattung *Daphnia*. — Crustacea-planktontanulmányok a Balatonon II. rész. Adatok a Daphnia genus rendszertanának és ciklomorfózisának megismeréséhez. — Поньи, Й.: Изучение ракообразных планктонов в Балатоне II. Данные к познанию систематики и цикломорфозы видов Daphnia.
32, 159—174.

188 7 8 PONYI, J. (1966)
Tájékozódó vizsgálatok a Balaton nyíltvize iszaplakó rákjainak minőségi és mennyiségi viszonyairól. — Orientierende Untersuchungen über die qualitativen und quantitativen Verhältnisse der schlammbewohnenden Krebse im offenen Wasser des Balaton. — Поньи, Й.: Качественные и количественные ориентировочные исследования рачков, живущих в иле открытой части Балатона.
33, 177—192.

189 7 8 PONYI, J. (1967)
Studien über das Crustaceen-Plankton des Balaton III. Beiträge zur Systematik und Cyclomorphose von *Acanthocyclops vernalis* (FISCHER), 1853. — Crustacea-planktontanulmányok a Balatonon. III. Adatok az *Acanthocyclops vernalis* (FISCHER)1853 rendszertanához és cyclomorphosisához. — Поньи, Й.: Изучение планктонных ракообразных Балатона III. Данные систематические и цикломорфозу *Acanthocyclops vernalis* (FISCHER), 1853.
34, 163—177.

190 7 8 PONYI, J. (1968).
Studien über das Crustaceen-Plankton des Balaton IV. Beiträge zur Kenntnis der in der Krebsgemeinschaft des Sees horizontal auftretenden Veränderungen. — Crustacea-plankton vizsgálatok a Balatonon IV. Adatok a tó rákegyüttesében horizontálisan fellépő változások megismeréséhez. — Поньи, Й.: Об изменениях в видовом составе ракообразных озера Балатон.
35, 169—182.

191 7 8 PONYI, J. (1969)
Quantitative investigations on mud-living crustaceans in the open water of Lake Balaton. — Mennyiségi vizsgálatok a Balaton nyíltvízi iszapjában élő rákokon. — Поньи, Й.: Количественные исследования раков, живущих в иле открытой воды озера Балатон.
36, 213—222.

192 7 8 PONYI, J. (1971)
Investigations on crustacean and molluscan remains in the upper sedi-

mentary layer of Lake Balaton. — A Balaton felső üledékrétegéből származó rák (Crustacea) és puhatestű (Mollusca) maradványok vizsgálata. *38*, 183—197.

193 *4 5 6 7 8* PONYI, J.—BIRÓ, P.—OLÁH, J.—P.-ZÁNKAI, N.—TAMÁS, G.—CSEKEI, T.—KISS, GY.—MORVAI, I.—BANCSI, I. (1973)
Limnological investigations of a fish-pond supplied with sewage -water in the vicinity of Lake Balaton. I. — Limnológiai vizsgálatok egy Balaton melletti szennyvizes halastóban I.
40, 227—284.

194 *2 7 8* PONYI, J.—BIRÓ, K.—P.-ZÁNKAI, N. (1969)
On some properties of the exopeptidase of *Gammarus (Rivulogammarus)* ROESELI GERVAIS (Amphipoda) and *Asellus aquaticus* (L.) (Isopoda). — *Gammarus (Rivulogammarus)* ROESELI GERVAIS (Amphipoda) és *Asellus aquaticus* (L.) (Isopoda) exopeptidázának néhány tulajdonságáról. — Поньи, Й.—Биро, К.—П.-Занкаи, Н.: Некоторые характерные свойства экзопептидаз *Gammarus (Rivulogammarus)* ROESELI GERVAIS *(Amphipoda* и *Asellus aquaticus* (L.) (Isopoda).
36, 223—228.

195 *4 5 6 7 8* PONYI, J.—BIRÓ, P.—P.-ZÁNKAI, N.—OLÁH, J.—TAMÁS, G.—CSEKEI, T.—KISS, GY.—MORVAI, T. (1974)
Limnological investigations of a fish-pond supplied with sewage-water in the vicinity of Lake Balaton II. — Limnológiai vizsgálatok egy Balaton melletti szennyvizes halastóban II.
41, 235—287.

196 *4 7 8* PONYI, J.—CSONTI, F.—BARON, F. (1968)
An investigation of the content of the chlorinated hydrocarbon residues of the Crustacean plankton in the Balaton. — A Crustacea-plankton klórozott szénhidrogén-maradék tartalmának vizsgálata a Balatonon. — Поньи, Й.—Чонти, Ф.—Барон, Ф.: Анализ накопления пестицидов в планктонных ракообразных озера Балатон.
35, 183—189.

197 *7 8* PONYI, J.—N.-HORVÁTH, J.—P.-ZÁNKAI, N. (1975)
Investigations on planktonic Crustacea in Lake Balaton VI. Quantitative changes in the Eudiaptomus gracilis population at various regions of Lake Balaton. — Az Eudiaptomus gracilis (G. O. Sars) populációjának mennyiségi alakulása a tó különböző területein.
42, 203—218.

198 *7 8* PONYI, J.—OLÁH, J.—BIRÓ, P.—BIRÓ, K. (1971)
Comparative investigations on the benthic fauna at two sewage inflows of Lake Balaton. — A Balaton fenékfaunájának összehasonlító vizsgálata két szennyvízbefolyó környékén.
38, 199—226.

199 *4 5 8* PONYI, J.—OLÁH, J.—FRANKÓ, A. (1972)
Distribution of organic matter and bacteria in the upper layer of bottom deposit in the open water of Lake Balaton. — Szervesanyag és baktériumok megoszlása a Balaton nyíltvizének felső üledékrétegében.
39, 141—148.

200 *7 8* PONYI, J.—P.-ZÁNKAI, N. (1972)
Investigations on planktonic Crustacea in Lake Balaton V. Horizontally occurring quantitative changes in the different areas of the lake in 1965—1966. — Crustacea-plankton vizsgálatok a Balatonon V. Horizontálisan fellépő mennyiségi eltérések a tó különböző területein, az 1965—1966. években.
39, 131—139.

201 *7 8* PONYI, J.—TUSNÁDI, GY.—VANGER, É.—RICHNOVSZKY, A. (1974)
Investigation with computer ICL system 4 on the morphometry and composition of the population of *Dreissena* shells from the upper sediment

R

S

209 *1* *9* S.-Rózsa, K.—Graul, Ch. (1964)
Is serotonin responsible for the stimulative effect of the extracardiac nerve in *Helix pomatia*? Serotonin felelős-e a *Helix pomatia* extracardialis idegének stimuláló hatásáért? — Ш. - Рожа, К.—Грауль, К.: Является-ли серотонин стумулирующим агентом в эффекте экстракардинального нерва виноградной улитки?
31, 85—96.

210 *2* *9* S.-Rózsa, K.—Lábos, E. (1967)
Biologically active compounds in the glochidia of *Anodonta cygnea* L. I. Identification of tryptamine and some amino acids by paper chromatography. — Biológiailag aktív anyagok *Anodonta cygnea* L. glochidiumaiban. I .Triptamin és néhány aminosav papírkromatográfiás identifikálása. — Ш.-Рожа, К.—Лабош, Э.: Биологически активные вещества в глохидиях беззубки I. Идентификация триптамина и некоторых других аминокислот посредством бумажной хроматографии.
34, 51—57.

211 *1* S.-Rózsa, K.—Mészáros, J.—Hiripi, L. (1974)
Effect of tranylcypromine on the contractile and electrical activities of the heart in *Helix pomatia*. — Tranylcipromin hatása *Helix pomatia* szívének kontraktilis és elektromos aktivitására.
41, 57—68.

212 *1* S.-Rózsa, K.—Pécsi, T. (1967)
Comparative studies on the effect produced by biologically active agents on the isolated hearts of *Helix pomatia* L. and *Anodonta cygnea* L. — Biológiailag aktív anyagok hatásának összehasonlító vizsgálata *Helix pomatia* L. és *Anodonta cygnea* L. izolált szívén. — Ш.-Рожа, К.—Печи, Т.: Сравнительный анализ действия некоторых биологически активных веществ на изолированном сердце виноградной улитки и беззубки.
34, 59—72.

213 *1* S.-Rózsa, K.—Pécsi, T. (1968)
Investigations of the role and mechanism of effect of nucleotides on the isolated hearts of molluscs. — Nukleotidok szerepének és hatásmechanizmusának vizsgálata molluszkák izolált szívén. — Ш.-Рожа, К.—Печи, Т.: Исследование роли и механизма действия некоторых нуклеотидов на изолированном сердце моллюсков.
35, 61—74.

214 *1* S.-Rózsa, K.—Salánki, J. (1973)
Responses of central neurones to the stimulation of heart chemoreceptors in the snail, *Helix pomatia* L. — Központi idegrendszeri neuronok válaszreakciói a szív kemoreceptorainak ingerlésére *Helix pomatián*.
40, 95—108.

215 *1* S.-Rózsa, K.—Salánki, J. (1974)
The role of interneuronal connections in the regulation of heart beats in the snail *Helix pomatia* L. — Interneuronális kapcsolatok szerepe a szívműködés szabályozásában csigán (*Helix pomatia* L.)
41, 45—55.

216 *1* *9* S.-Rózsa, K..—V.-Szőke, I. (1970)
Investigations on the chemical sensitivity of insect hearts. — Insecta szívek kémiai érzékenységének vizsgálata. — Ш.-Рожа, К.—, В.—Сёке, И.: Исследования химической чувствительности сердца насекомых.
37, 99—109.

217 *1* *9* S.-Rózsa, K.—V.-Szőke, I. (1970)
Pharmacological properties of the heart of *Lumbricus terrestris* L. — *Lumbricus terrestris* L. szívműködésének farmakológiai vizsgálata. — Ш.-Рожа, К.—В.—Сёке, И.: Фармакологические исследования на сердце дождевого червя *Lumbricus terrestris* L.
37, 85—97.

218 *1* *9* S.-Rózsa, K.—V.-Szőke, I. (1971)
Characteristics of the resting and action potentials of the heart muscle fibres in some insecta species. — Szívizomsejtek nyugalmi és akciós potenciáljainak jellemzői néhány rovarfajban.
38, 65—77.

219 *1* S.-Rózsa, K.—V.-Szőke, I. (1975)
Pharmacological properties of the receptors at the heart muscle membrane of *Locusta migratoria migratorioides* R. F. (Insecta). — Transzmitterek receptorainak farmakológiai tulajdonságai *Locusta migratoria migratorioides* R. F. (Insecta) szívének membránján.
42, 99—113.

220 *1* *9* S.-Rózsa, K.—Véró, M. (1971)
Electrocardiograms in insecta and gastropoda and their changes under experimental conditions. — Gastropoda és rovar szívek elektrokardiogramja és annak változása kísérletes körülmények között.
38, 79—86.

S.-Rózsa, K. see: 70, 71, 92, 105, 106, 107, 128, 180

221 *1* *9* Sakharov, D. A.—Pécsi, T. (1965)
Protecting and reactivating effect of serotonin on the heat-inactivated heart of the fresh water mussel. — A serotonin védő és reaktiváló hatása az édesvízi kagyló hőinaktivált szívén. — Сахаров, Д. А.—Печи, Т.: Защитное и восстановительное действие серотонина при температурной инактивации сердцебиений беззубки.
32, 117—121.

222 *6* Salah, M. (1967)
Description of new planktonic diatoms from Egypt. — Új pelagikus kovamoszatok Egyiptomból. — Салах, М.: Новые пелагические кремневые водоросли из Египта.
34, 179—189.

223 *1* *7* *9* Salánki, J. (1963)
Serotonin és rokonvegyületei, valamint catecholaminok és egyes farmakonok hatása egy édesvízi kagyló (*Anodonta cygnea* L.) periodikus aktivitásának idegi szabályozására. — Die Wirkung von Serotonin und verwandten Verbindungen sowie von Catecholaminen und einigen Pharmakonen auf die Nervenregelung der periodischen Aktivität der Süsswassermuschel *Anodonta cygnea* L. — Шаланки, Я.: Влияние серотонина и родственных ему веществ, катехоламинов и некоторых фармакологических средств на нервную регуляцию периодической активности беззубки *Anodonta cygnea* L.
30, 73—85.

224 *1* *7* *9* Salánki, J. (1964)
Contributions to the problem of daily rhythm in the activity of the fresh water mussel *Anodonta cygnea* L. — Van-e napszakos ingadozás a tavi kagyló (*Anodonta cygnea* L.) ritmikus és periodikus aktivitásában laboratóriumi körülmények között? — Шаланки, Я.: Суточные колебания ритмической и периодической активности беззубок в лабораторных условиях.
31, 109—116.

225 *1* *7* *9* Salánki, J. (1964)
Oxigénellátottság, mint a tavi kagyló (*Anodonta cygnea* L.) aktivitási ritmusának sajátos regulátora. — Шаланки, Я.: Снабжение кислородом—необычный регулятор ритма активности беззубок.
31, 97—108.

226 *1* *7* *9* Salánki, J. (1966)
Daily activity rhythm of two mediterranean lamellibranchia *(Pecten Jacobaeus* and *Lithophaga litophaga)* regulated by light-dark period. — — Két mediterrán kagyló *(Pecten Jacobaeus* és *Lithophaga lithophaga)* megvilágításfüggő napi aktivitási ritmusa. — Шаланки, Я.: Ритм суточной активности у двух средиземноморских двустворчатых моллюсков

(Pecten Jacobaeus и *Lithophaga lithophaga)* регулируемый периодичностью света и темноты.
33, 135—142.

227 *1* *9* SALÁNKI, J. (1968)
Studies on the effect of iontophoretically applied L-glutamate on the giant nerve cells of gastropoda *(Helix* and *Limnaea)*. — Iontoforetikusan applikált L-glutamát hatásának vizsgálata gastropodák *(Helix* és *Limnaea)* óriás idegsejtjein. — Шаланки, Я.: Исследование действия ионтофоретически в веденного глутамита на гигантские нервные клетки брюхоногих *(Helix* и *Limnaea)*.
35, 75—81.

228 *9* SALÁNKI, J.—BALLA, L. (1964)
Ink-lever equipment for continuous recording of activity in mussels (mussel-actograph). — Tintaírós készülék kagylók aktivitásának folyamatos regisztrálására (kagyló-aktográf). — Шаланки, Я.—Балла, Л.: Прибор для непрерывной регистрации активности беззубок с помощью чернильнопишущего прибора.
31, 117—121.

229 *1* *3* SALÁNKI, J.—BARANYI, I. (1965)
Studies on the relationship between periodic activity and neurosecretion in fresh-water mussel *Anodonta cygnea* L. — A periodikus aktivitás és neuroszekréciós tevékenység kapcsolatának vizsgálata tavi kagylón (*Anodonta cygnea* L.). — Шаланки, Я.—Барани, И. Б.: Исследование взаимосвязи нейросекреторной деятельности периодической активности беззубки (*Anodonta cygnea* L.)
32, 77—82.

230 *3* *9* SALÁNKI, J.—GUBICZA, A. (1967)
RNA in the ganglia of mollusca in normal conditions and following nerve damage. (A histochemical study). — RNS hisztokémiai vizsgálata mollusca ganglionban normál viszonyok között és idegkárosodás után. — Шаланки, Я.—Губица, А.: Гистохимическое исследование РНК в ганглиях моллюсков при нормальных условиях и после нарушения нерва.
34, 73—83.

231 *2* *9* SALÁNKI, J.—HIRIPI, L.—LÁBOS, E. (1966)
Cholinesterase activity in the central nervous system of *Anodonta cygnea* L. — Cholineszteráze-aktivitás *Anodonta cygnea* L. központi idegrendszerében. — Шаланки, Я.—Хирипи, Л.—Лабош, Э.: Холинэстеразная активность центральной нервной системы *Anodonta cygnea* L.
33, 143—150.

232 *1* *9* SALÁNKI, J.—KISS, I. (1969)
Identified cells in the central nervous system of *Lymnaea stagnalis* L. (Gastropoda). — Identifikált sejtek a *Lymnaea stagnalis* L. (Gastropoda) központi idegrendszerében. — Шаланки, Я.—Киш, И.: Идентифицированные клетки в центральной нервной системе большого прудовика.
36, 63—75.

233 *1* *7* SALÁNKI, J.—LÁBOS, E. (1963)
Kettős beidegzés vizsgálata édesvízi kagyló (*Anodonta cygnea* L.) záróizom tónusának szabályozásában. — Шаланки, Я.—Лабош, Э.: Исследование двойной иннервации в регулировании тонуса запирательной мышцы беззубки (*Anodonta cygnea* L.) Untersuchung der doppelten Innervation in der Regelung des Tonus des Schliessmuskels bei der Süsswassermuschel *Anodonta cygnea* L.
30, 87—101.

234 *1* *7* SALÁNKI, J.—LÁBOS, E. (1964)
Reflex investigations on the visceral ganglion of the fresh water mussel (*Anodonta cygnea* L.). — Reflexvizsgálatok tavi kagyló (*Anodonta cygnea* L.) viscerális ganglionján. — Шаланки, Я.—Лабош, Э.: Исследование рефлекса висцерального ганглия беззубки (*Anodonta cygnea* L.)
31, 123—132.

235 *1* *7* SALÁNKI, J.—LÁBOS, E. (1969)
On the role of cholinergic, adrenergic and tryptaminergic mechanisms in the regulation of a "catch" muscle (*Anodonta cygnea* L.). — Kolinerg, adrenerg és triptaminerg anyagok szerepe tónusos molluszkaizom (*Anodonta cygnea* L.) szabályozásában. — Шаланки, Я—Лабош, Э.: Роль холинергических, адренергических и триптаминергических веществ в регуляции тонической шышцы беззубки.
36, 77—93.

236 *1* SALÁNKI, J.—LÁBOS, E.—NÁN, I. (1964)
Electrophysiological properties of the cerebrovisceral connective of the fresh water mussel (*Anodonta cygnea* L.). — Tavi kagyló (*Anodonta cygnea* L.) cerebroviscerális konnektívumának elektrofiziológiai sajátságai. — Шаланки, Я.—Лабош, Э.—Нан, И.: Электрофизиологические свойства церебровисцерального коннектива беззубки (*Anodonta cygnea* L.)
31, 133—145.

237 *1* *7* *9* SALÁNKI, J.—LUKACSOVICS, F. (1965)
Effect of agents influencing the periodic activity of mussels on the *in vitro* respiration of siphon tissue of *Anodonta cygnea* L. — Kagylók periodikus aktivitását befolyásoló ágensek hatásának tanulmányozása *Anodonta cygnea* L. szifo-szöveténék *in vitro* légzésén. — Шаланки, Я.—Лукачевич, Ф.: Изучение эффекта веществ, влияющих на периодическую активность беззубки, на дыхание сифонной ткани *Anodonta cygnea* L. *in vitro*.
32, 83—92.

238 *1* *7* *9* SALÁNKI, J.—LUKACSOVICS, F. (1967)
Filtration and O_2 consumption related to the periodic activity of freshwater mussel (*Anodonta cygnea* L.) — Filtráció és O_2-fogyasztás összefüggése a periodikus aktivitással tavi kagylónál. — Шаланки, Я.—Лукачович, Ф.: Взаимодействие фильтрации и потребления кислорода с периодической активностью беззубки.
34, 85—98.

239 *1* *7* *9* SALÁNKI, J.—LUKACSOVICS, F.—HIRIPI, L. (1974)
The effect of temperature variations on the rhythmic and periodic activity of the fresh water mussel (*Anodonta cygnea* L.). — Hőmérsékletváltozás hatása tavi kagyló ritmikus és periodikus aktivitására.
41, 69—79.

240 *1* *9* SALÁNKI, J.—PÉCSI, T. (1965)
Reflex influences on the activity of adductors of fresh water mussel (*Anodonta cygnea* L.) by stimuli applied to the heart. — A tavi kagyló (*Anodonta cygnea* L.) záróizomműködésének reflexes befolyásolása szívre ható ingerekkel. — Шаланки, Я.—Печи, Т.: Рефлекторные изменения деятельности запирательных мышц беззубки (*Anodonta cygnea* L.) при раздражении сердца.
32, 93—109.

241 *1* *9* SALÁNKI, J.—TRUONG VAN BAY (1975)
Sensory input characteristics at the chemical stimulation of the lip in the snail *Helix pomatia* L. — Szenzoros bemenet elektrofiziológiai vizsgálata a száj körüli receptorok kémiai ingerlése esetén *Helix pomatia*-n.
42, 115—128.

242 *1* SALÁNKI, J.—VARANKA, I. (1971)
Differences in the chemical sensitivity of nerve pathways in the central nervous system of fresh water mussel (*Anodonta cygnea* L.). — Idegpályák eltérő kémiai érzékenysége tavi kagyló (*Anodonta cygnea* L.) központi idegrendszerében.
38, 87—96.

243 *2* SALÁNKI, J.—VARANKA, I.—HIRIPI, L. (1967)
Comparative study on the cholinesterase activity of different tissues of fresh-water mussel (*Anodonta cygnea* L.). — Különböző szövetek kolinészteráze aktivitásának összehasonlító vizsgálata tavi kagylón (*Anodonta*

cygnea L.). — Шаланки, Я.—Варанка, И.—Хирипи, Л.: Сравнительное исследование холинэстеразной активности разных тканей беззубки.
34, 99—116.

244 *1 7 9* Salánki, J.—Véró, M. (1969)
Diurnal rhythm of activity in freshwater mussel (*Anodonta cygnea* L.) under natural conditions. — Napi ritmus a természetes körülmények között tartott tavi kagyló (*Anodonta cygnea* L.) aktivitásában. — Шаланки, Я.—Веро, М.: Суточный ритм активности беззубки в естественных условиях.
36, 95—107.

245 *1 3* Salánki, J.—Zs.-Nagy, I.—H.-Vas, É. (1965)
Change of the Nissl-substance in connection with the periodic activity in the central nervous system of freshwater mussel (*Anodonta cygnea* L.) — A Nissl-anyag mennyiségének változása a periodikus aktivitással összefüggésben *Anodonta cygnea* L. központi idegrendszerében. — Шаланки, Я.—Ж.-Надь, И.—Х.-Ваш, Е.: Изменение вещества ниссля в центральной нервной системе беззубки в связи с периодической активностью.
32, 111—116.

Salánki, J. see: 72, 93, 95, 96, 100, 101, 102, 103, 126, 128, 129, 130, 133, 141, 142, 181, 214, 215, 304, 328, 329

246 *6 7 8* Sebestyén, O. (1960)
Állományokról, különös tekintettel a tavi planktonra. (Balatoni tanulmányok alapján). — Über Bestände, mit besonderer Berücksichtigung des See-Planktons.
27, 93—113.

247 *7 8* Sebestyén, O. (1960)
Horizontális planktonvizsgálatok a Balatonon. I. Tájékozódás a planktonrákok horizontális elterjedéséről. — Horizontale Planktonuntersuchungen im Balaton. I. Orientierende Untersuchungen über die horizontale Verbreitung der Planktonkrebse.
27, 115—130.

248 *7 8* Sebestyén, O. (1960)
Quantitative plankton studies on Lake Balaton X. Notes on the distribution of *Leptodora Kindtii* Focke. — Mennyiségi planktontanulmányok a Balatonon X. Néhány adat a *Leptodora Kindtii* Focke népességsűrűségéről.
27, 131—138.

249 *7 8* Sebestyén, O. (1961)
Occurrence of *Plumatella casmiana* Oka (Bryozoa) in Lake Balaton. — A *Plumatella casmiana* Oka (Bryozoa) előfordulása a Balatonban.
28, 125—133.

250 *8 10* Sebestyén, O. (1962)
Ergebnisse der Balaton-Forschung der letzten fünfzehn Jahren 1946—1960.
29, 217—266.

251 *8 10* Sebestyén, O. (1962)
Az utóbbi tizenöt év Balaton-kutatásának eredményei 1946—1960.
29, 165—216.

252 *7* Sebestyén, O. (1964)
Horizontale Plankton-Untersuchungen im Balaton. III. Weitere orientierende Untersuchungen über die horizontale Verbreitung der Planktonkrebse, mit besonderer Rücksicht auf die Verhältnisse der Bucht von Keszthely und derer Cladoceren Krebse. — Horizontális planktonvizsgálatok a Balatonon. III. További tájékozódás a planktonrákok elterjedéséről, különös tekintettel a Keszthelyi-öbölre és a balatoni kladocerákra. — Шебештен, О.: Горизонтальные исследования планктона в Балатоне. III. Дальнейшая ориентация о распространении планктоновых рачков, главным образом Cladocera в заливе Keszthely.
31, 223—243

253 *7* *8* SEBESTYÉN, O. (1965)
Kladocera tanulmányok a Balatonon. III. Tótörténeti előtanulmányok. — Cladocera studies in Lake Balaton III. Preliminary studies for lake history investigations. — Шебештен, О.: Исследования Cladocera в Балатоне. III. Предварительное изучение истории озера.
32, 187—228.

254 *7* *8* SEBESTYÉN, O. (1968)
A balatoni szivacsfauna néhány problémája tótörténeti vizsgálatok tükrében. — On some problems of fresh-water sponges occurring in Lake Balaton with reference to lake-history investigations. — Шебештен, О.: Некоторые вопросы фауны губок озера Балатон в связис изучением истории озера. *35*, 191—201.

255 *6* *8* SEBESTYÉN, O. (1968)
Remains of *Pediastrum kawraiskyi* SCHMIDLE (Chlorophyta, Protococcales) in the sediments of Lake Balaton. A paleolimnological study. — *Pediastrum kawraiskyi* SCHMIDLE maradványok balatoni üledékekben. Paleolimnológiai tanulmány. — Шебештен, О.: Остатки *Pediastrum kawraiskyi* в осадках Балатона, очерк по истории озера.
35, 203—226.

256 *7* *8* SEBESTYÉN, O. (1969)
Kladocera tanulmányok a Balatonon. IV. Szubfosszilis maradványok balatoni üledékekben. I. — Cladocera studies in Lake Balaton. IV. Subfossil remains in the sediments of Lake Balaton I. — Шебештен, О.: Изучение кладоцер озера Балатон. IV. Супфоссилные осатки в осадках Балатона I.
36, 229—256.

257 *7* *8* SEBESTYÉN, O. (1970)
Calcareous microfossils in the sediments of Lake Balaton. — Mésztartalmú mikrofossziliák a Balaton üledékeiben. — Шебештен, О.: Микрокопические известковые ископаемые в осадках Балатона.
37, 281—289.

258 *7* *8* SEBESTYÉN, O. (1970)
Kladocera tanulmányok a Balatonon IV. Szubfosszilis maradványok balatoni üledékekben II.
37, 247—279.

259 *7* *8* SEBESTYÉN, O. (1971)
Kladocera tanulmányok a Balatonon IV. Negyedkori maradványok balatoni üledékekben III. — Cladocera studies in Lake Balaton IV. Quaternary remains in the sediments of Lake Balaton III.
38, 227—268.

260 *7* *8* SEBESTYÉN, O. (1974)
Present and past occurrence of members of the genus *Filinia* BORY DE ST. VINCENT, 1826 (Testudinellidae Rotatoria) in Lake Balaton. — A *Filinia* genusba (Testudinellidae, Rotatoria) tartozó fajok előfordulása a Balaton jelenében és múltjában.
41, 289—315.

261 *1* *9* SOLOGUB, M. I.—KISS, T. (1971)
Intracellular potentials during protracted recording from the neurones of *Hirudo medicinalis*. — A pióca intracelluláris potenciáljának tanulmányozása hosszú idejű elvezetés alatt.
38, 97—105.

262 *4* *5* *8* SZABÓ, E. (1960)
Biologische Aktivität des Schlammes der Uferzone und ihre Wirkung auf den Chemismus des Wassers im Balaton. — A parti öv iszapjának biológiai aktivitása és ennek hatása a víz kemizmusára.
27, 139—145.

263 *5* *8* SZABÓ, E.—F. KALKÓ, ZS.—FELFÖLDY, L. (1961)
On the use of toluene as inhibitor in enzymological surveys of fresh-water bottom deposite. — A toluol gátló hatásának vizsgálata az édesvízi fenéküledékek biológiai aktivitásának mérésénél.
28, 135—138.

264 *2* *6* Szabó, E.—Ruff, F.—Felföldy, L. (1961)
Egysejtű algák össz-szterin tartalmáról. — On sterol content in some unicellular algae.
28, 139—141.

Szabó, E. see: 21, 22, 53, 289, 290
Szász, Á. see: 152

T

265 *6* *8* Tamás, G. (1961)
Horizontale Plankton-Untersuchungen im Balaton. II. Über das Phytoplankton im nordöstlichen Teil des Sees, auf Grund des Filtrats der in 1955, 1956 und 1958 entnommenen Proben. — Horizontális planktonvizsgálatok a Balatonon. II. A tó ÉK-i részének fitoplanktonjáról 1955, 1956 és 1958-ban gyűjtött hálószűredék alapján.
28, 143—149.

266 *6* *8* Tamás, G. (1962)
Beiträge zu der Algenflora des Balaton-Sees II. Einige neuest vorgekommenen epiplanktonische und im Periphyton lebende Organismen.
29, 267—273.

267 *6* *8* Tamás, G. (1963)
Kieselalgen des Balaton-Sees 1956—1961.
30, 167—217.

268 *6* *8* Tamás, G. (1964)
Die Algenflora des Balaton-sees. (Zusammengestellt nach Angaben aus den Jahren 1959—1963).
31, 245—253.

269 *6* *8* Tamás, G. (1964)
Beiträge zur Algenflora des Balaton-Sees. III. Algologische Untersuchungen im Aufwuchs der Makrovegetation des Sees im Jahre 1963.
31, 255—272.

270 *6* *8* Tamás, G. (1965)
Horizontale Plankton-Untersuchungen im Balaton IV. Über das Phytoplankton im südwestlichen Teil des Sees auf Grund von Schöpf- und Netzfilterproben vom Juli 1962. — Horizontális planktonvizsgálatok a Balatonon IV. A tó DNy-i részének fitoplanktonjáról az 1962 júliusi merített minták és hálószűredékek alapján.
32, 229—245.

271 *6* *8* Tamás, G. (1966)
Beiträge zur Algenflora des Balaton-Sees. IV. Vorkommen der epiplanktonischen Organismen *Colacium cyclopicola* (Gicklh.) Bourr. und *C. simplex* Huber—Pestalozzi. — Adatok a Balaton moszatflórájához IV. A *Colacium cyclopicola* (Gicklh) Bourr. és a *C. simplex* Huber—Pestalozzi epiplanktonikus szervezetek előfordulása. — Тамаш, Г.: Данные к флоре водорослей Балатона. IV. Распространение эпипланктонных *Colacium cyclopicola* (Gicklh.) Bourr. *C. Simplex* Huber—Pestalozzi.
33, 211—216.

272 *6* *8* Tamás, G. (1966)
Tájékozódó jellegű algológiai vizsgálatok a Balaton fenékiszapján az 1965. évi gyűjtések alapján. — Orientierende algologische Untersuchungen im Bodenschlamm des Balaton-Sees auf Grund der Sammlungen des Jahres 1965. — Тамаш, Г.: Ориентировочные исследование водорослей ила Балатона на основе материала, собранного в 1965 году.
33, 193—210.

273 *6* *8* Tamás, G. (1967)
Horizontale Plankton-Untersuchungen im Balaton V. Über das Phytoplankton des Sees auf Grund der im Jahre 1965 Geschöpften- und Netz-

filter-Proben. — Horizontális planktonvizsgálatok a Balatonon V. A tó fitoplanktonjáról az 1965. évi merített minták és hálószűredék alapján. — Тамаш, Г.: Горизонтальное исследование планктона Балатона V. О. фитопланктоне озера по образцу сачка и погруженной пробы.
34, 191–231.

274 *6* *8* TAMÁS, G. (1967)
Quantitative algologische Untersuchungen im Bodenschlamm des Balaton auf Grund der Sammlungen des Jahres 1966. — Mennyiségi algológiai vizsgálatok a Balaton fenékiszapján az 1966. évi gyűjtések alapján. — Тамаш, Г.: Количественные исследования водорослей ила Балатона на основе материала собранного в 1966 году.
34, 233–254.

275 *6* *8* TAMÁS, G. (1968)
Quantitative Untersuchungen des Mikrophytobentos aus dem Eprofundal des Balaton-Sees auf Grund der Sammlungen des Jahres 1967. — Mennyiségi vizsgálatok a Balaton mikrofitobentoszán az 1967. évi gyűjtések alapján. — Тамаш, Г.: Количественное изучение микрофитобентоса озера Балатон по сборам 1967 года.
35, 227–246.

276 *6* *8* TAMÁS, G. (1969)
Horizontal plankton investigations in Lake Balaton VII. On the phytoplankton of Lake Balaton, based on scooped samples and filtrates taken in 1966. — Horizontális planktonvizsgálatok a Balatonon VII. A tó fitoplanktonjáról az 1966. évi merített minták és hálószűredékek alapján. — Тамаш, Г.: Горизонтальные исследования планктона озера Балатон VII. О фитопланктоне озера по образцу сачка и погруженной пробы.
36, 257–292.

277 *6* *8* TAMÁS, G. (1971)
Quantitative investigations on microphytobenthos in 25 transversal sections of Lake Balaton. — Mennyiségi mikrofitobentosz vizsgálatok a Balaton 25 harántszelvényén az 1968. évi szeptemberi gyűjtések alapján.
38, 269–283.

278 *6* *8* TAMÁS, G. (1972)
Horizontal phytoplankton studies in Lake Balaton based on scooped samples and filtrates taken in 1967. — Horizontális fitoplankton vizsgálatok a Balatonon az 1967. évi merített minták és hálószűredékek alapján.
39, 151–188.

279 *6* *8* TAMÁS, G. (1972)
The occurrence of *Rhizochrysis limnetica* G. M. SMITH in the plankton of Lake Balaton. — *Rhyzochrysis limnetica* G. M. SMITH előfordulása a Balaton planktonjában.
39, 149–150.

280 *6* *8* TAMÁS, G. (1974)
The biomass changes of microphytobenthos in Lake Balaton during the 1960s. — A Balaton mikrofitobentoszának biomassza változása a hatvanas években.
41, 343–356.

281 *6* *8* TAMÁS, G. (1974)
The biomass changes of phytoplankton in Lake Balaton during the 1960s. — Balaton fitoplanktonjának biomassza változása a hatvanas években.
41, 323–342.

282 *6* *8* TAMÁS, G. (1974)
The occurrence of *Rhaphidiopsis mediterranea* SKUJA in the plankton of Lake Balaton. — *Rhapidiopsis mediterranea* SKUJA előfordulása a Balaton planktonjában.
41, 317–321.

283 *6* *8* TAMÁS, G. (1975)
Horizontally occurring quantitative phytoplankton investigations in Lake Balaton, 1974. — Horizontális mennyiségi fitoplankton vizsgálatok a Balatonban 1974. évben.
42, 219—279.

284 *6* *8* TAMÁS, G.—GELLÉRT, J. (1960)
Adatok a balatoni hidropszammon élővilágának ismeretéhez. — Daten zur Erkennung der Lebewelt des Hydropsammons im Balaton.
27, 65—73.

285 *10* (1975)
Tamás Gizella. Nekrológ.
42, 281—283.

TAMÁS, G. see: 33, 63, 85, 86, 87, 193, 195

286 *6* *8* TÓTH, L. (1960)
Phytozönologische Untersuchungen über die Röhrichte des Balaton-Sees. — Balatoni nádasok cenológiai vizsgálata. — Тот, Л.: Ценологическое исследование тростников озера Балатона.
27, 209—242.

287 *2* *6* TÓTH, L. (1962)
On some chemical properties of *Wolffia arrhiza* (L.) WIMM. — A *Wolffia arrhiza* (L.) WIMM néhány kémiai tulajdonságáról.
29, 275—282.

288 *2* *6* TÓTH, L. (1965)
Studies on the oxidative assimilation of unicellular algae. I. Effect of sugars on the respiration of *Chlorella vulgaris*. — Tanulmányok az egysejtű algák oxidatív asszimilációjáról I. Különféle cukrok hatása *Chlorella vulgaris* BEYER légzésére. — Тот, Л.: Наблюдения по окислительной ассимиляции одноклеточных водорослей. I. Влияние различных сахаров на *Chlorella vulgaris* BEYER.
32, 297—306.

289 *6* *8* TÓTH, L.—FELFÖLDY, L.—SZABÓ, E. (1961)
A balatoni nádas-produkció mérésének néhány problémájáról. — On some problems of production measurements in Phragmiteta in Lake Balaton.
28, 169—178.

290 *6* *8* TÓTH, L.—SZABÓ, E. (1961)
Zönologische und ökologische Untersuchungen in den Röhrichten des Neusiedlersees (Fertő-tó). — Cenológiai és ekológiai tanulmányok a Fertő-tó nádasaiban. — Тот, Л.—Сабо, Э.: Ценологические и экологические исследования в тростниках озера Фертэ.
28, 151—168.

TÓTH, L. see: 53, 54

291 *7* *8* TÖLG, I. (1960)
Untersuchung der Nahrung von Kaulbarsch-Jungfischen (*Acerina cernua* L.) im Balaton. — A vágódurbincs (*Acerina cernua* L.) ivadékának táplálkozása a Balatonban. — Тэлг, И.: Питание потомства ерша (*Acerina cernua* L.) в озера Балатон.
27, 147—167.

292 *7* *8* TÖLG, I. (1961)
Über die Ursache des Nahrungsmangels des Balaton-Zanders (*Lucioperca lucioperca* L.) und Begründung des Nahrungsersatz-Planes. — A balatoni fogassüllő táplálékhiányának oka és a táplálékpótlás tervének indokolása.
28, 179—195.

293 *7* *9* TÖLG, I. (1962)
Sicherung beständiger Temperatur bei Aquarien-Experimenten mit Fischen grösseren Sauerstoffbedarfes.
29, 283—285.

U

V

301 *1* VARANKA, I. (1972)
Some properties of the evoked potential and the ganglionic transmission in fresh-water mussel (*Anodonta cygnea* L., Pelecypoda). — A kiváltott potenciál néhány tulajdonsága és a ganglionáris áttevődés édesvízi kagylóban (*Anodonta cygnea* L., Pelecypoda).
39, 49—63.

302 *1* VARANKA, I. (1974)
The investigation of the spontaneous activity and evoked potentials at cellular level in the central nervous system of fresh-water mussel (*Anodonta cygnea* L.). — A spontán aktivitás és a kiváltott potenciálok sejtszintű vizsgálata tavi kagyló (*Anodonta cygnea* L.) központi idegrendszerében.
41, 91—109.

303 *1* VARANKA, I.—LÁBOS, E. (1972)
The effect of metabolic inhibitors and local anaesthetics on the response of *Anodonta* nerves to electric stimulation. — Anyagcseregátlók és lokálanesztetikumok hatása *Anodonta*-ideg elektromos ingerre adott válaszára.
39, 65—74.

304 *1* VARANKA, I.—SALÁNKI, J. (1970)
Pharmacological analysis of the spontaneous activity and transmission of impulses on the visceral ganglion of *Anodonta cygnea* L. — A spontán aktivitás és ingerületáttevődés farmakológiai vizsgálata *Anodonta cygnea* L. viscerális ganglionján. — Варанка, И.—Шаланки, Я.: Фармакологические исследования спонтанной активности и передачи возбуждения на висцеральном ганглии *Anodonta cygnea* L.
37, 111—130.

VARANKA, I. see: 130, 132, 242, 243

305 *7* VARGA, L. (1960)
Ereszcsatorna mohás törmelékanyagának mikrofaunájáról. — Über die moosbewohnende Mikrofauna aus einer Dachrinne von Tihany.
27, 169—182.

306 *10* VARGA, L. (1960)
Thienemann August emlékezete. — August Thienemann — zum Gedächtnis.
27, 243—254.

307 *7* VARGA, L. (1961)
Beiträge zur Kenntnis der streubewohnenden Mikrofauna des Aszófőer Waldes sowie zur Anabiose dieser Mikrofauna. — Adatok az Aszófői-erdő avarlakó mikrofaunájának és e mikrofauna anabiózisának ismeretéhez.
28, 203—209.

VÁSÁRHELYI, R. see: 164, 165

308 *2* VEREB, GY.—CSORNAI, M. (1969)
Phosphorylase activity and its inhibition with glucose-6-phosphate of the mussel's adductor muscle. — Kagyló záróizom foszforiláz aktivitása és ennek glukóz-6-foszfáttal való gátolhatósága. — Вереб, Г.—Чорнаи, М.: Активность фосфорилазы запирательно ймышцы беззубки и ее торможение при помощи глюкозо-6-фосфата.
36, 109—114.

309 *9* VÉRÓ, M. (1971)
Negative capacitance amplifier for microelectrode investigations. — Negatív kapacitású erősítő mikroelektródás vizsgálatokhoz.
38, 107—115.

310 *9* VÉRÓ, M. (1972)
Transistorized square wave generator for biological investigations. — Tranzisztoros négyszöggenerátor biológiai vizsgálatokhoz.
39, 75—80.

W

Z

320 *3* Zs.-Nagy, I. (1966)
New data on the anatomy of the visceral ganglion of fresh-water mussel. — Újabb adatok az édesvízi kagylók viscerális ganglionjának anatómiájához. — Ж.-Надь, И.: Новые данные об анатомии висцерального ганглия беззубки.
33, 103—110.

321 *3* Zs.-Nagy, I. (1967)
Histological, histochemical and electron-microscopical studies on the cytosomes of the nerve cells in *Anodonta cygnea* L. (Mollusca, Lamellibranchiata). — Hisztológiai, hisztokémiai és elektronmikroszkópos vizsgálatok az *Anodonta cygnea* L. (Mollusca, Lamellibranchiata) idegsejtjeinek cytosomáin. — Ж.-Надь, И.: Гистологические, гистохимические и электронномикроскопические исследования в цитосомах нервных клеток беззубки.
34, 25—39.

322 *3* Zs.-Nagy, I. (1968)
Fine structural analysis of the neurons of *Anodonta cygnea* L. (Pelecypoda). — Újabb adatok az *Anodonta cygnea* L. (Pelecypoda) neuronjainak szubmikroszkópos szerkezetéhez. — Ж.-Надь, И.: Новые данные о субмикроскопическом строении нейронов беззубки.
35, 35—59.

323 *3* Zs.-Nagy, I. (1971)
Pigmentation and energy dependent Sr^{++}-accumulation of Molluscan neurons under anaerobic conditions. — Összefüggés puhatestűek idegsejtjeinek pigmentációja és energiafüggő Sr^{++}-akkumulációja között anaerob állapotban.
38, 117—129.

324 *3* Zs.-Nagy, I. (1973)
The distribution of cytosomes in the non nervous tissues of *Anodonta cygnea* L. (Mollusca, Pelecypoda). — Citoszómák extraneuronális előfordulása az *Anodonta cygnea* L. (Mollusca, Pelecypoda) különböző szöveteiben.
40, 121—134.

325 *3* Zs.-Nagy, I.—B.-Muskó, I. (1972)
The fine structure of corpora pedunculata in *Gryllotalpa gryllotalpa* L. (Insecta, Orthoptera). — *Gryllotalpa gryllotalpa* L. (Insecta, Orthoptera) corpora pedunculatajának finomszerkezete.
39, 81—87.

326 *3* Zs.-Nagy, I.—Csukás, Cs. (1969)
Histochemical investigation of cytosomal lipids in the neurons of *Anodonta cygnea* L. under normal and anoxybiotic conditions. — A citoszomális lipidek hisztokémiai vizsgálata normál és anoxiás körülmények között *Anodonta cygnea* L. neuronjaiban. — Ж.—Надь, И.—Чукаш, Ч.: Гистохимические исследования липидов цитосомы в нервных клетках беззубок в нормальных условиях и после аноксии.
36, 115—122.

327 *3* Zs.-Nagy, I.—Lábos, E. (1969)
Light and electron microscopical investigations on the adductor muscle and nervous elements in the larva of *Anodonta cygnea* L. — Szövettani és elektronmikroszkópos vizsgálatok az *Anodonta cygnea* L. lárvájának záróizmán és idegelemein. — Ж.—Надь, И.—Лабош, Э.: Гистологические и электронномикроскопические исследования запирательных мышц и нервных элементов глохидиев беззубки.
36, 123—133.

328 *1 3* Zs.-Nagy, I.—Salánki, J. (1964)
Funkcionális állapottól függő struktúraváltozások a tavi kagyló (*Anodonta cygnea* L.) záróizmában. — Structural changes depending on functional conditions in the adductor of fresh-water mussel (*Anodonta cyg-*

nea L). — Ж.-Надь, И.—Шаланки, Я.: Структурные изменения, зависящие от функционального состояния в запирательной мышце беззубки (*Anodonta cygnea* L.)
31, 159—164.

329 *3* Zs.-Nagy, I.—Salánki, J. (1970)
The fine structure of neuromuscular and intermuscular connections in the adductors of *Anodonta cygnea* L. (Mollusca, Pelecypoda). — A neuromuszkuláris és intermuszkuláris kapcsolatok finom szerkezete az *Anodonta cygnea* L. (Mollusca, Pelecypoda) záróizmaiban. — Ж.-Надь, И.—Шаланки, Я.: Тонкая структура нервно-мышечных и межмышечных связей в аддукторах *Anodonta cygnea* L.
37, 131—143.

Zs.-Nagy, I. see: 3, 24, 25, 26, 73, 74, 75, 133, 134, 245

INDEX — SZAKMUTATÓ

8. *Limnology — Limnológia — Лимнология*

5 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 27 28 29 30 31 32 38 39 40 41 42 43 44 45 46 47 48 49 51 53 56 57 58 59 63 78 83 84 85 86 87 97 140 144 145 146 147 148 149 150 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 246 247 248 249 250 251 253 254 255 256 257 258 259 260 262 263 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 286 289 290 290 291 292 294 295 296 315 316

9. *Methods — Módszerek — Методика*

21 23 32 73 74 88 90 94 95 99 100 102 103 104 105 106 107 116 117 118 119 120 121 135 136 137 138 139 140 141 142 151 152 156 179 181 205 209 210 216 217 218 220 221 223 224 225 226 227 228 230 231 232 237 238 239 240 241 244 261 293 297 298 299 300 309 310 311 312 313 314

10. *Miscellanies — Varia — Разное*

2 6 60 61 62 112 114 250 251 285 306

INDEX

I. ZOOLOGY — ÁLLATTAN

II. HYDROBIOLOGY — HIDROBIOLÓGIA

III. VARIA — KÜLÖNFÉLE

A kiadásért felel az Akadémiai Kiadó igazgatója
Műszaki szerkesztő: Agács András
A kézirat nyomdába érkezet: 1976. VII. 14. Terjedelem: 15,4 (B/5 ív)
Akadémiai Nyomda, Budapest—Felelős vezető: Bernát György